Photomultiplier Tubes

PHOTOMULTIPLIER TUBES AND RELATED PRODUCTS

HAMAMATSU

Opening The Future with Photonics

Human beings obtain more than 70 percent of the information visually by using their eyes. However, there are vast sums of information and unknown possibilities hidden within light not visible to the naked eye. This kind of light includes ultraviolet, infrared, X-ray and ultra-low level light impossible for human eyes to detect.

Since its founding over 55 years ago, Hamamatsu Photonics has been investigating not only light seen by the human eye but also light that far exceeds this level. As a leading manufacturer specializing in the field of photonics, Hamamatsu Photonics has marketed dozens of photosensitive devices, light sources and related products. Through these state-of-the-art products, Hamamatsu Photonics has committed itself to pioneering industrial and academic research work in still unexplored areas in many fields.

Hamamatsu Photonics will continue to deliver innovative breakthroughs in a diverse range of fields, always striving to make human life fuller and richer by "researching the many ways to use light".

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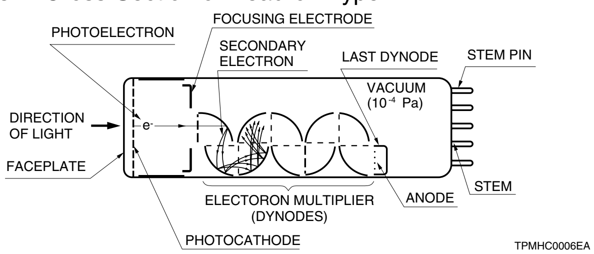
INTRODUCTION

Among photosensitive devices in use today, the photomultiplier tube (or PMT) is a versatile device providing ultra-fast response and extremely high sensitivity. A typical photomultiplier tube consists of a photoemissive cathode (photocathode) followed by focusing electrodes, an electron multiplier and an electron collector (anode) in a vacuum tube, as shown in Figure 1.
When light enters the photocathode, the photocathode emits photoelectrons into the vacuum. These photoelectrons are then directed by the focusing electrode voltages towards the electron multiplier where electrons are multiplied by a secondary emission process. The multiplied electrons then are collected by the anode as an output signal.
Because of secondary-emission multiplication, photomultiplier tubes provide extremely high sensitivity and exceptionally low noise compared to other photosensitive devices currently used to detect radiant energy in the ultraviolet, visible, and near infrared regions. The photomultiplier tube also features fast time response and a choice of large photosensitive areas.
This section describes the prime features of photomultiplier tube construction and basic operating characteristics.

Figure 1: Cross-Section of Head-on Type PMT



CONSTRUCTION

The photomultiplier tube generally has a photocathode in either a side-on or a head-on configuration. The side-on type receives incident light through the side of the glass bulb, while the head-on type receives light through the end of the glass bulb. In general, the side-on type photomultiplier tube is relatively low priced and widely used for spectrophotometers and general photometric systems. Most side-on types employ an opaque photocathode (reflection-mode photocathode) and a circular-cage structure electron multiplier (see description of "ELECTRON MULTIPLIER") which has good sensitivity and high amplification at a relatively low supply voltage.
The head-on type (or the end-on type) has a semitransparent photocathode (transmission-mode photocathode) deposited upon the inner surface of the entrance window. The head-on type provides better uniformity (see page 9) than the side-on type having a reflection-mode photocathode. Other features of head-on types include a choice of photosensitive areas ranging from tens to hundreds of square centimeters.
Variants of the head-on type having a large-diameter hemispherical window have been developed for high energy physics experiments where good angular light reception is important.

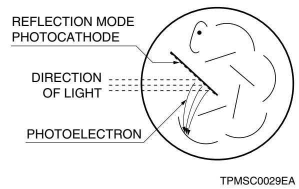
Figure 2: External Appearance

a) Side-on Type

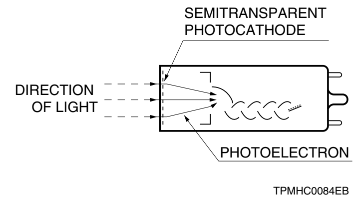
b) Head-on Type

Figure 3: Types of Photocathode

a) Reflection Mode



b) Transmission Mode

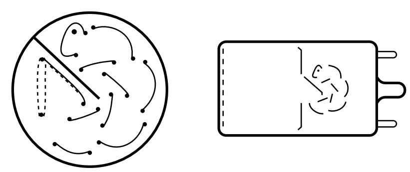


ELECTRON MULTIPLIER

The superior sensitivity (high current amplification and high S/N ratio) of photomultiplier tubes is due to the use of a low-noise electron multiplier which amplifies electrons by a cascade secondary emission process. The electron multiplier consists of 8 to 19 stages of electrodes called dynodes.
There are several principal types in use today.

1) Circular-cage type

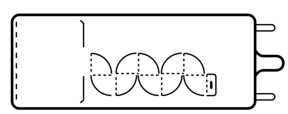
The circular cage is generally used for the side-on type of photomultiplier tube. The prime features of the circular-cage are compactness, fast response and high gain obtained at a relatively low supply voltage.



Side-On Type Head-On Type

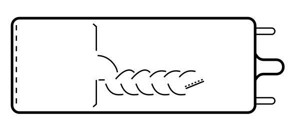
2) Box-and-grid type

This type consists of a train of quarter cylindrical dynodes and is widely used in head-on type photomultiplier tubes because of good electron collection efficiency and excellent uniformity.



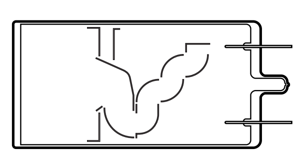
3) Linear-focused type

The linear-focused type features extremely fast response time and is widely used in applications where time resolution and pulse linearity are important. This type also has the advantage of providing a large output current.

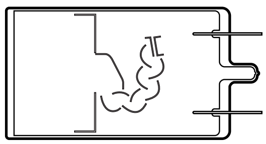


4) Box-and-line type

This structure consists of a combination of box-and-grid and linear-focus dynodes. Compared to box-and-grid type, this structure has advantages in time response, time resolution, pulse linearity, and electron collection efficiency.



5) **Circular and linear-focused type**
The circular and linear-focused type has a structure that combines a circular-cage type and a linear-focused type. It offers improved pulse linearity while maintaining the compactness of the circular-cage type.



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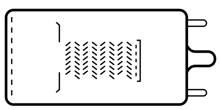
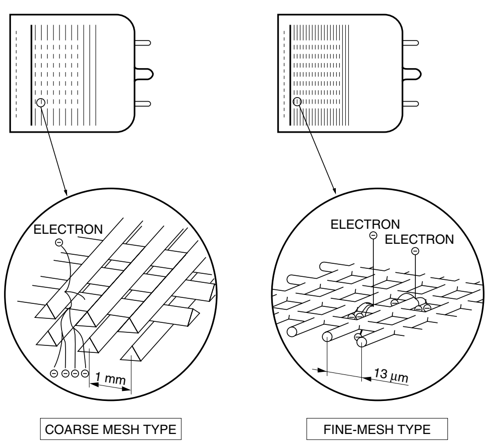
6) **Venetian blind type**
The venetian blind type has a large dynode area and is primarily used for tubes with large photocathode areas. It offers better uniformity and a larger output current. This structure is usually used when time response is not a prime consideration.



TPMOC0080EA

7) **Mesh type**
The mesh type has a structure of fine mesh electrodes stacked in close proximity. There are two mesh types of dynode: a coarse mesh type and a fine mesh type. Both types provide improved pulse linearity and high resistance to magnetic fields. The mesh type also has position-sensitive capability when used with cross-wire anodes or multiple anodes. The fine mesh type is particularly suited for use in applications where high magnetic fields are present.



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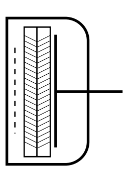
8) **Microchannel plate (MCP)** (see page 70)
The MCP is a thin disk consisting of millions of microglass tubes (channels) fused in parallel with each other. Each channel acts as an independent electron multiplier. The MCP offers much faster time response than other discrete dynodes. It also features good immunity from magnetic fields and two-dimensional detection ability when multiple anodes are used.



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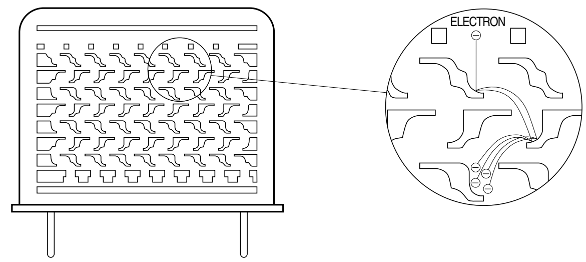
9) **Metal Channel type**
The metal channel dynode has a compact dynode construction manufactured by our unique fine machining techniques. It delivers high-speed response due to a space between each dynode stage that is much smaller than other types of conventional dynodes. The metal channel dynode is also ideal for position sensitive measurement.



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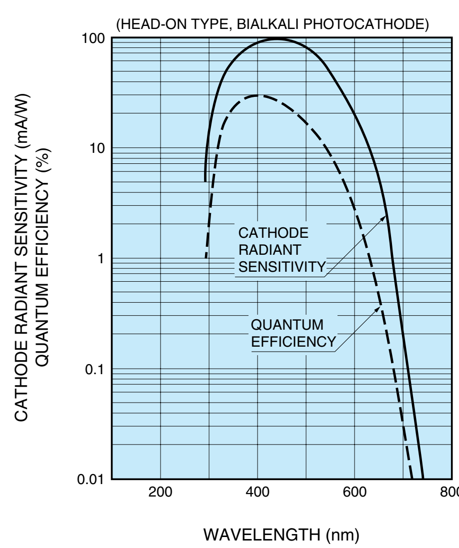
Hybrid dynodes combining two of the above dynodes are also available. These hybrid dynodes combine the best features of each dynode type.

SPECTRAL RESPONSE

The photocathode of a photomultiplier tube converts energy from incident light into electrons. The conversion efficiency (photocathode sensitivity) varies with the wavelength of the incident light. This relationship between photocathode sensitivity and wavelength is called the spectral response characteristic. Figure 4 shows the typical spectral response of a bialkali photomultiplier tube. The spectral response on long wavelengths is determined by the photocathode material and on short wavelengths by the window material. Typical spectral response characteristics for various types of photomultiplier tubes are shown on pages 132 and 133. In this catalog, the long-wavelength cutoff of the spectral response characteristic is defined as the wavelength at which the cathode radiant sensitivity is 1 % of the maximum sensitivity in bialkali and Ag-O-Cs photocathodes, and 0.1 % of the maximum sensitivity in multialkali photocathodes.
Spectral response characteristics shown at the end of this catalog are typical curves for representative tube types. Actual data may be different from tube to tube.

Figure 4: Typical Spectral Response of Bialkali Photocathode



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Construction and Operating Characteristics

PHOTOCATHODE MATERIALS

The photocathode is a photoemissive surface usually consisting of alkali metals with very low work functions. The photocathode materials most commonly used in photomultiplier tubes are as follows:

1) Ag-O-Cs
The transmission mode photocathode using this material is designated S-1 and sensitive in the visible to near infrared region. Since Ag-O-Cs has relatively high thermionic dark emission (refer to "ANODE DARK CURRENT" on page 8), this photocathode is cooled for detecting light in the near infrared region.

2) GaAs
The spectral response of this photocathode material usually covers a wider spectral response range than multialkali, from ultraviolet to 930 nm, which is comparatively flat over the range between 300 mm and 850 nm.

3) GaAsP
GaAsP (gallium arsenide phosphied) crystal activated in cesium is used as a transmission mode photocathode. This photocathode delivers very high quantum efficiency in the visible light region.

4) InGaAs
This photocathode material has greater extended sensitivity in the infrared range than GaAs. Moreover, in the range between 900 mm and 1000 nm, InGaAs has a much higher S/N ratio than Ag-O-Cs.

5) InP/InGaAsP(Cs), InP/InGaAs(Cs)
These are field-assisted photocathodes utilizing a PN junction formed by growing InP/InGaAsP or InP/InGaAs on an InP substrate. These photocathodes were developed by our own in-house semiconductor microprocess technology. Applying a bias voltage to this photocathode lowers the conduction band barrier, and allows for higher sensitivity at long wavelengths extending to 1.4 µm or even 1.7 µm which have up till now been impossible to detect with a photomultiplier tube. Since these photocathodes produce large amounts of dark current when used at room temperatures, they must be cooled to between -60 °C to -80 °C during operation.

6) Sb-Cs
Sb-Cs has a spectral response in the ultraviolet to visible range and is mainly used in reflection-mode photocathodes.

7) Bialkali (Sb-Rb-Cs, Sb-K-Cs)
These materials have a spectral response range similar to the Sb-Cs photocathode, but have higher sensitivity and lower dark current than Sb-Cs. They also have a blue sensitivity index matching the scintillation flashes of NaI scintillators, and so are frequently used for radiation measurement using scintillation counting.

8) High temperature bialkali or low noise bialkali (Na-K-Sb)
This is particularly useful at higher operating temperatures since it can withstand up to 175 °C. One major application is in the oil well logging industry. At room temperatures, this photocathode operates with very low dark current, making it ideal for use in photon counting applications.

9) Multialkali (Na-K-Sb-Cs)
The multialkali photocathode has a high, wide spectral response from the ultraviolet to near infrared region. It is widely used for broad-band spectrophotometers and photon counting applications. The long wavelength response can be extended to 930 nm by special photocathode activation processing.

10) Cs-Te, Cs-I
These materials are sensitive to vacuum UV and UV rays but not to visible light and are therefore referred to as solar blind. Cs-Te is quite insensitive to wavelengths longer than 320 nm, and Cs-I to those longer than 200 nm.

WINDOW MATERIALS

Window materials commonly used in photomultiplier tubes are described below. The window material must carefully be selected according to the application because the window material determines the spectral response short wavelength cutoff.

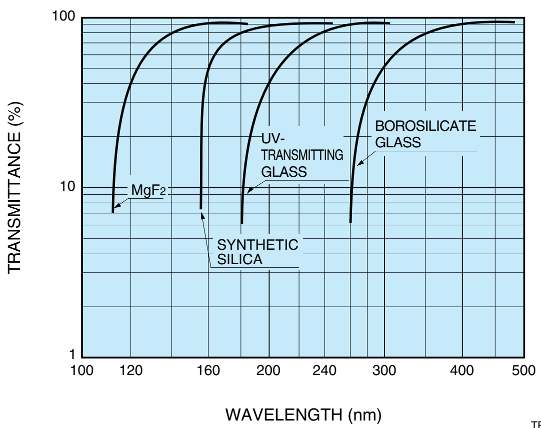
1) Borosilicate glass
This is the most frequently used window material. Borosilicate glass transmits radiation from the infrared to approximately 300 nm. It is not suitable for detection in the ultraviolet region. For some applications, a combination of a bialkali photocathode and a low-noise borosilicate glass (so called K-free glass) is used. The K-free glass contains very low potassium (^{40}K) which can cause unwanted background counts. Tubes designed for scintillation counting often employ K-free glass not only for the faceplate but also for the side bulb to minimize noise pulses.

2) UV-transmitting glass (UV glass)
This glass as the name implies is ideal for transmitting ultraviolet radiation and is used as widely as a borosilicate glass. The UV cutoff is approximately 185 nm.

3) Synthetic silica
The synthetic silica transmits ultraviolet radiation down to 160 nm and offers lower absorption in the ultraviolet range compared to fused silica. Since the synthetic silica has a different thermal expansion coefficient than Kovar, which is used for the tube leads, it is not suitable as the tube stem material (see Figure 1 on page 4). Borosilicate glass is used for the stem, and a graded seal using glass with gradually different thermal expansion coefficients is connected to the synthetic silica window. The graded seal structure is vulnerable to shock so the tube should be handled carefully.

4) MgF_2 (magnesium fluoride)
Crystals of alkali halide are superior in transmitting ultraviolet radiation, but have the disadvantage of deliquescence. Among these crystals, MgF_2 is known as a practical window material because it offers low deliquescence and transmits ultraviolet radiation down to 115 nm.

Figure 5: Typical Transmittance of Various Window Materials



RADIANT SENSITIVITY AND QUANTUM EFFICIENCY

As Figure 4 shows, spectral response is usually expressed in terms of radiant sensitivity or quantum efficiency as a function of wavelength. Radiant sensitivity is the photoelectric current from the photocathode, divided by the incident radiant power at a given wavelength, expressed in A/W (amperes per watt). Quantum efficiency (QE) is the number of photoelectrons emitted from the photocathode divided by the number of incident photons. Quantum efficiency is usually expressed as a percent. Quantum efficiency and radiant sensitivity have the following relationship at a given wavelength.

$$QE = \frac{S \times 1240}{\lambda} \times 100$$

where S is the radiant sensitivity in A/W at the given wavelength and λ is the wavelength in nm (nanometers).

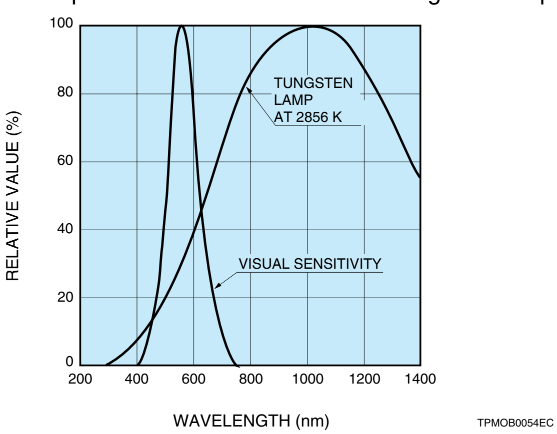
LUMINOUS SENSITIVITY

Since measuring the spectral response characteristic of photomultiplier tubes requires a sophisticated system and a great deal of time, we instead provide figures for anode or cathode luminous sensitivity and only provide spectral response characteristics when specially required by the customer.

Cathode luminous sensitivity is the photoelectric current from the photocathode per incident light flux (10^{-5} to 10^{-2} lumens) from a tungsten filament lamp operated at a distribution temperature of 2856 K. Anode luminous sensitivity is the anode output current (amplified by the secondary emission process) per incident light flux (10^{-10} to 10^{-5} lumens) on the photocathode. Although the same tungsten lamp is used, the light flux and the applied voltage are adjusted to an appropriate level. These parameters are particularly useful when comparing tubes having the same or similar spectral response range. Hamamatsu final test sheets accompanying the tubes usually indicate these parameters except for tubes with Cs-I or Cs-Te photocathodes insensitive to tungsten lamp light. (Radiant sensitivity at a specific wavelength is listed for those tubes using Cs-I or Cs-Te.)

The cathode luminous sensitivity is expressed in µA/lm (microamperes per lumen) and anode luminous sensitivity is expressed in A/lm (amperes per lumen). Note that the lumen is a unit used for luminous flux in the visible region and therefore these values may be meaningless for tubes that are sensitive beyond the visible light region.

Figure 6: Typical Human Eye Response and Spectral Distribution of 2856 K Tungsten Lamp



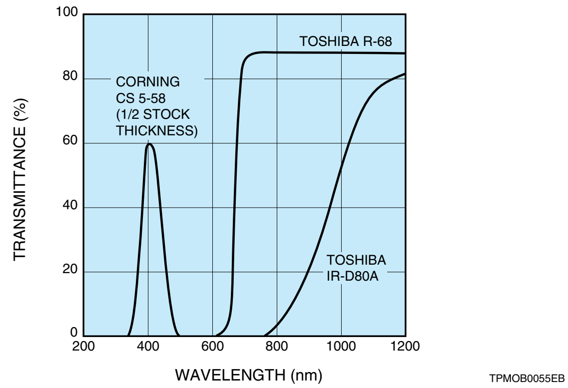
BLUE SENSITIVITY INDEX AND RED/WHITE RATIO

The cathode blue sensitivity index and the red/white ratio are often used as a simple comparison of photomultiplier tube spectral response.

The cathode blue sensitivity index is the photoelectric current from the photocathode produced by a light flux of a tungsten lamp at 2856 K passing through a blue filter (Corning CS 5-58 polished to half stock thickness), measured under the same conditions as the cathode luminous sensitivity measurement. The light flux, once transmitted through the blue filter cannot be expressed in lumens. The blue sensitivity index is an important parameter in scintillation counting using an NaI scintillator since the NaI scintillator produces emissions in the blue region of the spectrum, and may be the decisive factor in energy resolution.

The red/white ratio is used for photomultiplier tubes with a spectral response extending to the near infrared region. This parameter is defined as the quotient of the cathode sensitivity measured with a light flux of a tungsten lamp at 2856 K passing through a red filter (Toshiba IR-D80A for the S-1 photocathode or R-68 for others) divided by the cathode luminous sensitivity measured without filters under the same conditions as in cathode luminous sensitivity measurement.

Figure 7: Transmittance of Various Filters



GAIN (CURRENT AMPLIFICATION)

Photoelectrons emitted from a photocathode are accelerated by an electric field so as to strike the first dynode and produce secondary electron emissions. These secondary electrons then impinge upon the next dynode to produce additional secondary electron emissions. Repeating this process over successive dynode stages achieves a high current amplification. A very small photoelectric current from the photocathode can therefore be observed as a large output current from the anode of the photomultiplier tube.

Gain is simply the ratio of the anode output current to the photoelectric current from the photocathode. Ideally, the gain of a photomultiplier tube having n dynode stages and an average secondary emission ratio δ per stage is δ^n. While the secondary electron emission ratio δ is given by $\delta = A \cdot E^{\alpha}$

where A is the constant, E is the interstage voltage, and α is a coefficient determined by the dynode material and geometric structure. This usually has a value of 0.7 to 0.8.

When a voltage V is applied between the cathode and the anode of a photomultiplier tube having n dynode stages, the gain μ, becomes

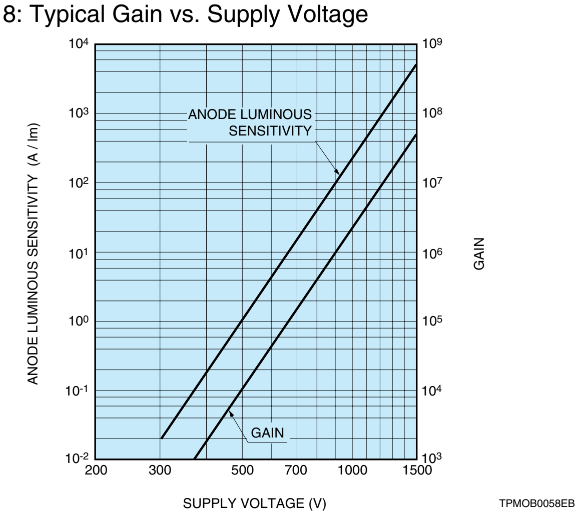
$$\mu = \delta^n = (A \cdot E^{\alpha})^n = \left\{ A \cdot \left(\frac{V}{n+1} \right)^{\alpha} \right\}^n$$

$$= \frac{A^n}{(n+1)^{\alpha n}} \cdot V^{\alpha n} = K \cdot V^{\alpha n}$$

(K: constant)

Since photomultiplier tubes generally have 9 to 12 dynode stages, the anode output has a 6th to 10th power gain proportional to the input voltage. So just a slight fluctuation in the applied voltage will appear as magnified 6 to 10 times in the photomultiplier tube output. This means the photomultiplier tube is extremely susceptible to fluctuations in the power supply voltage, so the power supply must be extremely stable and provide a minimum ripple, drift and temperature coefficient. Various types of well-regulated high-voltage power supplies designed for these requirements are available from Hamamatsu (see page 112).

Figure 8: Typical Gain vs. Supply Voltage

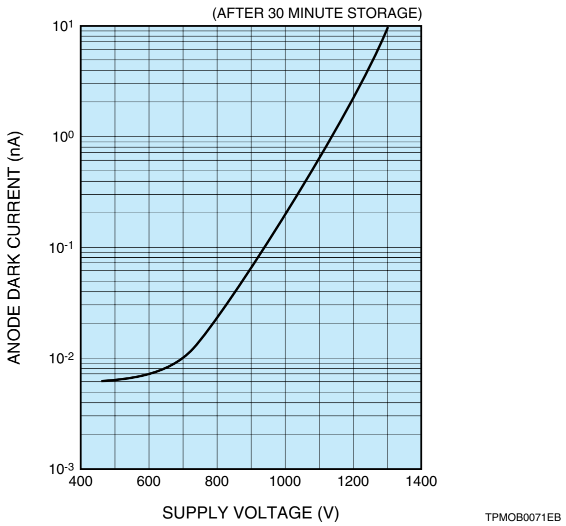


Construction and Operating Characteristics

ANODE DARK CURRENT

A small amount of current flows in a photomultiplier tube even when the tube is 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 limit of light detection. As Figure 9 shows, dark current is greatly dependent on the supply voltage.

Figure 9: Typical Dark Current vs. Supply Voltage



Major sources of dark current may be categorized as follows:

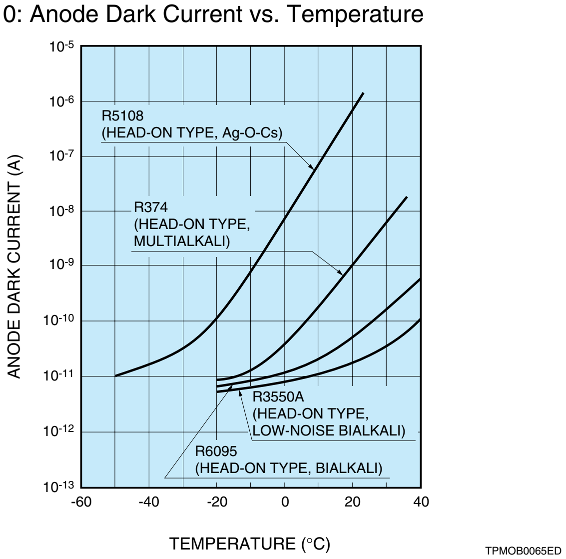
1) Thermionic emission of electrons

The materials of the photocathode emit tiny quantities of thermionic electrons even at room temperature. Most dark currents originate from the thermionic emissions, especially those from the photocathode since they are successively multiplied by the dynodes. Cooling the photocathode is most effective in reducing thermionic emission and is particularly useful in applications where low dark current is essential such as in photon counting.

Figure 10 shows the relationship between dark current and temperature for various photocathodes. Photocathodes which have high sensitivity in the red to infrared region, especially S-1, show higher dark current at room temperature. Photomultiplier tubes using these photocathodes are usually cooled during operation.

Hamamatsu provides thermoelectric coolers (C9143, C9144, C10372, C10373) designed for various sizes of photomultiplier tubes (see page 118, 120).

Figure 10: Anode Dark Current vs. Temperature



2) Ionization of residual gases (ion feedback)

Residual gases inside a photomultiplier tube can be ionized by collision with electrons. When these ions strike the photocathode or earlier stages of dynodes, secondary electrons may be emitted. These secondary electrons result in relatively large output noise pulses. These noise pulses are usually observed as afterpulses following the primary signal pulses and may be a problem in detecting short light pulses. Present photomultiplier tubes are designed to minimize afterpulses.

3) Glass scintillation

When electrons deviating from their normal trajectories strike the glass envelope, scintillations may occur and a dark pulse may result. To eliminate this type of dark pulse, photomultiplier tubes may be operated with the anode at a high voltage and the cathode at ground potential. But this is not always possible during tube operation. To obtain the same effect without difficulty, Hamamatsu developed an "HA treatment" in which the glass bulb is coated with a conductive paint making the same electrical potential as the cathode (see "GROUND POLARITY AND HA TREATMENT" on page 11).

4) Leakage current (ohmic leakage)

Leakage current resulting from imperfect insulation of the glass stem base and socket may be another source of dark current. This is predominant when the photomultiplier tube is operated at a low voltage or low temperature. The flatter slopes in Figure 9 and 10 are mainly due to leakage current.

Contamination from dirt and moisture on the surface of the tube stem, base or socket may increase the leakage current, and should therefore be avoided.

5) Field emissions

When a photomultiplier tube is operated at a voltage near the maximum rated value, electrons might be emitted from electrodes by the strong electric field and cause dark pulses. So operating the photomultiplier tube at a voltage 20 % to 30 % lower than the maximum rating is recommended.

The anode dark current decreases with time after the tube is placed in a dark state. In this catalog, anode dark currents are measured after 30 minutes of storage in a dark state.

ENI (EQUIVALENT NOISE INPUT)

ENI indicates the photon-limited signal-to-noise ratio. ENI refers to the amount of light in watts necessary to produce a signal-to-noise ratio of unity in the output of a photomultiplier tube. The value of ENI is given by:

$$\mathrm{ENI} = \frac{\sqrt{2q \cdot Idb \cdot g \cdot \Delta f}}{S} \text{ (watts)}$$

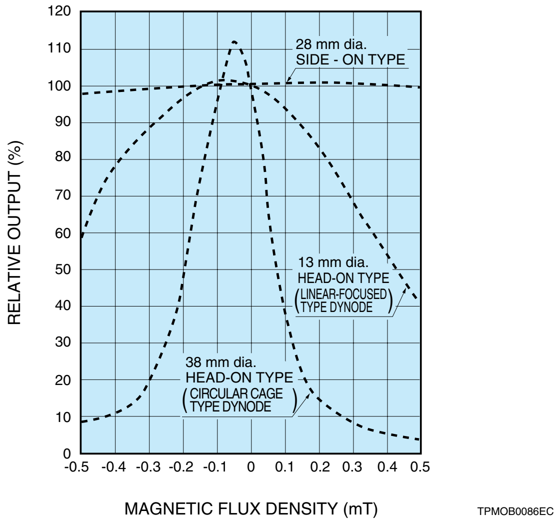
where q = electronic charge (1.60×10^{-19} coul.)
Idb = anode dark current in amperes after 30 minute storage in darkness
g = gain
Δf = bandwidth of the system in hertz (usually 1 hertz)
S = anode radiant sensitivity in amperes per watt at the wavelength of interest

For tubes listed in this catalog, the value of ENI may be calculated by the above equation. Usually it has a value between 10^{-15} and 10^{-16} watts (at the peak sensitivity wavelength).

MAGNETIC FIELD EFFECTS

Most photomultiplier tubes are affected by the presence of magnetic fields. Magnetic fields may deflect electrons from their normal trajectories and cause a loss of gain. The extent of the gain loss depends on the type of photomultiplier tube and its orientation in the magnetic field. Figure 11 shows typical effects of magnetic fields on some types of photomultiplier tubes. In general, tubes having a long path from the photocathode to the first dynode (such as large diameter tubes) tend to be more adversely affected by magnetic fields.

Figure 11: Typical Effects by Magnetic Fields Perpendicular to Tube Axis

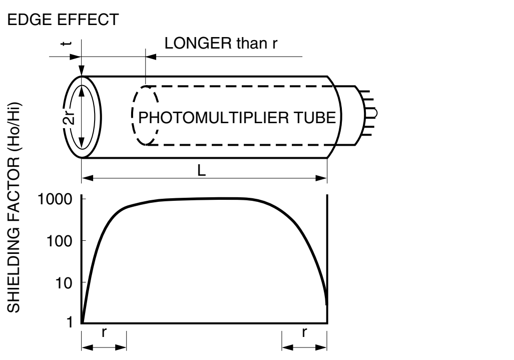


When a photomultiplier tube has to be operated in magnetic fields, it may be necessary to shield the tube with a magnetic shield case. (Hamamatsu provides a variety of magnetic shield cases. See page 122). The magnetic shielding factor is used to express the effect of a magnetic shield case. This is the ratio of the strength of the magnetic field outside the shield case or Hout, to that inside the shield case or Hin. The magnetic shielding factor is determined by the permeability μ, the thickness t (mm) and inner diameter r (mm) of the shield case as follows.

$$\frac{Hout}{Hin} = \frac{3\,\mu t}{4\,r}$$

Note that the magnetic shielding effect decreases towards the edge of the shield case as shown in Figure 12. Covering the tube with a shield case longer than the tube length by at least half the shield case inner diameter is recommended.

Figure 12: Edge Effect of Magnetic Shield Case



Hamamatsu provides photomultiplier tubes using fine-mesh type dynodes (see page 66). These photomultiplier tubes exhibit much higher resistance to external magnetic fields than the photomultiplier tubes with other dynodes. When the light level to be measured is high, "triode" and "tetrode" type tubes can be used even in highly magnetic fields.

SPATIAL UNIFORMITY

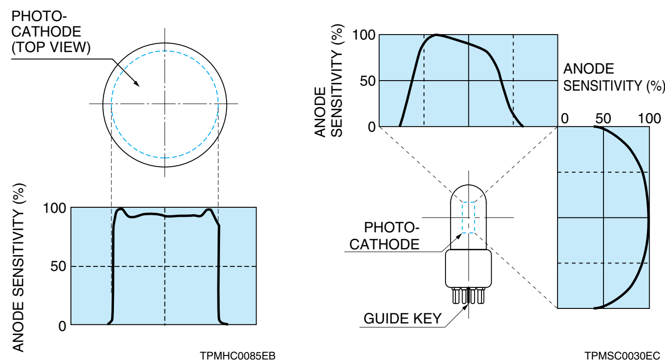
Although the focusing electrodes of a photomultiplier tube are designed so that electrons emitted from the photocathode or dynodes are collected efficiently by the first or following dynodes, some electrons may deviate from their desired trajectories causing lower collection efficiency. The collection efficiency varies with the position on the photocathode from which the photoelectrons are emitted and influences the spatial uniformity of a photomultiplier tube. The spatial uniformity is also determined by the photocathode surface uniformity itself.

In general, head-on type photomultiplier tubes provide better spatial uniformity than side-on types because of the photocathode to first dynode geometry. Tubes especially designed for gamma camera applications have excellent spatial uniformity, because uniformity is the decisive factor in the overall performance of a gamma camera.

Figure 13: Examples of Spatial Uniformity

1) Head-on Type (R6231-01 for gamma camera)

2) Side-on Type Reflection-mode photocathode

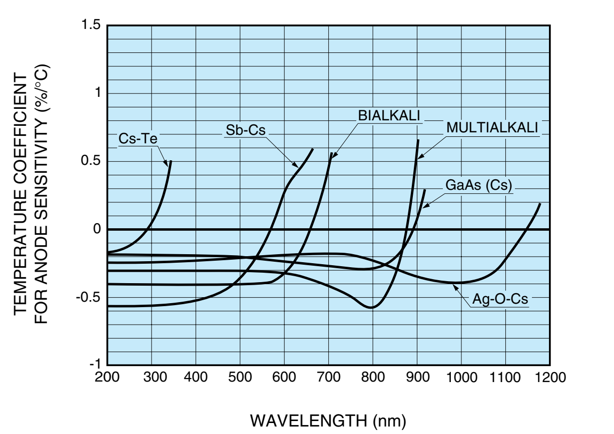


TEMPERATURE CHARACTERISTICS

Dark current originating from thermionic emissions can be reduced by decreasing the ambient temperature of a photomultiplier tube. The photomultiplier tube sensitivity also varies with the temperature, but these changes are smaller than temperature-induced changes in dark current, so cooling a photomultiplier tube will significantly improve the S/N ratio.

In the ultraviolet to visible region, the sensitivity temperature coefficient has a negative value, while near the long wavelength cutoff it has a positive value. Figure 14 shows typical temperature coefficients for various photocathodes versus wavelength, measured at room temperatures. Since the change in temperature coefficient change is large near the long wavelength cutoff, temperature control may be needed in some applications.

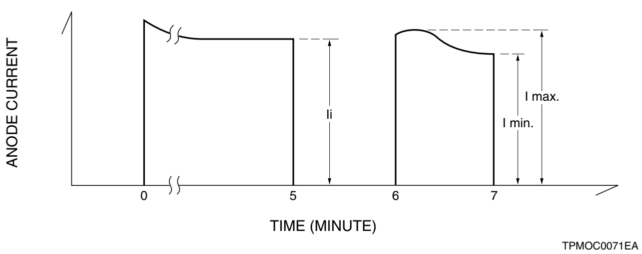
Figure 14: Temperature Coefficient for Anode Sensitivity (Typ.)



HYSTERESIS

Photomultiplier tubes exhibit a slightly unstable output for several seconds to nearly 1 minute after a voltage is applied or light is input, and the output may overshoot or undershoot before reaching a stable level (Figure 15). This unstable condition is called hysteresis and may be a problem in spectrophotometry and other applications.
Hysteresis is mainly caused by electrons deviating from their planned trajectories and electrostatically charging the dynode support section and glass bulb. When the applied voltage changes along with a change in the input light, noticeable hysteresis can occur.
As a countermeasure, many Hamamatsu side-on photomultiplier tubes employ an "anti-hysteresis design" which virtually eliminates hysteresis.

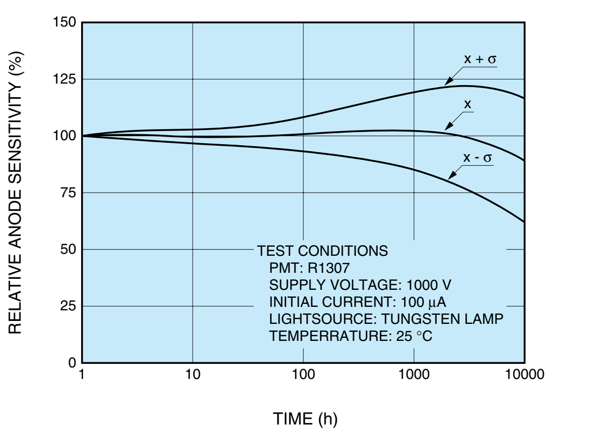
Figure 15: Hysteresis



DRIFT AND LIFE CHARACTERISTIC

While operating a photomultiplier tube continuously over a long period, the anode output current of the photomultiplier tube may vary slightly over time, even though operating conditions have not changed. Among the anode current fluctuations, changes over a relatively short time are called "drift", while changes over long periods such as 1000 to 10000 hours or more are called the life characteristic. Figure 16 shows typical drift curves.
Drift is primarily caused by damage to the last dynode by heavy electron bombardment. Therefore the use of lower anode current is desirable. When stability is of prime importance, keeping the average anode current within 1 µA or less is recommended.

Figure 16: Typical Life Characteristics



TIME RESPONSE

In the measurement of pulsed light, the anode output signal should faithfully reproduce a waveform resembling the incident pulse waveform. This reproducibility is greatly affected by the electron transit time, anode pulse rise time, and electron transit time spread (T.T.S.).
As illustrated in Figure 17, the electron transit time is the time interval between the arrival of a delta function light pulse (pulse width less than 50 ps) at the photocathode and the instant when the anode output pulse reaches its peak amplitude. The anode pulse rise time is defined as the time needed to rise from 10 % to 90 % of peak amplitude when the entire photocathode is illuminated by a delta function light pulse (pulse width less than 50 ps).
The electron transit time fluctuates between individual light pulses. This fluctuation is called transit time spread (T.T.S.) and defined as the FWHM of the frequency distribution of electron transit times (Figure 18). The T.T.S. is an important factor in time-resolved measurement.
The time response characteristics depend on the dynode structure and applied voltage. In general, photomultiplier tubes using a linear-focused or circular-cage structure exhibit better time response than tubes using a box-and-grid or venetian blind structure. Photomultiplier tubes for high-speed photometry use a spherical window or plano-concave window (flat on one side and concave on the other) and electrodes specifically designed to shorten the electron transit time. MCP-PMTs, which employ an MCP in place of conventional dynodes, offer better time response than tubes using other dynodes. For example, these have a significantly better T.T.S. compared to normal photomultiplier tubes because a nearly parallel electric field is applied between the photocathode, the MCP and the anode. Figure 19 shows typical time response characteristics vs. applied voltage for Hamamatsu R2059 (51 mm diameter head-on, 12-stage, linear-focused type).

Figure 17: Anode Pulse Rise Time and Electron Transit Time

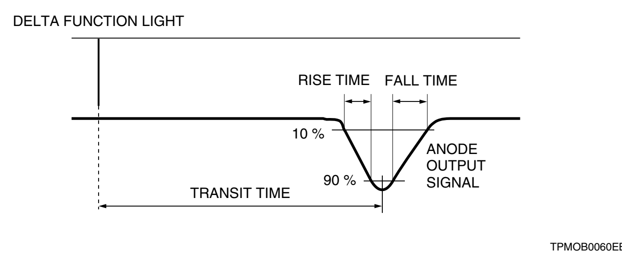


Figure 18: Electron Transit Time Spread (T.T.S.)

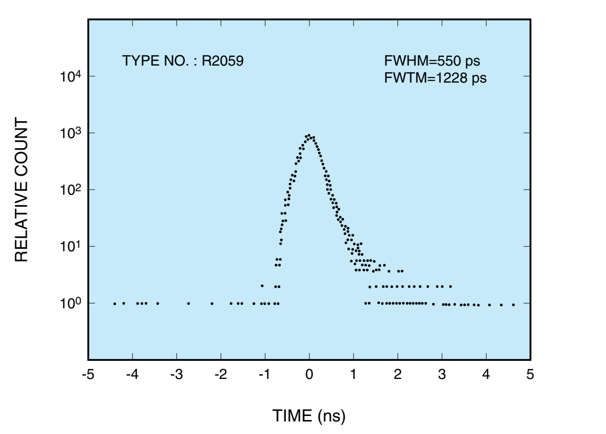
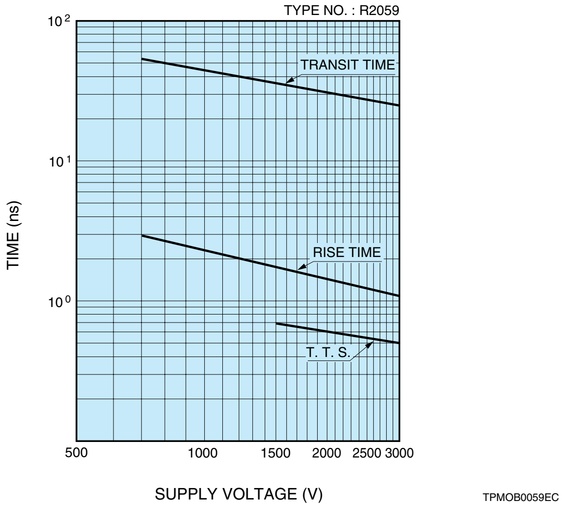


Figure 19: Time Response Characteristics vs. Supply Voltage

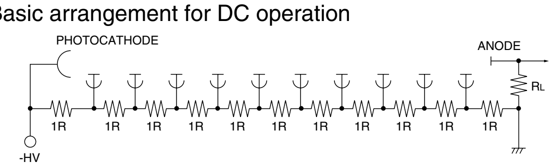


VOLTAGE-DIVIDER CIRCUITS

Interstage voltages for the dynodes of a photomultiplier tube are usually supplied by voltage-divider circuits consisting of series-connected resistors. Schematic diagrams of typical voltage-divider circuits are illustrated in Figure 20. Circuit (a) is a basic arrangement (DC output) and (b) is for pulse operations. Figure 21 shows the relation between the incident light level and the output current of a photomultiplier tube using the voltage-divider circuit of figure 20. Deviation from ideal linearity occurs at a certain incident level (region B). This is caused by an increase in dynode voltage due to the redistribution of the voltage loss between the last few stages, resulting in an apparent increase in sensitivity. As the input light level is increased, the anode output current begins to saturate near the value of the current flowing through the voltage divider (region C). To prevent this problem, it is recommended that the voltage-divider current be maintained at least at 20 times the average anode output current required from the photomultiplier tube.

Figure 20: Schematic Diagrams of Voltage-Divider Circuits

a) Basic arrangement for DC operation



b) For pulse operation

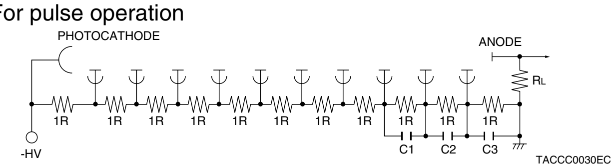
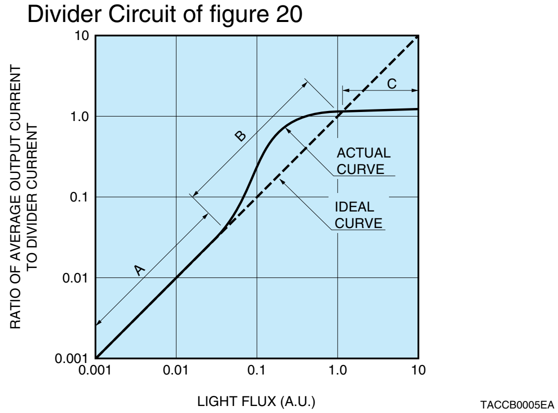


Figure 21: Output Characteristics of PMT Using Voltage-Divider Circuit of figure 20

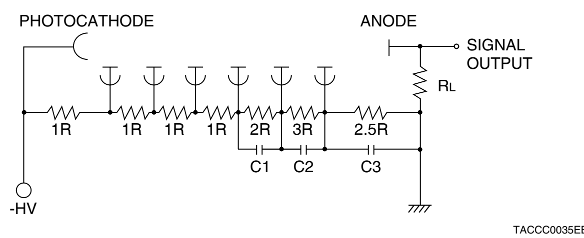


Generally high output current is required in pulsed light applications. In order to maintain dynode potentials at a constant value during pulse durations and obtain high peak currents, capacitors are placed in parallel with the divider resistors as shown in Figure 20 (b). The capacitor values depend on the output charge. When the output linearity versus input pulsed light needs to be better than 1 %, the capacitor value should be at least 100 times the photomultiplier output charge per pulse. If the peak output current (amperes) is I, the pulse width (seconds) t, and the voltage across the capacitor (volts) V, then the capacitor value C should be as follows:

$$C > 100 \frac{I \cdot t}{V} \text{ (farads)}$$

In high energy physics applications where a high pulse output is required, output saturation will occur at a certain level as the incident light is increased while the interstage voltage is kept fixed,. This is caused by an increase in electron density between the electrodes, causing space charge effects which disturb the electron current flow. As a corrective measure to overcome these space charge effects, the voltage applied to the last few stages, where the electron density becomes high, should be set to a higher value than the standard voltage distribution so that the voltage gradient between those electrodes is enhanced. For this purpose, a so-called tapered divider circuit (Figure 22) is often employed. Use of this tapered divider circuit improves pulse linearity 5 to 10 times better than in normal divider circuits.
Hamamatsu provides a variety of socket assemblies incorporating voltage-divider circuits. They are compact, rugged, lightweight and carefully engineered to obtain the maximum performance of a photomultiplier tube with just a simple connection.

Figure 22: Typical Tapered Divider Circuit



GROUND POLARITY AND HA TREATMENT

The general technique used for voltage-divider circuits is to ground the anode with a high negative voltage applied to the cathode, as shown in Figure 20. This scheme facilitates the connection of such circuits as ammeters or current-to-voltage conversion operational amplifiers to the photomultiplier tube. However, when a grounded anode configuration is used, bringing a grounded metallic holder or magnetic shield case near the bulb of the tube can cause electrons to strike the inner bulb wall, resulting in the generation of noise. Also, in head-on type photomultiplier tubes, if the faceplate or bulb near the photocathode is grounded, the slight conductivity of the glass material causes a current to flow between the photocathode (which has a high negative potential) and ground. This may cause significant deterioration of the photocathode. For this reason, extreme care is required when designing housings for photomultiplier tubes and when using electrostatic or magnetic shield cases.
.In addition, when using foam rubber or similar material to mount the tube in its housing, it is essential that material having sufficiently good insulation properties be used. This problem can be solved by applying a black conductive coat around the bulb, connecting it to the cathode potential and covering the bulb with a protective film. This is called an "HA Treatment" (see Figure 23).

As mentioned above, the HA treatment can be effectively used to eliminate the effects of external potential on the side of the bulb. However, if a grounded object is located on the photocathode faceplate, there are no effective countermeasures. Glass scintillation, if occurring in the faceplate, has adverse noise effects and also causes deterioration of the photocathode sensitivity. To solve these problems, it is recommended that the photomultiplier tube be operated in the cathode grounding scheme, as shown in Figure 24, with the anode at a high positive voltage. For example in scintillation counting, since the grounded scintillator is directly coupled to the faceplate of a photomultiplier tube, grounding the cathode and maintaining the anode at a high positive voltage is recommended. In this case, a coupling capacitor Cc must be used to isolate the high positive voltage applied to the anode from the signal, and DC signals cannot be output.

Figure 23: HA Treatment

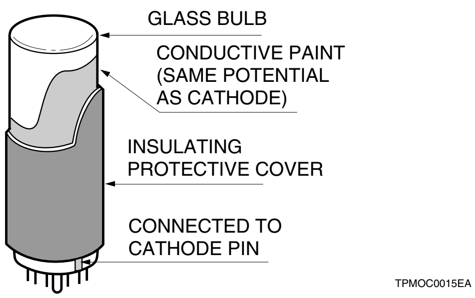
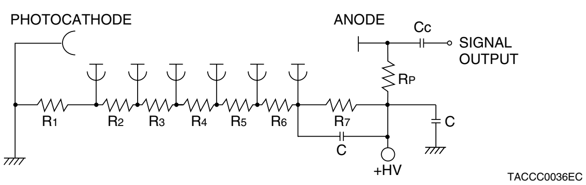


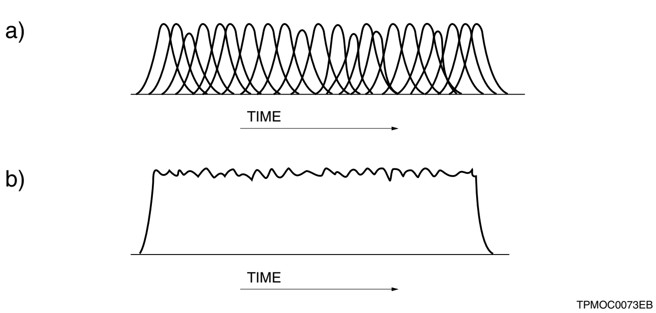
Figure 24: Cathode Ground Scheme



PHOTON COUNTING

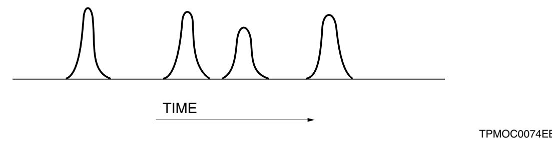
Photon counting is one effective way to use a photomultiplier tube for measuring extremely low light levels and is widely used in astronomical photometry and for making chemiluminescence and bioluminescence measurements. In its usual application, a number of photons enter the photomultiplier tube and create an output pulse train like that in (a) of Figure 25. The actual output obtained by the measurement circuit is a DC current with a fluctuation as shown at (b).

Figure 25: Overlapping Output Pulses



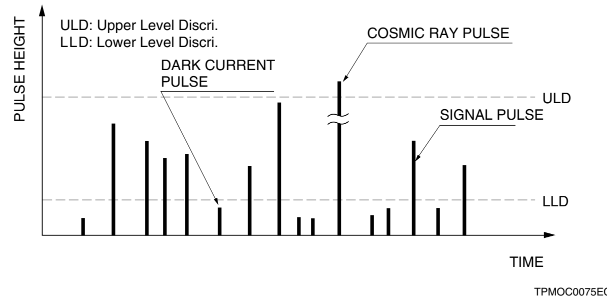
When the light intensity becomes so low that the incident photons are separated as shown in Figure 26. This condition is called a single photon event. The number of output pulses is in direct proportion to the amount of incident light and this pulse counting method has the advantages of better S/N ratio and stability than the current measurement method that averages all the pulses. This pulse counting technique is known as the photon counting method.

Figure 26: Discrete Output Pulses (Single Photon Event)



Simply counting the photomultiplier tube output pulses will not result in an accurate measurement, since the output contains noise pulses such as dark pulses and cosmic ray pulses extraneous to the signal pulses representing photoelectrons as shown in Figure 27. The most effective method for eliminating the noise is to discriminate the output pulses according to their amplitude. (Dark current pulese by thermal electrons emitted from the photocathode cannot be eliminated.)

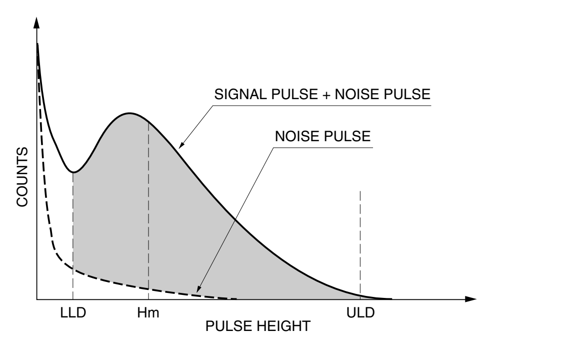
Figure 27: Output Pulse and Discrimination Level



A typical pulse height distribution (PHD) for a photomultiplier tube output is shown in Figure 28. In this PHD, the lower level discrimination (LLD) is set at the valley trough and the upper level discrimination (ULD) at the foot where there are very few output pulses. Most pulses smaller than the LLD are noise and pulses larger than the ULD result from cosmic rays, etc. Therefore, by counting the pulses remaining between the LLD and ULD, accurate light measurements can be made. In the PHD, Hm is the mean height of the pulses. The LLD should be set at 1/3 of Hm and the ULD at triple Hm. The ULD may be omitted in most cases.

Considering the above, a clearly defined peak and valley in the PHD is a very significant characteristic required of photomultiplier tubes for photon counting. Figure 28 shows the typical PHD of a photomultiplier tube selected for photon counting.

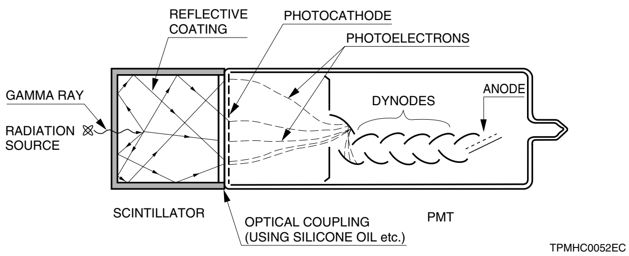
Figure 28: Typical Single Photon Pulse Height Distribution



SCINTILLATION COUNTING

Scintillation counting is one of the most sensitive and effective methods for detecting radiation. It uses a photomultiplier tube coupled to a scintillator that produces light when struck by radiation.

Figure 29: Scintillation Detector Using PMT and Scintillator



In radiation particle measurements, there are two parameters that should be measured. One is the energy of individual radiation particles and the other is the amount of radiation. Radiation measurement should determine these two parameters.

When radiation particles enter the scintillator, they produce light flashes in response to each particle. The amount of flash is extremely low, but is proportional to the energy of the incident particle. Since individual light flashes are detected by the photomultiplier tube, the output pulses obtained from the photomultiplier tube contain information on both the energy and amount of pulses, as shown in Figure 30. By analyzing these output pulses using a multichannel analyzer (MCA), a pulse height distribution (PHD) or energy spectrum is obtained, and the amount of incident particles at various energy levels can be measured accurately. Figure 31 shows typical PHDs or energy spectra when radiation (^{55}Fe, ^{137}Cs, ^{60}Co) is detected by the combination of an NaI(Tl) scintillator and a photomultiplier tube. The PHD must show distinct peaks at each energy level. These peaks are evaluated as pulse height resolution which is the most significant characteristic in the radiation measurements. As Figure 32 shows, the pulse height resolution is defined as the FWHM (a) divided by the peak value (b) when pulse height distribution is measured using a single radiation source such as ^{137}Cs and ^{55}Fe.

Figure 30: Incident Radiation Particles and PMT Output

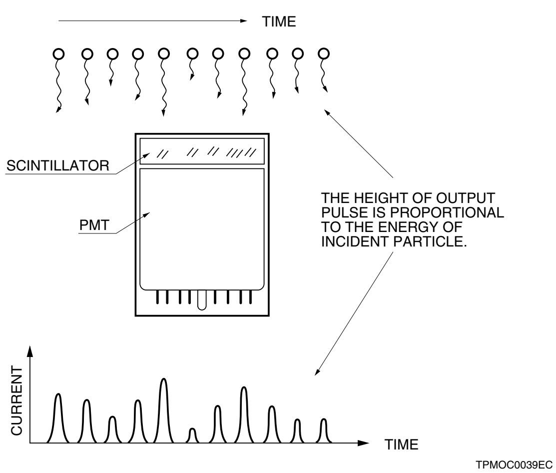
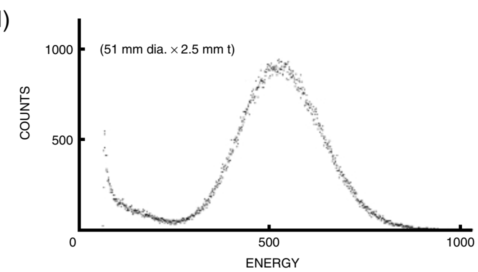
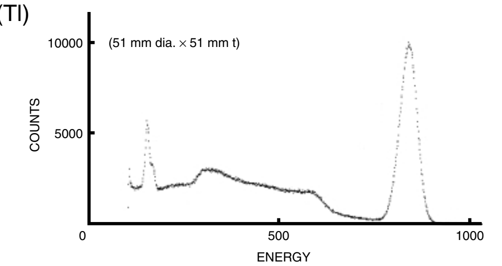


Figure 31: Typical Pulse Height Distributions (Energy Spectra)

a) ^{55}Fe+NaI (Tl)



b) ^{137}Cs+NaI (Tl)



c) ^{60}Co+NaI (Tl)

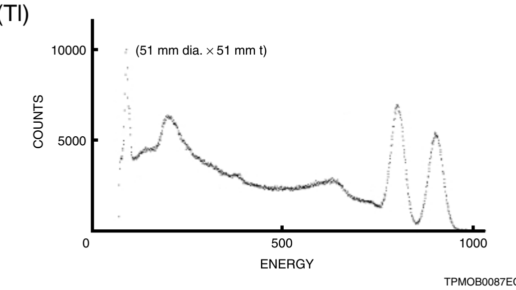
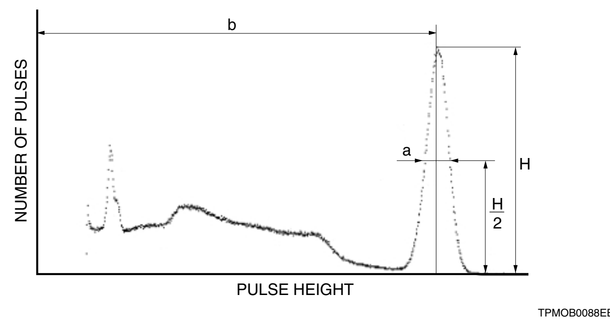
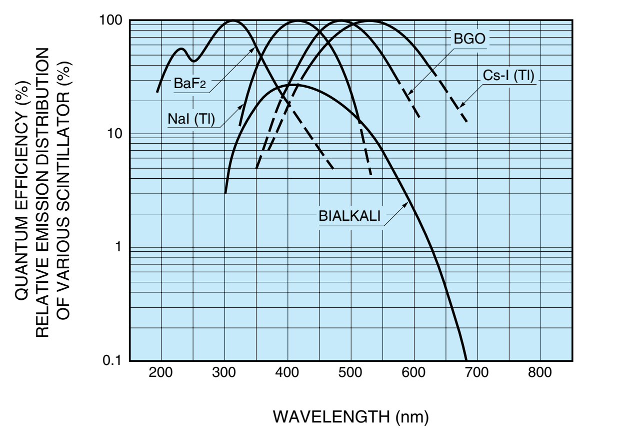


Figure 32: Definition of Pulse Height Resolution (FWHM)



$$\text{Energy resolution} = \frac{a}{b} \times 100\ \%$$

Figure 33: PMT Spectral Response and Spectral Emission of Scintillators



Pulse height resolution is mainly determined by the quantum efficiency of the photomultiplier tube that detects the scintillator emission. In the case of thallium-activated sodium iodide or NaI(Tl), which is one of the most popular scintillators, a head-on type photomultiplier tube with a bialkali photocathode is widely used since its spectral response matches the NaI(Tl) scintillator spectrum.

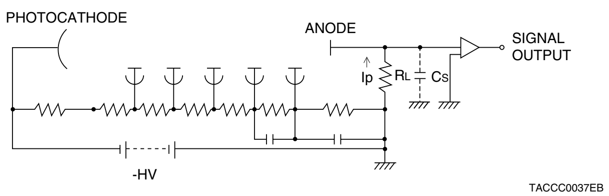
Connections to External Circuits

LOAD RESISTANCE

Since the output of a photomultiplier tube is a current signal and the type of external circuit to which photomultiplier tubes are usually connected has voltage inputs, a load resistor is used for current-voltage conversion. This section describes factors to consider when selecting this load resistor.

Since for low output current levels, the photomultiplier may be assumed to act as virtually an ideal constant-current source, the load resistance can be made arbitrarily large, when converting a low-level current output to a high-level voltage output. In practice, however, using a very large load resistance causes poor frequency response and output linearity as described below.

Figure 34: Photomultiplier Tube Output Circuit

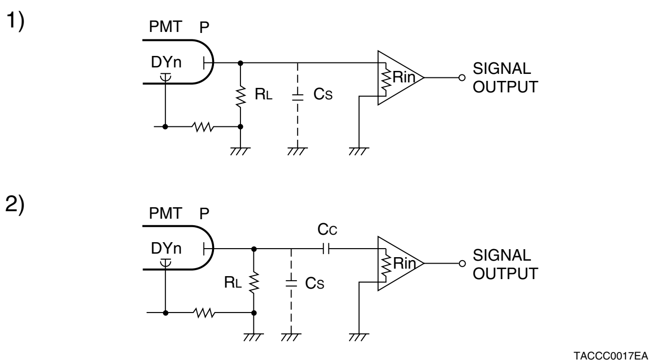


In the circuit of Figure 34, if we let the load resistance be R_L and the total capacitance of the photomultiplier tube anode to all other electrodes including stray capacitance such as wiring capacitance be Cs, then the cutoff frequency fc is expressed by the following relationship.

$$fc = \frac{1}{2\,\pi\,Cs \cdot R_L}$$

This relationship indicates that even if the photomultiplier tube and amplifier have very fast response, the response will be limited to the cutoff frequency fc of the output circuit. If the load resistance is made large, then the voltage drop across R_L becomes large at high current levels, affecting the voltage differential between the last dynode stage and the anode. This increases the effect of the space charge and lowers the efficiency of the anode in collecting electrons. In effect, the output becomes saturated above a certain current, causing poor output linearity (output current linearity versus incident light level) especially when the circuit is operated at low voltages.

Figure 35: Amplifier Internal Resistance



In Figure 35, let us consider the effect of the internal resistance of the amplifier. If the load resistance is R_L and the input impedance of the amplifier is R_{in}, the combined parallel output resistance of the photomultiplier tube, R_o, is given by the following equation.

$$R_o = \frac{R_L \cdot R_{in}}{R_L + R_{in}}$$

This value of R_o, which is less than the value of R_L, is then the effective load resistance of the photomultiplier tube. If, for example, $R_L = R_{in}$, then the effective load resistance is 1/2 that of R_L alone. From this we see that the upper limit of the load resistance is actually the input resistance of the amplifier and that making the load resistance much greater than this value does not have a significant effect.

While the above description assumed the load and input impedances to be purely resistive, stray capacitances, input capacitance and stray inductances affect the phase relationships during actual operation. Therefore, as the frequency is increased, these circuit elements must be considered as compound impedances rather than pure resistances.

From the above, three guides can be derived for selecting the load resistance:

1) When frequency response is important, the load resistance should be made as small as possible.
2) When output linearity is important, the load resistance should be chosen to keep the output voltage within a few volts.
3) The load resistance should be less than the input impedance of the external amplifier.

HIGH-SPEED OUTPUT CIRCUITS

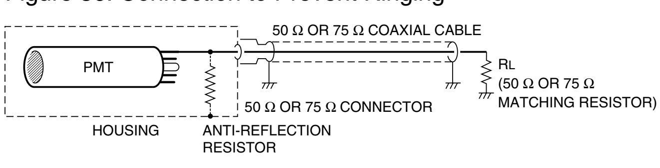
When detecting high-speed and pulsed light signals, a coaxial cable is used to make the connection between the photomultiplier tube and the electronic circuit. Since commonly used cables have characteristic impedances of 50 Ω, this cable must be terminated in a pure resistance equal to the characteristic impedance to match the impedance and ensure distortion-free transmission of the signal waveform. If a matched transmission line is used, the impedance of the cable as seen by the photomultiplier tube output will be the characteristic impedance of the cable, regardless of the actual cable length so no distortion will occur in the signal waveform.

If the impedance is not properly matched when the signal is received, the impedance seen at the photomultiplier tube output will differ depending on both frequency and cable length, causing significant waveform distortion. Impedance mismatches might also be due to the connectors being used. So these connectors should be chosen according to the frequency range to be used, to provide a good match with the coaxial cable.

When a mismatch at the signal receiving end occurs, not all of the pulse energy from the photomultiplier tube is dissipated at the receiving end and is instead partially reflected back to the photomultiplier tube via the cable. However if an impedance match has been achieved at the cable end on the photomultiplier tube side, then this reflected energy will be fully dissipated there. If this is a mismatch, however, the energy will be reflected and returned to the signal-receiving end because the photomultiplier tube itself acts as an open circuit. Since part of the pulse makes a round trip in the coaxial cable and is again input to the receiving end, this reflected signal is delayed with respect to the main pulse and results in waveform distortion (so called ringing phenomenon).

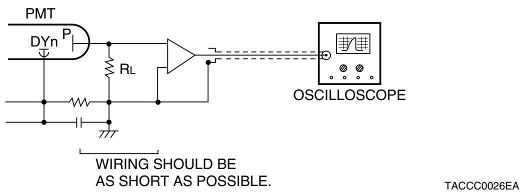
To prevent this phenomenon, in addition to matching the impedance at the receiving end, a resistor is needed for matching the cable impedance at the photomultiplier tube end as well (Figure 36). If this is provided, it is possible to eliminate virtually all ringing caused by an impedance mismatch, although the output pulse height of the photomultiplier tube is reduced to one-half of the normal level by use of this impedance matching resistor.

Figure 36: Connection to Prevent Ringing



Next, let us consider waveform observation of high-speed pulses using an oscilloscope. This type of operation requires a low load resistance. However, the oscilloscope sensitivity is limited so an amplifier may be required.
Cables with a matching resistor have the advantage that the cable length will not affect the electrical characteristics of the cable. However, since the matching resistance is very low compared to the usual load resistance, the output voltage becomes too small. While this situation can be remedied with a high gain amplifier, the inherent noise of such an amplifier can itself hurt measurement performance. In such cases, the photomultiplier tube should be brought as close as possible to the amplifier to reduce stray capacitance and a larger load resistance should be used (while still maintaining the frequency response), to achieve the desired input voltage. (See Figure 37.)

Figure 37: Measurement with Ringing Suppression Measures



It is relatively simple to implement a high-speed amplifier using a wide-band video amplifier or operational amplifier. However, as a trade-off for design convenience, these ICs tend to create performance problems (such as noise). This makes it necessary to know their performance limits and take corrective action if necessary.
As the pulse repetition frequency increases, baseline shift becomes one reason for concern. This occurs because the DC signal component has been eliminated from the signal circuit by coupling with a capacitor which blocks the DC components. If this occurs, the reference zero level observed at the last stage is not the actual zero level. Instead, the apparent zero level is a time-average of the positive and negative fluctuations of the signal waveform. This is known as baseline shift. Since the height of the pulses above this baseline level is affected by the repetition frequency, this phenomenon can be a problem when observing waveforms or discriminating pulse levels.

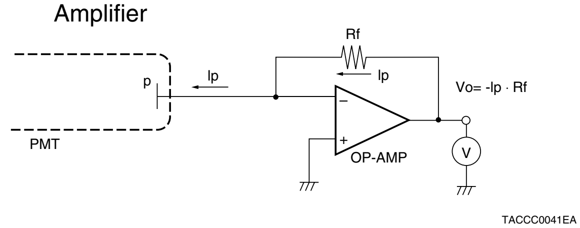
OPERATIONAL AMPLIFIERS

When a high-sensitivity ammeter is not available, using an operational amplifier allows making measurements with an inexpensive voltmeter. This section explains the technique for converting the output current of a photomultiplier tube to a voltage signal. The basic circuit is as shown in Figure 38, for which the output voltage, V_o, is given by the following relationship.

$$V_o = -Rf \cdot Ip$$

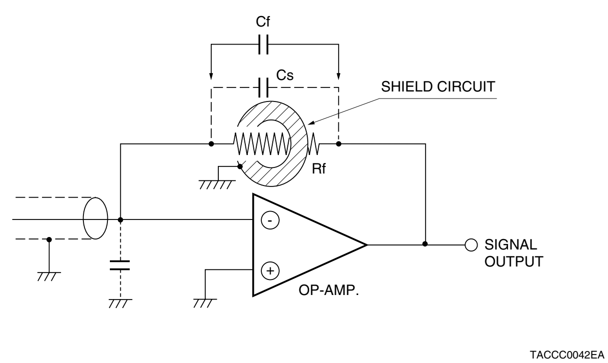
This relationship is derived for the following reason. If the input impedance of the operational amplifier is extremely large, and the output current of the photomultiplier tube is allowed to flow into the inverted (–) input terminal of the amplifier, most of the current will flow through Rf and subsequently to the operational amplifier output circuit. The output voltage V_o is therefore given by the expression $-R_f \times Ip$. When using such an operational amplifier, it is not of course possible to make unlimited increases in the output voltage because the actual maximum output is roughly equal to the operational amplifier supply voltage. At the other end of the scale, for extremely small currents, there are limits due to the operational amplifier offset current (I_{os}), the quality of R_f, and other factors such as the insulation materials used.

Figure 38: Current-Voltage Conversion Using Operational Amplifier



If the operational amplifier has an offset current (I_{os}), the above-described output voltage becomes $V_o = -R_f\ (Ip+I_{os})$, with the offset current component being superimposed on the output. Furthermore, the magnitude of the temperature drift may create a problem. In general, a metallic film resistor which has a low temperature coefficient is used for the resistance R_f, and for high resistance values, a vacuum-sealed type with a low leakage current is used. Carbon resistors with their highly temperature-dependent resistance characteristics are not suitable for this application.
In addition to the above factors, when measuring extremely low level currents such as 100 pA and below, the materials used to fabricate the circuit also require careful selection. For example, materials such as bakelite are not suitable. More suitable materials include teflon, polystyrol or steatite. Low-noise cables should also be used, since general-purpose coaxial cables exhibit noise due to physical factors. An FET input operational amplifier is recommended for measuring low-level current.

Figure 39: Frequency Compensation by Operational Amplifier



In Figure 39, if a capacitance C_f (including any stray capacitance) is in parallel with the resistance Rf, the circuit exhibits a time constant of ($R_f \times C_f$), and the response speed is limited to this time constant. This is a particular problem if the R_f is large. Stray capacitance can be reduced by passing R_f through a hole in a shield plate. When using coaxial signal input cables, oscillations may occur and noise might be amplified since the cable capacitance C_c and R_f are in a feedback loop. While one method to avoid this is to connect C_f in parallel with R_f, to reduce high frequency gain as described above, this method creates a time constant of $R_f \times C_f$ which limits the response speed.

Selection Guide by Applications

Applications	Required Major Characteristics	Applicable PMT
Spectroscopy		
●**Equipment Utilizing Absorption**		
UV/Visible/IR Spectrophotometer When light passes through a substance, the light energy causes changes in the electron energy of the substance, resulting in partial energy loss. This is called absorption and can be used to yield analytical data. In order to determine the quantity of a sample substance, it is irradiated while its light wavelength is scanned continuously. The spectral intensities of the light before and after passing through the sample are then detected by a photomultiplier tube and the amount of absorption in this way measured.	1) Wide spectral response 2) High stability 3) Low dark noise 4) High quantum efficiency 5) Low hysteresis 6) Good polarization characteristics	R6357 R928, R955, R3896 R7639 R374 R375
Atomic Absorption Spectrophotometer This is widely used in analysis of minute quantities of metallic elements. A special elementary hollow cathode lamp for each element to be analyzed is used to irradiate a sample which is burned to atomize it. A photomultiplier tube then detects the light passing through the sample to measure the amount of absorption, which is compared with a pre-measured reference sample.		R928 R955 R7154
●**Equipment Utilizing Emission**		
Photoelectric Emission Spectrophotometer When external energy is applied to a sample, that sample then emits light. . By using a monochromator to disperse this light emission into characteristic spectral lines of elements and measuring their presence and intensity simultaneously with photomultiplier tubes, the photoelectric emission spectrophotometer can perform rapid qualitative and quantitative analysis of the elements contained in the sample.	1) High sensitivity 2) Low dark noise 3) High stability	R6350, R6351, R6352, R6354 R6355, R6356-06, R10824 R11568, R1527 R7446, R8486
Fluorescence Spectrophotometer The fluorescence spectrophotometer is used in biological science, especially in molecular biology. When an excitation light is applied, some substances emit light with a wavelength longer than that of the excitation light. This light is known as fluorescence. The intensity and spectral characteristics of the fluorescence are measured by a photomultiplier tube, and the substance then analyzed qualitatively and quantitatively.		R6353, R6357, R6358 R3788, R4220, R1527 R928, R3896
Raman Spectroscopy When monochromatic light strikes a substance and scatters, a process called Raman scattering also occurs at a wavelength different from the excitation light. Since this wavelength differential is a unique characteristic of a molecule, spectral measurement of Raman scattering can provide qualitative and quantitative data of molecules. Raman scattering is extremely weak and a sophisticated optical system is required for measurement, with the photomultiplier tube operated in the photon counting mode.	1) High quantum efficiency 2) Less dark count 3) Single photon discrimination ability	R2949, R9110 R1463P R943-02, R649
Other Spectrophotometric Equipment Using Photomultiplier Tubes • Liquid or gas chromatography • X-ray diffractometers, X-ray fluorescence analyzers • Electron microscopes		R3788, R4220 R647, R1166, R6095, R580 R9880U-01, R7600U-01

Applications	Required Major Characteristics	Applicable PMT
Mass Spectroscopy and Solid Surface Analysis		
Solid Surface Analysis The composition and structure of a solid surface can be studied by irradiating a narrow beam of electrons, ions, light or X-rays onto the surface and measuring the secondary electrons, ions or X-rays that are produced. Due to the rapid progress being made in the semiconductor industry, this kind of technology is essential for measuring semiconductors, including defects, surface analysis, adhesion, and density profile. Electrons, ions, and X-rays are measured with electron multipliers and MCPs.	1) High environmental resistance 2) High stability 3) High gain 4) Low dark current	R474, R515, R596, R595 R2362, R5150-10 The above product is an electron multiplier
Pollution Monitoring		
Dust Counter A dust counter measures the density of dust or particles floating in the atmosphere or inside rooms. The dust counter makes use of light scattering or absorption of beta-rays by the dust particles.	1) Less dark count 2) Less spike noise 3) High quantum efficiency	R6350 R11558, R3788 R647, R1924A, R6095
Turbidimeter When floating particles are contained in a liquid, the light incident on the liquid is absorbed, scattered or refracted by these particles. This process merely appears cloudy or hazy to the human eye. A turbidimeter is a device that numerically measures the turbidity by using light transmission and scattering.	1) Low dark current 2) Less spike noise 3) High quantum efficiency	R6350, R6357 R11558, R9880U-110 R1924A
Other Pollution Monitoring Equipment Using Photomultiplier Tubes • NOx meters, SOx meters	1) High quantum efficiency at target wavelengths 2) Low dark current 3) Good temperature characteristic 4) High stability	NOx= R3896, R5984, R374 R2228, R5929, R5070A H7844 SOx= R3788, R1527, R6095
Biotechnology		
Flow Cytometer A flow cytometer uses a laser to irradiate cells labeled with fluorescent substance and measures the resulting fluorescence or scattered light from those cells with a photomultiplier tube, in order to identify each cell. A cell sorter is one kind of flow cytometer having the function of sorting specific cells.	1) High quantum efficiency 2) High stability 3) Low dark current 4) High gain	R6357, R6358 R928, R3788 R4220, R3896 R9880U-01, R9880U-20 R7600U-01, R7600U-01-M4 R7600U-20, R7600U-20-M4 R5900U-20-L16 H7260-20 H7516B-20 H8711-20
DNA Sequencer The DNA sequence is used to decode the base arrangement of DNA. When a voltage is applied across the both ends of a gelatinous substance (gel) into which DNA segments are injected, those DNA segments with a negative electric charge are drawn towards the plus electrode. The shorter the DNA segment, the faster it moves, resulting in a separation according to the DNA segment length. The base arrangement of each DNA segment can be determined by detecting the fluorescence emitted from the labeling pigment at the end of each DNA.		
DNA Microarray Scanner In this equipment, a DNA sample labeled by fluorescent dye is combined with a DNA probe having a large number of DNAs whose arrangement is known and fixed at a high density on a glass plate or silicon substrate. A laser beam is used to scan the sample and the resulting fluorescent intensity is measured to investigate the gene information.		

Selection Guide by Applications

Applications	Required Major Characteristics	Applicable PMT
Medical Applications		
Gamma Camera The gamma camera obtains an image of a radioisotope injected into the body of a patient to locate abnormalities. This equipment originated from a scintillation scanner and has been gradually improved. Its detection section uses a large diameter NaI(Tl) scintillator and light-guide coupled to a photomultiplier tube array.	1) High energy resolution 2) Good uniformity 3) High stability 4) Uniform gain (between each tube)	R6231-01, R6233-01 R6234-01, R6235-01 R6236-01, R6237-01 R1307-01 H8500C, H9500 R8900U-00-C12
Positron CT The positron CT provides tomographic images by detecting the coincident gamma-ray emission that accompanies the annihilation of positrons emitted from a tracer radioisotope (^{11}C, ^{15}O, ^{13}N, ^{18}F, etc.) injected into the body. Photomultiplier tubes coupled to scintillators are used to detect these gamma-rays.	1) High energy resolution 2) High stability 3) Fast response time 4) Compact size	R8900U-00-C12 R1450 R7899 R1548-07 H8500C, H9500 R9800, R9420, R9797
Liquid Scintillation Counter Liquid scintillation counters are used for tracer analysis in age measurement and biochemical research. A sample containing radioisotopes is dissolved into a solution containing an organic scintillator, and this is placed in the center between a pair or photomultiplier tubes. These tubes simultaneously detect the emission of the organic scintillator.	1) High quantum efficiency 2) Low thermionic emission noise 3) Less glass scintillation at bulb and other materials 4) Fast response time 5) High pulse linearity	R331, R331-05
In-Vitro Assay In-vitro assay is used for physical checkups, diagnosis, and evaluation of drug potency by making use of the specific antigen/antibody reaction characteristics of tiny amounts of insulin, hormones, drugs and viruses that are contained in blood or urine. Photomultiplier tubes are used to optically measure the amount of antigens labeled by radioisotopes or fluorescent, chemiluminescent or bioluminescent substances. • Radioimmunoassay (RIA) Uses radioactive isotopes for labeling and scintillators for measurement. • Chemiluminoassay CLIA (Chemilulminoassay) CLEIA (Enzyme-intensified chemiluminoassay) Uses luminescent substances for labeling to measure chemiluminescence or bioluminescence. • Fluoroimmunoassay Uses fluorescent substances for labeling.	1) High quantum efficiency 2) High stability 3) Low dark current	R1166, R5610A, R5611A-01 R6350, R6352, R6353 R6356-06, R6357 R4220, R928, R3788, R3896 R647, R1463 R1925A, R1924A, R3550A R6095, R374 R9880U-01 R9880U-20
Others • X-ray phototimer This equipment automatically controls the X-ray film exposure during X-ray examinations. The X-rays transmitting through a subject are converted into visible light by a phosphor screen. A photomultiplier tube detects this light and converts it into electrical signals. When the accumulated electrical signal reaches a preset level, the X-ray irradiation is shut off, to allow obtaining an optimum film density.	1) High sensitivity 2) Low dark current 3) High stability	R6350 R11558

Applications	Required Major Characteristics	Applicable PMT
Radiation Measurement		
Area Monitor Area monitors are designed to continuously measure changes in environmental radiation levels. Area monitors use a photomultiplier tube coupled to a scintillator to monitor low level gamma-rays and beta-rays.	1) Long term stability 2) Low background noise 3) Good plateau characteristic	R1306, R6231 R329-02 R1307, R6233 R877, R877-01
Survey Meter Survey meters are used to measure low level gamma-rays and beta-rays by using a photomultiplier tube coupled to a scintillator.	1) Long term stability 2) Low background noise 3) Good plateau characteristic	R1635 R647 R1924A R6095 R9880U-110
Resource Inquiry		
Oil Well Logging Oil well logging is used to locate an oil deposit and determine its size. A probe containing a radiation source and a scintillator/photomultiplier tube is lowered into on oil well as it is being drilled. The scattered radiation or natural radiation from the geological formation is detected and analyzed, to determine the type and density of the rock that surrounds the well.	1) Stable operation at high temperatures up to 175 °C 2) Rugged structure resistant to shock and vibration 3) Good plateau characteristic	R4177-01 R3991A R1288A, R1288A-01 R9722A R4607A-01
Industrial Measurement		
Thickness Meter The thickness meter uses a radiation source and a scintillator/photomultiplier tube detector to measure product thickness such as for paper, plastic, copper sheet on factory production lines. Beta-rays are used as a radiation source to measure small density products such as rubber, plastic, and paper. Gamma-rays are used for large density products such as copper plates. X-ray fluorescence is utilized to measure film thickness for plating, evaporation, etc.)	1) Wide dynamic range 2) High energy resolution	R647, R7899 R6095 R580 R1306, R6231 R329-02, R7724
Semiconductor Inspection System This is widely used for semiconductor wafer inspection and pattern recognition such as semiconductor mask alignment. In wafer inspection, the wafer is scanned by a laser beam, and the scattered light caused by dirt or defects is detected by a photomultiplier tube.	1) High quantum efficiency at target wavelengths 2) Good uniformity 2) Low spike noise	R3896 R9880U-01 R9880U-20

Selection Guide by Applications

Applications	Required Major Characteristics	Applicable PMT
High Energy Physics		
●Accelerator Experiment		
Hodoscope Photomultiplier tubes are coupled to the ends of long, thin plastic scintillator arrays arranged in two layers intersecting with each other in order to measure the time and position at which charged particles pass through the scintillator arrays.	1) Fast response time 2) Compact size	R9880U Series, R7600U Series R1635 (H3164-10) R647-01 (H3165-10) R1450 (H6524), R1166 (H6520)
TOF Counter Two counters are arranged along a path of charged particles, with each counter consisting of a scintillator and a photomultiplier tube. The velocity of the particles is measured by the time difference between the two counters.	1) Fast response time 2) Compact size	R9880U Series, R7600U Series R7899, R1635 (H3164-10) R1450 (H6524), R4998 (H6533) R1828-01 (H1949-51) R2083 (H2431-50)
	3) Resistance to magnetic fields (when used in magnetic fields)	R5505-70 (H6152-70) R7761-70 (H8409-70) R5924-70 (H6614-70)
Cherenkov Counter A Cherenkov counter is used to identify secondary particles generated by the collision reaction of particles. Cherenkov radiation is emitted from charged particles with energy higher than a certain level when they pass through a gas or silicon aerogel. This weak Cherenkov radiation is detected by a photomultiplier tube. These particles are then identified by measuring the Cherenkov radiation emission angle.	1) High quantum efficiency 2) Single photon discrimination ability 3) High gain 4) Fast response time	R329-02 (H6410), R5113-02 R1250 (H6527), R1584 (H6528) R7600U Series, R7724 H8500C, H9500
	5) Resistance to magnetic fields (when used in magnetic fields)	R5505-70 (H6152-70) R7761-70 (H8409-70) R5924-70 (H6614-70)
Calorimeter The calorimeter measures the accurate energy of secondary particles generated by the collision reaction of particles.	1) Good pulse linearity 2) High energy resolution 3) High stability	R580 (H3178-51) R7600U Series R329-02 (H6410), R7724 R6091 (H6559)
	4) Resistance to magnetic fields	R5924 (H6614-70)
●Neutrino and Proton Decay Experiment, Cosmic Ray Detection		
Neutrino Experiment Research on solar neutrinos or particle astophysics is utilized in a neutrino experiment. This experimental system consists of a large amount of a medium surrounded by a great number of large-diameter photomultiplier tubes. When cosmic rays such as neutrinos enter and pass through the medium, their energy and traveling direction are measured by detecting Cherenkov radiation that occurs from interaction with the medium.	1) Large photocathode area 2) Fast time response 3) High stability 4) Less dark count	R5912* R7081* R8055* R3600-02*
Neutrino and Proton Decay Experiment In the neutrino and proton decay experiments being conducted at Kamioka, Japan, 11,200 photomultiplier tubes each 20" diameter are installed to surround from all directions a huge tank storing 50,000 t of pure water. The photomultiplier tubes are used to watch the subtle flash of Cherenkov radiation that occurs when proton decays or solar neutrinos pass through the pure water tank.	1) Large photocathode area 2) Fast time response 3) High stability 4) Less dark count	R5912* R7081* R8055* R3600-02*
Air Shower Counter When cosmic rays collide with the earth's atmosphere, secondary particles are created by the interaction of the cosmic rays and atmospheric atoms. These secondary particles generate more secondary particles, which continue to increase in a geometrical progression. This is called an air shower. The gamma-rays and Cherenkov radiation emitted in this air shower are detected by photomultiplier tubes arranged in a lattice array on the ground.	1) Large photocathode area 2) Fast time response 3) High stability 4) Less dark count	R329-02 (H6410) R6091 (H6559) R1250 (H6527)

* These are listed in our catalog "Photomultiplier Tubes and Assemblies for Scintillation Counting & High Energy Physics".

The assembly type is given in parentheses.

Applications	Required Major Characteristics	Applicable PMT
Aerospace		
Astronomical X-ray Measurement X-rays from outer space include information on the enigmas of space. As an example, the X-ray observation satellite "Asuka" developed by a group of the ISAS (Institute of Space and Astronomical Science - Japan), uses a gas-scintillation proportional counter in conjunction with a position-sensitive photomultiplier tube to measure X-rays from supernovas, etc.	1) High energy resolution 2) Resistance to shock and vibration	R3998-02 R3991A R6231 R2486-02 Ruggedized PMT with high resistance to vibration and shock will be required. Consult with our sales office.
Measurement of Scattered Light from Fixed Stars and Interstellar Dust Ultraviolet rays from space contain a great deal of information about the surface temperatures of stars and interstellar substances. However, these ultraviolet rays are absorbed by the earth's atmosphere making is impossible to measure them from the earth's surface. So photomultiplier tubes are mounted in rockets or artificial satellites, to measure ultraviolet rays with wavelengths shorter than 300 nm.	1) Resistance to shock and vibration 2) Sensitivity only in VUV to UV range (Solar blind response with no sensitivity to visible light: See page 6 for Cs-Te and CsI photocathodes)	R1080, R976 R6834, R6835, R6836 Ruggedized PMT with high resistance to vibration and shock will be required. Consult with our sales office.
Lasers		
Laser Radar The laser radar is used in applications such as atmospheric measurement for highly accurate range finding or aerosol scattering detection.	1) Fast time response 2) Less dark count 3) High gain 4) Less afterpulses	R3809U Series R5916U Series R9880U-20
Fluorescence Lifetime Measurement A laser is used as an excitation light for fluorescence lifetime measurement. The molecular structure of a substance can be studied by measuring the changes in temporal intensity in the emitted fluorescence.		R3809U Series R5916U Series R7600U-01, R7600U-01-M4 R7600U-20, R7600U-20-M4 H7546B-01, H7546B-20 H8711-01, H8711-20
Plasma		
Plasma Observation Photomultiplier tubes are used in the electron density and electron temperature measurement system for plasma in the Tokamak-type nuclear fusion test reactor in Japan. Photomultiplier tubes and MCPs are also used in similar measurements on plasma using Thompson scattering and the Doppler effect to observe the spatial distribution of plasma, and to measure impurities in the plasma with the objective of controlling impurities and ions.	1) High detection capability at low light level 2) Quantum efficiency with less wavelength dependence 3) Gate operation	R636-10 R2257 R943-02

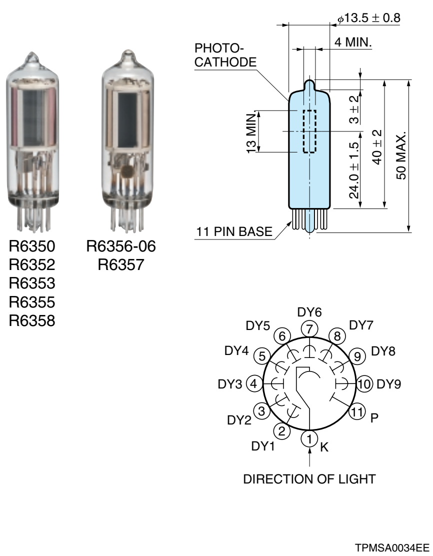
Side-on Type Photomultiplier Tubes

Type No. Ⓐ	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code Ⓑ	Peak Wave-length (nm)	Remarks: Photo-cathode Material Ⓒ	Win-dow Mate-rial Ⓓ	Out-line No. Ⓔ	Dynode Structure / Stages Ⓕ	Socket & Socket Assembly Ⓖ	Max. Ratings Ⓗ: Anode to Cathode Voltage (V)	Average Anode Current (mA) Ⓙ	Anode to Cathode Supply Voltage (V) Ⓛ
13 mm (1/2") Dia. Types												
R6350	4 × 13	185 to 650	350U	340	Sb-Cs	U	❶	CC/9	E678-11U* ❶❷	1250	0.01	1000 ⑨
R6352	4 × 13	185 to 750	452U	420	BA	U	❶	CC/9	E678-11U* ❶❷	1250	0.01	1000 ⑨
R6353	4 × 13	185 to 680	456U	400	LBA	U	❶	CC/9	E678-11U* ❶❷	1250	0.01	1000 ⑨
R6355	4 × 13	185 to 850	550U	530	MA	U	❶	CC/9	E678-11U* ❶❷	1250	0.01	1000 ⑨
R6356-06	4 × 13	185 to 900	—	400	MA	U	❶	CC/9	E678-11U* ❶❷	1250	0.01	1000 ⑨
R6357	4 × 13	185 to 900	—	450	MA	U	❶	CC/9	E678-11U* ❶❷	1250	0.01	1000 ⑨
R6358	4 × 13	185 to 830	561U	530	MA	U	❶	CC/9	E678-11U* ❶❷	1250	0.01	1000 ⑨

Lenses for side-on type photomultipliers are available. See page 75 for more details.

Dimensional Outlines (Unit: mm)

❶ R6350, R6352, R6353 etc.



(at 25 °C)

Cathode Characteristics: Luminous Min. (µA/lm)	Cathode Characteristics: Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Ⓚ Radiant Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Min. (A/lm)	Anode Characteristics Ⓜ: Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	Ⓐ Type No.
20	40	5.0	—	48	50	300	3.6×10^5	7.5×10^6	0.5	5	1.4	15	For photon counting: R6350P Silica glass window: R6351	R6350
80	120	10.0	—	90	100	700	5.2×10^5	5.8×10^6	1	10	1.4	15		R6352
30	70	6.5	—	65	100	400	3.7×10^5	5.7×10^6	0.1	2	1.4	15	For photon counting: R6353P	R6353
80	150	6.0	0.15	45	100	600	1.8×10^5	4.0×10^6	1	10	1.4	15		R6355
200	300	10.0	0.3	77	400	1200	3.1×10^5	4.0×10^6	1	10	1.4	15		R6356-06
350	500	13.0	0.4	105	1000	2000	4.2×10^5	4.0×10^6	2	10	1.4	15		R6357
140	200	7.5	0.15	70	300	700	2.5×10^5	3.5×10^6	0.1	1	1.4	15	For photon counting: R6358-10	R6358

Side-on Type Photomultiplier Tubes

Type No. (A)	Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
28 mm (1-1/8") Dia. Types with UV to Visible Sensitivity												
*R11558	8 × 24	300 to 650	453K	400	BA	K	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
*R11568	8 × 24	185 to 650	453U	400	BA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R3788	8 × 24	185 to 750	452U	420	BA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
*R11540	8 × 24	185 to 760	452U	420	BA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R1527	8 × 24	185 to 680	456U	400	LBA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R4220	8 × 24	185 to 710	456U	410	LBA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R7518	8 × 24	185 to 730	456U	410	LBA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R5983	10 × 24	185 to 710	456U	410	LBA	U	❷	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨

Lenses for side-on type photomultipliers are available. See page 75 for more details.

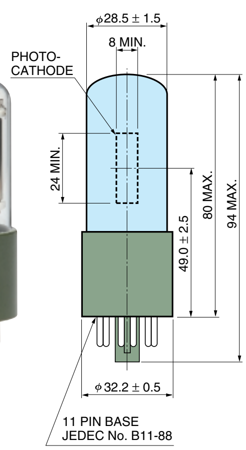
Dimensional Outlines (Unit: mm)

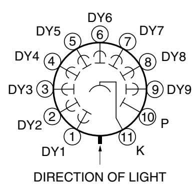
❶ R11558, R3788, R11540 etc.

R11558
R11568

R11540

R3788
R1527
R4220
R7518





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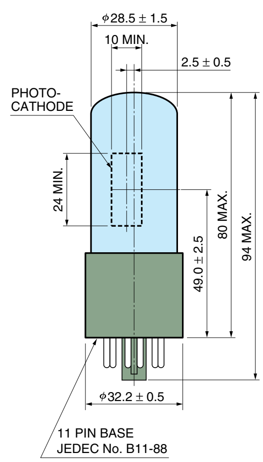
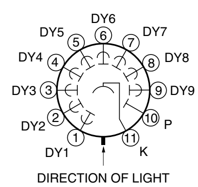
❷ R5983





TPMSA0035EC

(at 25 °C)

Cathode Characteristics: Luminous Min. (µA/lm)	Cathode Characteristics: Luminous Typ. (µA/lm)	Cathode Characteristics: Blue Sensitivity Index (CS 5-58) Typ.	Cathode Characteristics: Red / White Ratio (R-68) Typ.	Cathode Characteristics: Radiant (K) Typ. (mA/W)	Anode Characteristics (M): Luminous Min. (A/lm)	Anode Characteristics (M): Luminous Typ. (A/lm)	Anode Characteristics (M): Radiant Typ. (A/W)	Anode Characteristics (M): Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	(A) Type No.
40	60	7.1	—	60	200	600	6.0×10^5	1.0×10^7	1	10	2.2	22		**R11558***
40	60	7.1	—	60	200	600	6.0×10^5	1.0×10^7	1	10	2.2	22		**R11568***
100	120	10.0	0.01	90	500	1200	9.0×10^5	1.0×10^7	5	50	2.2	22	Silica glass window: R4332	**R3788**
160	190	16.0	0.02	120	1300	1900	1.2×10^6	1.0×10^7	5	50	2.2	22		**R11540***
40	60	6.4	—	60	200	400	4.0×10^5	6.7×10^6	0.1	2	2.2	22	For photon counting: R1527P Silica glass window: R7446	**R1527**
80	100	8.0	—	70	1000	1200	8.4×10^5	1.2×10^7	0.2	2	2.2	22	For photon counting: R4220P Silica glass window: R7447	**R4220**
120	130	10.0	—	85	1200	1560	1.0×10^6	1.2×10^7	0.2	2	2.2	22	For photon counting: R7518P	**R7518**
60	100	8.0	—	70	500	1000	7.0×10^5	1.0×10^7	0.2	2	2.2	22	For photon counting: R5983P Borosilicate glass window: R10491	**R5983**

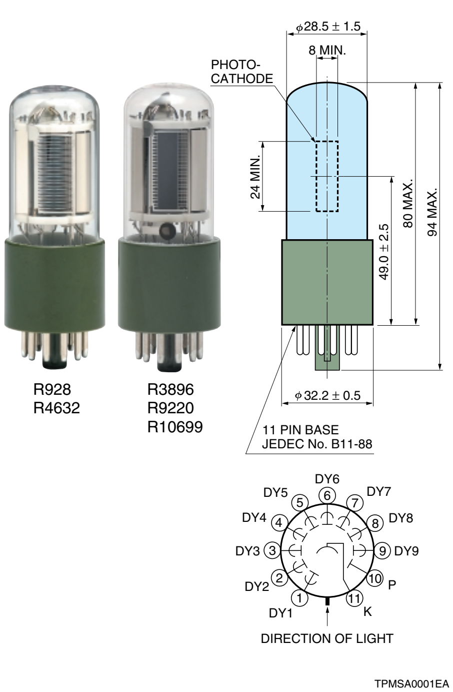
Side-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	(B) Curve Code	Peak Wavelength (nm)	(C) Photocathode Material	(D) Window Material	(E) Outline No.	(F) Dynode Structure / Stages	(G) Socket & Socket Assembly	Max. Ratings (H) Anode to Cathode Voltage (V)	Max. Ratings (J) Average Anode Current (mA)	(L) Anode to Cathode Supply Voltage (V)
28 mm (1-1/8") Dia. Types with UV to Near IR Sensitivity												
*R10699	8 × 24	185 to 900	557U	450	MA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R3896	8 × 24	185 to 900	555U	450	MA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R9220	8 × 24	185 to 900	555U	450	MA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R928	8 × 24	185 to 900	562U	400	MA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R5984	10 × 24	185 to 900	562U	400	MA	U	❷	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
28 mm (1-1/8") Dia. Types with Low Dark Current												
R9110	8 × 6	185 to 900	555U	450	MA	U	❸	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R2949	8 × 6	185 to 900	552U	400	MA	U	❹	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R4632	8 × 24	185 to 850	556U	430	MA	U	❶	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨

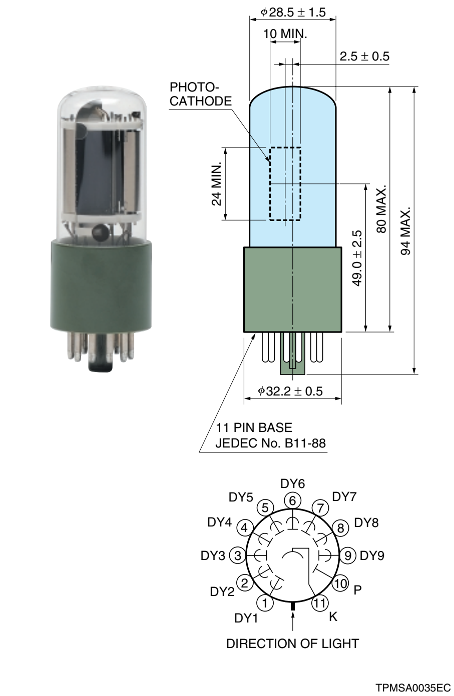
Lenses for side-on type photomultipliers are available. See page 75 for more details.

Dimensional Outlines (Unit: mm)

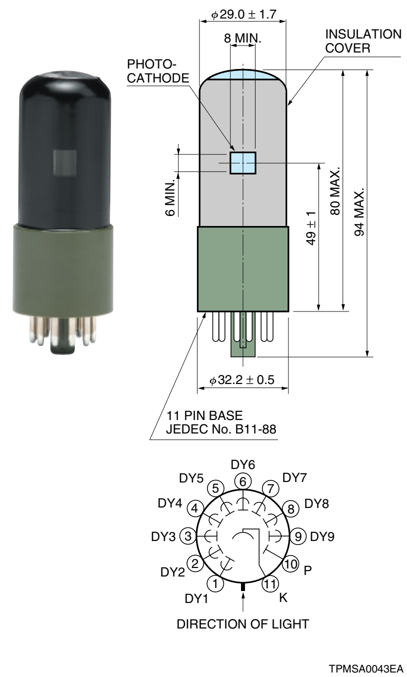
❶ R10699, R3896, R928 etc.



❷ R5984

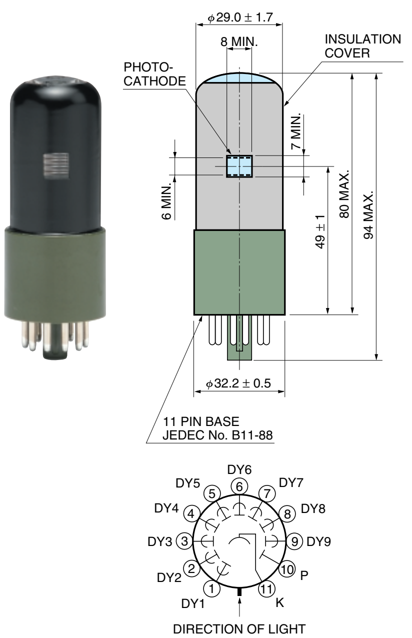


❸ R9110



Cathode Characteristics					Anode Characteristics Ⓜ									(at 25 °C)
Luminous		Blue Sensitivity Index (CS 5-58)	Red / White Ratio (R-68)	Ⓚ Radiant	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Ⓐ Type No.
Min. (µA/lm)	Typ. (µA/lm)	Typ.	Typ.	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
620	650	15.0	0.43	109	1600	8500	1.4×10^6	1.3×10^7	2ⓘ	10ⓘ	2.2	22		R10699*
475	525	15.0	0.4	90	3000	5000	8.6×10^5	9.5×10^6	10	50	2.2	22		R3896
375	450	12.5	0.4	85	1000	4500	8.5×10^5	1.0×10^7	10	50	2.2	22		R9220
140	250	8.0	0.3	74	400	2500	7.4×10^5	1.0×10^7	3	50	2.2	22	Silica glass window: R955	R928
140	300	9.0	0.32	76	400	3000	7.6×10^5	1.0×10^7	5	50	2.2	22	With thermoelectric cooler: H7844	R5984
400	525	15.0	0.4	90	4000	10000	1.7×10^6	1.9×10^7	5	15	2.2	22	For photon counting: R9110P	R9110
140	250	8.0	0.3	74	1000	2500	7.4×10^5	1.0×10^7	300ⓕ	500ⓕ	2.2	22		R2949
140	200	7.5	0.15	80	300	700	2.8×10^5	3.5×10^6	50ⓕ	100ⓕ	2.2	22		R4632

❹ R2949



TPMSA0016EB

Side-on Type Photomultiplier Tubes

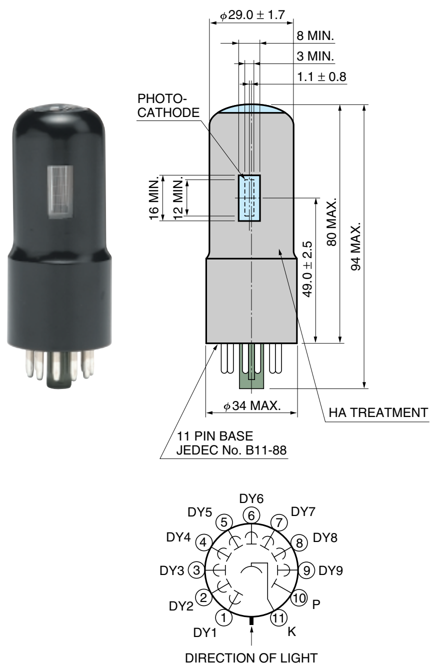
Type No. (A)	Effective Area (mm) / Wavelength (nm)	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings (H): Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
28 mm (1-1/8") Dia. Types with UV to Near IR Sensitivity												
R636-10	3 × 12	185 to 930	650U	300-800	GaAs	U	1	CC/9	E678-11A 3 4	1500	0.001	1250 9
R2658	3 × 12	185 to 1010	850U	400	InGaAs	U	2	CC/9	E678-11A 3 4	1500	0.001	1250 9
R5108	18 × 16	400 to 1200	700K	800	Ag-O-Cs	K	3	CC/9	E678-11A 3 4	1500	0.01	1250 9

Wavelength scale (nm): 100 200 300 400 500 600 700 800 900 1000 1100 1200

Lenses for side-on type photomultipliers are available. See page 75 for more details.

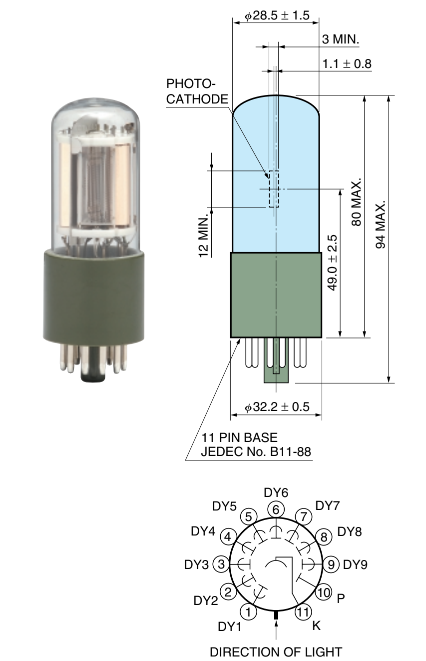
Dimensional Outlines (Unit: mm)

1 R636-10



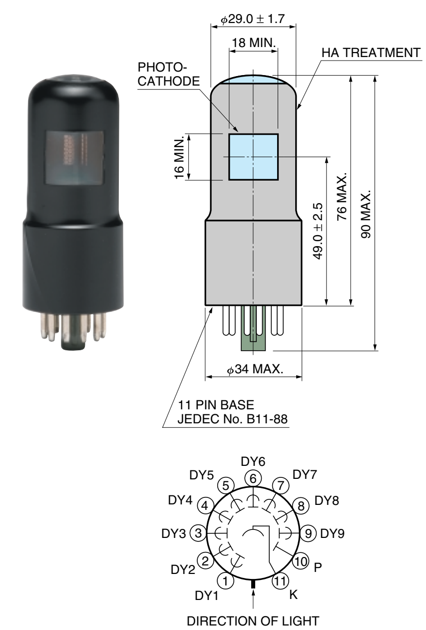
TPMSA0027EF

2 R2658



TPMSA0012ED

3 R5108



TPMSA0023EC

(at 25 °C)

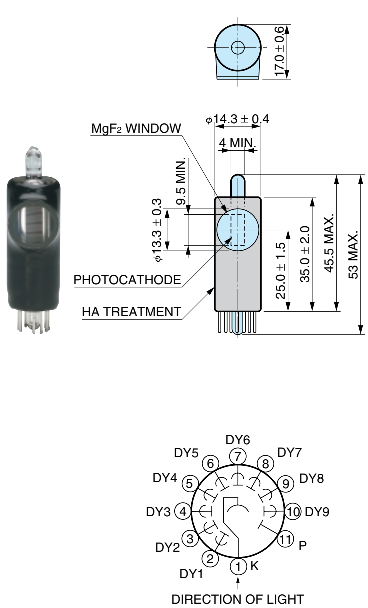
Cathode Characteristics: Luminous Min. (µA/lm)	Cathode Characteristics: Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Ⓚ Radiant Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Min. (A/lm)	Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	Ⓐ Type No.
400	550	9.0	0.53	62	100	250	2.8×10^4	4.5×10^5	0.1ⓔ	2ⓔ	2.0	20	Silica glass window: R758-10	**R636-10**
50	100	4.5	0.4	1 at 1000 nm	5	16	1.6×10^2	1.6×10^5	1	10	2.0	20	For photon counting: R2658P	**R2658**
10	25	—	—	2.2	3.5	7.5	6.6×10^2	3.0×10^5	350ⓓ	1000ⓓ	1.1	17		**R5108**

Side-on Type Photomultiplier Tubes

Type No. (A)	Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Anode to Cathode Voltage (V) (Max. Ratings H)	Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
13 mm (1/2") Dia. Types with Solar Blind Response												
*R10825	4 × 9.5	115 to 195	150M	130	Cs-I	MF	❶	CC/9	E678-11U*	1250	0.01	1000 ⑨
R6354	4 × 13	160 to 320	250S	230	Cs-Te	Q	❷	CC/9	E678-11U* ①②	1250	0.01	1000 ⑨
*R10824	4 × 9.5	115 to 320	250M	200	Cs-Te	MF	❶	CC/9	E678-11U*	1250	0.01	1000 ⑨
28 mm (1-1/8") Dia. Types with Solar Blind Response												
R7154	8 × 24	160 to 320	250S	230	Cs-Te	Q	❸	CC/9	E678-11A ③④⑤	1250	0.1	1000 ⑨
R7639	3 × 12	115 to 230	—	155	DIA	MF	❹	CC/9	E678-11A	1250	0.1	1000 ⑨
R8486	8 × 12	115 to 320	250M	200	Cs-Te	MF	❺	CC/9	E678-11A	1250	0.1	1000 ⑨
R8487	8 × 12	115 to 195	150M	130	Cs-I	MF	❺	CC/9	E678-11A	1250	0.1	1000 ⑨
R10454	8 × 12	115 to 195	150M	130	Cs-I	MF	❺	CC/9	E678-11A	1250	0.1	1000 ⑨

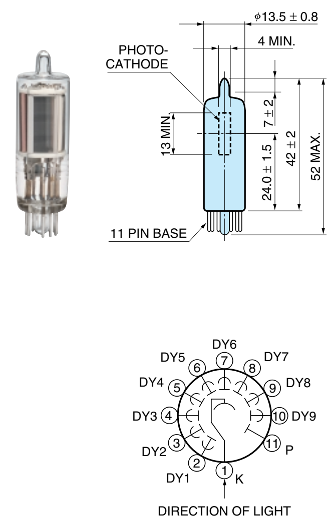
Dimensional Outlines (Unit: mm)

❶ R10825, R10824



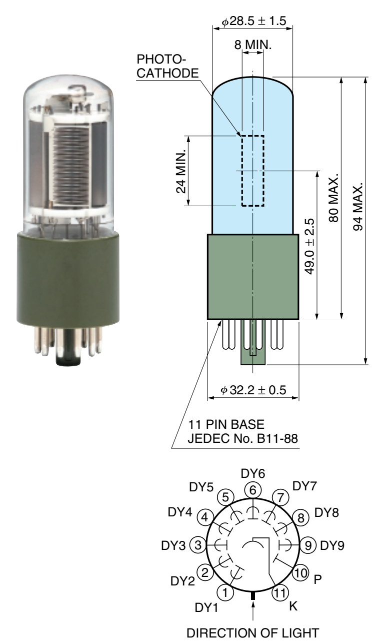
TPMSA0044EA

❷ R6354



TPMSA0034EE

❸ R7154

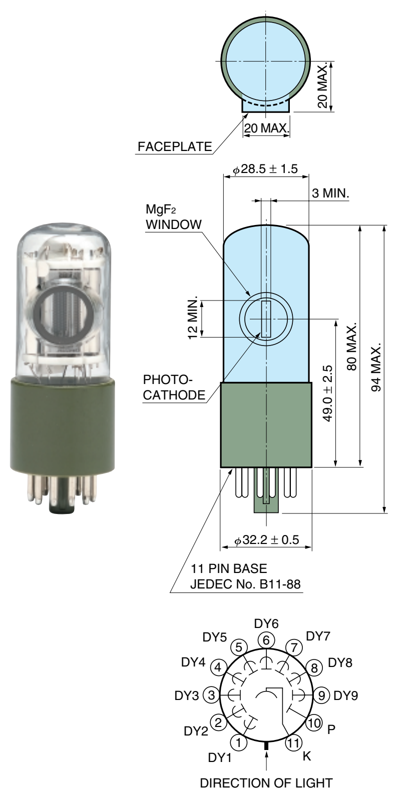


TPMSA0001EA

(at 25 °C)

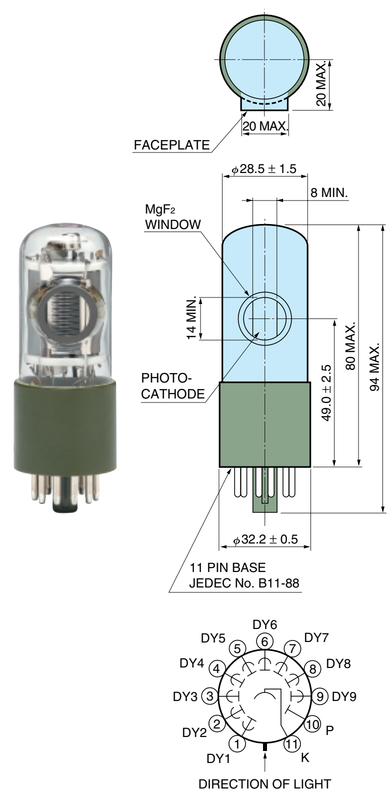
Cathode Characteristics: Luminous Min. (µA/lm)	Cathode: Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Ⓚ Radiant Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Min. (A/lm)	Anode: Luminous Typ. (A/lm)	Anode: Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	Ⓐ Type No.
—	—	—	—	23ⓐ	—	—	9.2×10^4ⓐ	4.0×10^6	0.3	3	1.4	15		R10825*
—	—	—	—	50ⓑ	—	—	2.0×10^5ⓑ	4.0×10^6	0.5	5	1.4	15		R6354
—	—	—	—	33ⓑ	—	—	2.0×10^5ⓑ	6.0×10^6	0.3	3	1.4	15		R10824*
—	—	—	—	62ⓑ	—	—	6.2×10^5ⓑ	1.0×10^7	1	10	2.2	22		R7154
—	—	—	—	50	—	—	1.5×10^5	3.0×10^6	0.5	5	2.2	22		R7639
—	—	—	—	52ⓑ	—	—	5.2×10^5ⓑ	1.0×10^7	1	10	2.2	22		R8486
—	—	—	—	25.5ⓐ	—	—	1.0×10^5ⓐ	3.9×10^6	0.1	—	2.2	22		R8487
—	—	—	—	25.5ⓐ	—	—	1.0×10^5ⓐ	3.9×10^6	0.1	—	2.2	22	Better solar-blind characteristics Anode sensitivity ratio (122/300): 8500	R10454

❹ R7639



TPMSA0040EB

❺ R8486, R8487, R10454



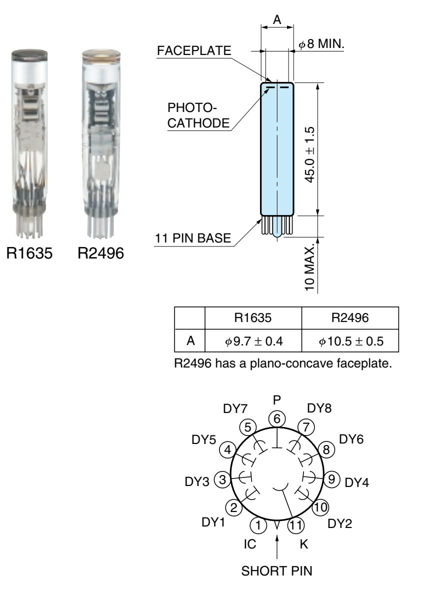
TPMSA0042EB

Head-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings (H): Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
10 mm (3/8") Dia. Types												
R2496	φ8	160 to 650	400S	420	BA	Q	❶	L/8	E678-11N* ⑦⑧	1500	0.03	1250 ⑤
R1635	φ8	300 to 650	400K	420	BA	K	❶	L/8	E678-11N* ⑥	1500	0.03	1250 ①
13 mm (1/2") Dia. Types												
R1081	φ6	115 to 200	100M	140	Cs-I	MF	❷	L/10	E678-12A*	2250	0.01	2000 ⑫
R1080	φ6	115 to 320	200M	240	Cs-Te	MF	❷	L/10	E678-12A*	1250	0.01	1000 ⑫
R759	φ10	160 to 320	200S	240	Cs-Te	Q	❸	L/10	E678-13F* ⑨⑩	1250	0.01	1000 ⑫
R647	φ10	300 to 650	400K	420	BA	K	❸	L/10	E678-13F* ⑨⑩	1250	0.1	1000 ⑫
R4124	φ10	300 to 650	400K	420	BA	K	❹	L/10	E678-13F* ⑪	1250	0.03	1000 ⑱
R2557	φ10	300 to 650	402K	375	LBA	K	❸	L/10	E678-13F* ⑫	1500	0.03	1250 ⑮
R4177-01	φ10	300 to 650	401K	375	HBA	K	❺	L/10	E678-13E*	1800	0.02	1500 ⑫
R1463	φ10	185 to 850	500U	420	MA	U	❸	L/10	E678-13F* ⑨⑩	1250	0.01	1000 ⑫

Dimensional Outlines (Unit: mm)

❶ R2496, R1635

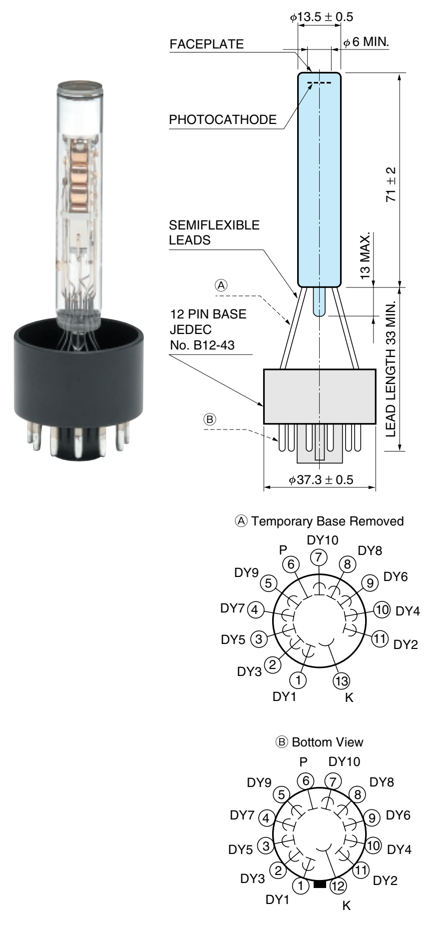


	R1635	R2496
A	φ9.7 ± 0.4	φ10.5 ± 0.5

R2496 has a plano-concave faceplate.

TPMHA0100EB

❷ R1081, R1080



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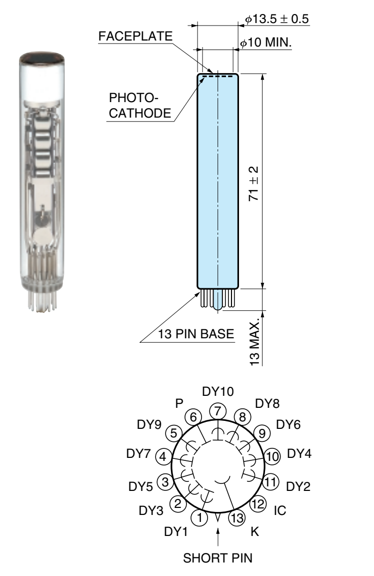
❸ R759, R647, R2557, R1463

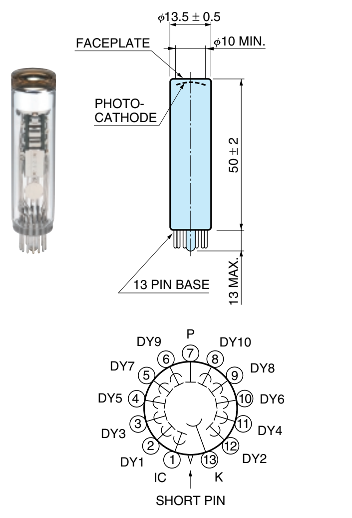


TPMHA0014EA

(at 25 °C)

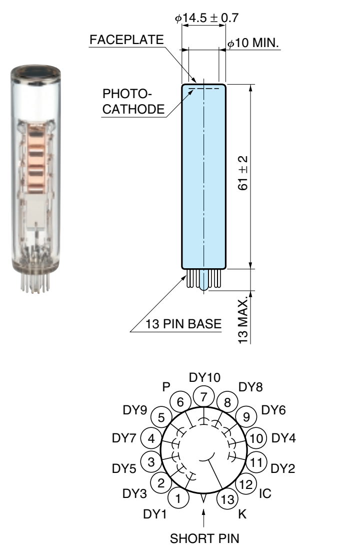
Cathode Characteristics					Anode Characteristics Ⓜ									
Luminous		Blue Sensitivity Index (CS 5-58)	Red / White Ratio (R-68)	Radiant Ⓚ	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Type No. Ⓐ
Min. (µA/lm)	Typ. (µA/lm)	Typ.	Typ.	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
60	100	10.0	—	80	30	100	8.0×10^4	1.0×10^6	2	50	0.7	9.0		R2496
60	100	10.0	—	80	30	100	8.0×10^4	1.0×10^6	1	50	0.8	9.0	For photon counting: R1635P UV glass window: R3878	R1635
—	—	—	—	12ⓐ	2×10^2 (A/W)ⓐ	—	1.2×10^3ⓐ	1.0×10^5	0.03	0.05	1.8	18		R1081
—	—	—	—	28ⓑ	4×10^3 (A/W)ⓑ	—	1.4×10^4ⓑ	5.0×10^5	0.3	1	2.5	24	For photon counting: R1080P	R1080
—	—	—	—	28ⓑ	4×10^3 (A/W)ⓑ	—	1.4×10^4ⓑ	5.0×10^5	0.3	1	2.5	24		R759
40	110	10.0	—	80	30	110	8.0×10^4	1.0×10^6	1	15	2.1	22	For photon counting: R647P UV glass window: R960 Silica glass window: R760	R647
40	100	10.0	—	80	30	100	8.0×10^4	1.0×10^6	1	15	1.1	12	UV glass window: R4141	R4124
25	40	5.5	—	50	50	200	2.5×10^5	5.0×10^6	0.5	4	2.2	22	For photon counting: R2557P	R2557
20	40	6.0	—	51	10	20	2.5×10^5	5.0×10^5	0.5	10	2.0	20	High temp. operation (Maximum Temp.: +175 °C)	R4177-01
80	120	—	0.2	51	30	120	5.1×10^4	1.0×10^6	4	20	2.5	24	For photon counting: R1463P	R1463

❹ R4124



TPMHA0102EA

❺ R4177-01



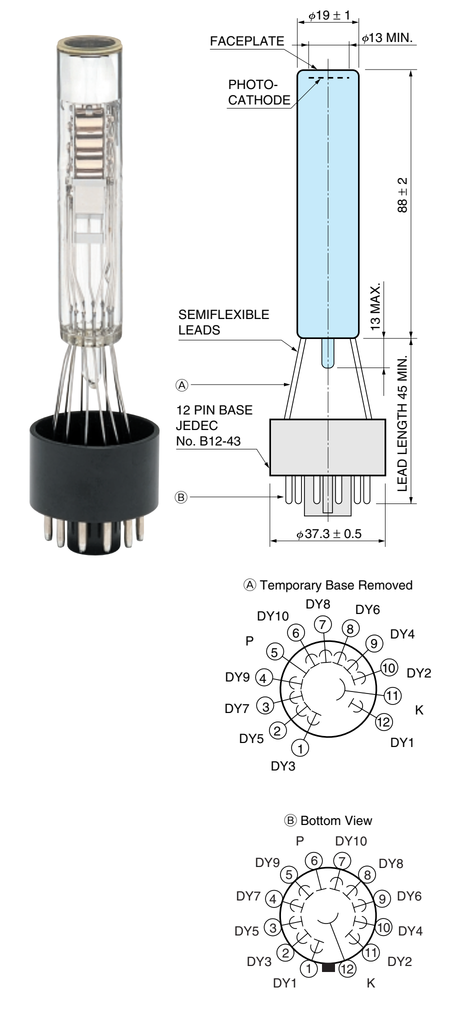
TPMHA0006EA

Head-on Type Photomultiplier Tubes

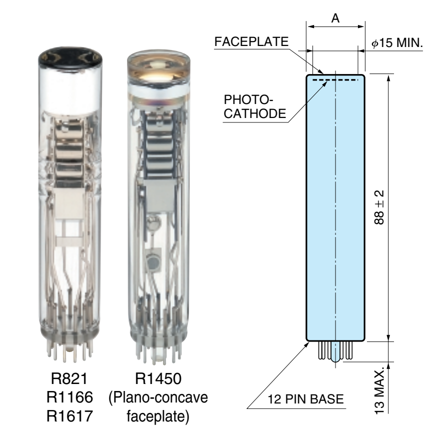
Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings: Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
19 mm (3/4") Dia. Types												
R972	ϕ13	115 to 200	100M	140	Cs-I	MF	1	L/10	E678-12A*	2250	0.01	2000 (14)
R821	ϕ15	160 to 320	200S	240	Cs-Te	Q	2	L/10	E678-12L* (13)(14)(15)	1250	0.01	1000 (14)
R1166	ϕ15	300 to 650	400K	420	BA	K	2	L/10	E678-12L* (13)(14)(15)	1250	0.1	1000 (14)
R1450	ϕ15	300 to 650	400K	420	BA	K	2	L/10	E678-12L* (16)	1800	0.1	1500 (16)
R3478	ϕ15	300 to 650	400K	420	BA	K	3	L/8	E678-12L* (17)(18)	1800	0.1	1700 (6)
R5610A	ϕ15	300 to 650	402K	375	LBA	K	4	C+L/10	E678-12T*	1250	0.1	1000 (17)
R5611A-01	ϕ15	300 to 650	400K	420	BA	K	5	C+L/10	E678-12A*	1250	0.1	1000 (17)
R3991A	ϕ15	300 to 650	401K	375	HBA	K	5	C+L/10	E678-12R*	1800	0.02	1500 (17)
R1617	ϕ15	300 to 850	500K	420	MA	K	2	L/10	E678-12L* (13)(14)(15)	1250	0.1	1000 (14)
R1878	ϕ4	300 to 850	500K	420	MA	K	6	L/10	E678-12L* (19)	1250	0.1	1000 (15)

Dimensional Outlines (Unit: mm)

1 R972

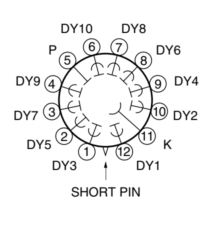


2 R821, R1166, R1450, R1617

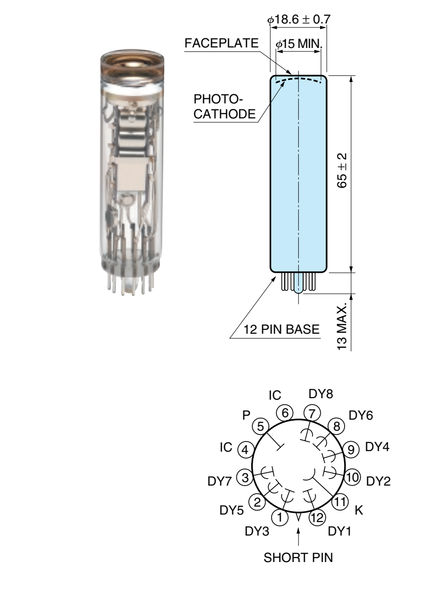


	R821	Others
A	ϕ19 ± 1	ϕ18.6 ± 0.7

R1450 has a plano-concave faceplate.

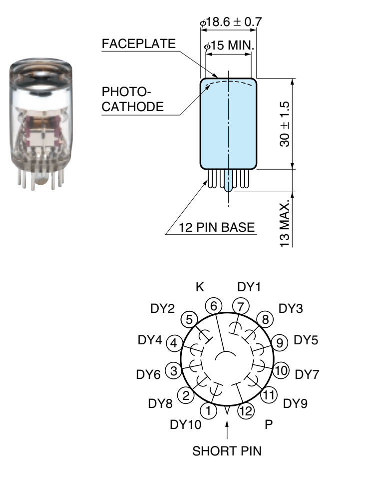


3 R3478

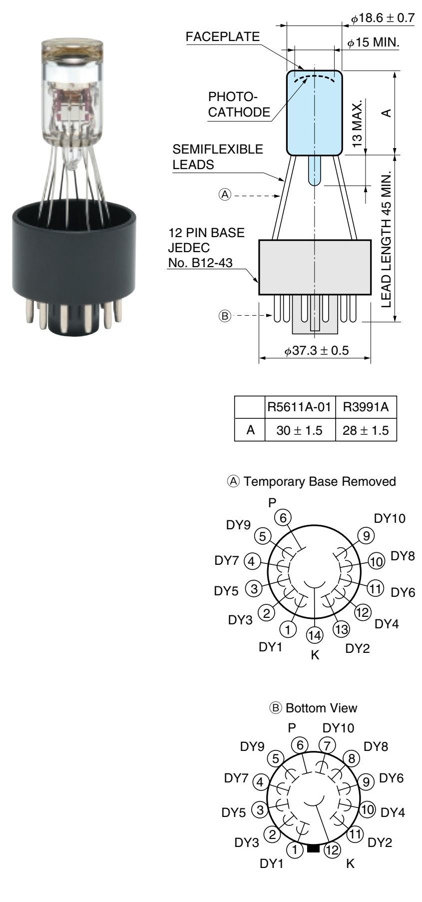


Cathode Characteristics					Anode Characteristics Ⓜ									(at 25 °C)
Luminous		Blue Sensitivity Index (CS 5-58)	Red / White Ratio (R-68)	Ⓚ Radiant	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Ⓐ Type No.
Min. (µA/lm)	Typ. (µA/lm)	Typ.	Typ.	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
—	—	—	—	12ⓐ	2×10^2 (A/W)ⓐ	—	1.2×10^3ⓐ	1.0×10^5	0.03	0.05	1.6	17		R972
—	—	—	—	28ⓑ	4×10^3 (A/W)ⓑ	—	1.0×10^4ⓑ	3.6×10^5	0.3	0.5	2.5	27	MgF_2 window: R976 (Dimensional Outline: ❶)	R821
70	110	10.5	—	85	10	110	8.5×10^4	1.0×10^6	1	5	2.5	27	For photon counting: R1166P UV glass window: R750	R1166
70	115	11.0	—	88	100	200	1.5×10^5	1.7×10^6	3	50	1.8	19	Semiflexible lead: R1450-13	R1450
70	115	11.0	—	88	100	200	1.5×10^5	1.7×10^6	10	300	1.3	14	UV glass window: R3479 Silica glass window: R2076	R3478
30	50	6.5	—	50	20	100	1.0×10^5	2.0×10^6	0.5	4	1.3	12	For photon counting: R5610P Maximum Temp.: +70 °C	R5610A
60	90	10.5	—	85	10	50	4.7×10^4	5.5×10^5	3	20	1.3	12	Button stem: R5611A	R5611A-01
20	40	6.0	—	51	5	20	1.9×10^4	5.0×10^5	0.1	10	1.0	10	High temp. operation (Maximum Temp.: +175 °C)	R3991A
80	120	—	0.2	51	30	120	5.1×10^4	1.0×10^6	4	20	2.5	27	UV glass window: R1464 Silica glass window: R2027	R1617
80	120	—	0.2	51	30	150	6.1×10^4	1.2×10^6	100ⓕ	250ⓕ	1.7	24	Bialkali photocathode: R2295	R1878

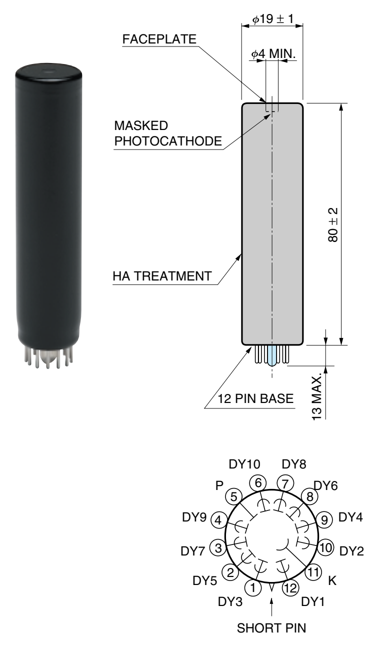
❹ R5610A



❺ R5611A-01, R3991A



❻ R1878

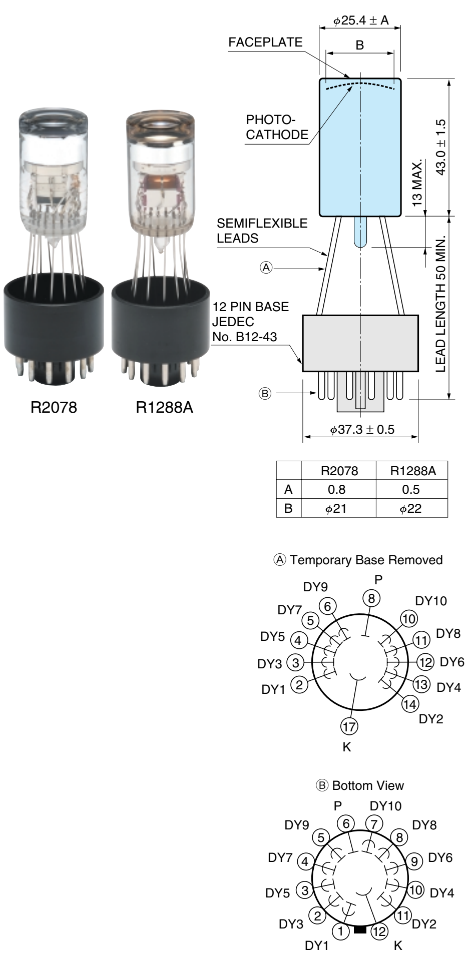


Head-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wave-length (nm)	Photo-cathode Material (C)	Win-dow Mate-rial (D)	Out-line No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings: Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
25 mm (1") Dia. Types												
R2078	φ21	160 to 320	201S	240	Cs-Te	Q	1	CC/10	E678-12A*	2000	0.015	1500 (15)
*R9800	φ22	300 to 650	400K	420	BA	K	2	L/8	E678-12A*	1500	0.1	1300 (8)
R7899	φ22	300 to 650	400K	420	BA	K	3	L/10	E678-14C* (20)	1800	0.1	1250 (18)
R4998	φ20	300 to 650	400K	420	BA	K	4	L/10	E678-12A*	2500	0.1	2250 (22)
R1924A	φ22	300 to 650	400K	420	BA	K	5	C+L/10	E678-14C* (21)(22)(23)	1250	0.1	1000 (17)
R3550A	φ22	300 to 650	402K	375	LBA	K	5	C+L/10	E678-14C* (21)(22)(23)	1250	0.1	1000 (17)
R1288A	φ22	300 to 650	401K	375	HBA	K	1	C+L/10	E678-12R*	1800	0.02	1500 (17)
R1925A	φ22	300 to 850	500K	420	MA	K	5	C+L/10	E678-14C* (21)(22)(23)	1250	0.1	1000 (17)
R5070A	φ21	300 to 900	502K	420	MA	K	6	C+L/10	E678-14C* (21)(22)(23)	1250	0.1	1000 (17)

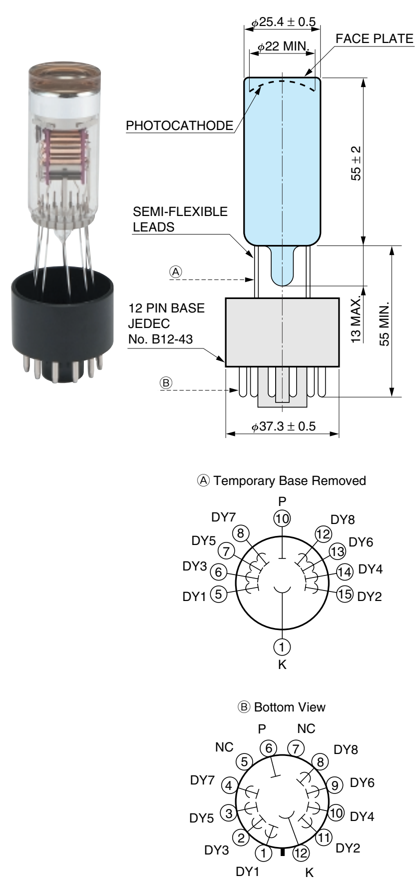
Dimensional Outlines (Unit: mm)

1 R2078, R1288A

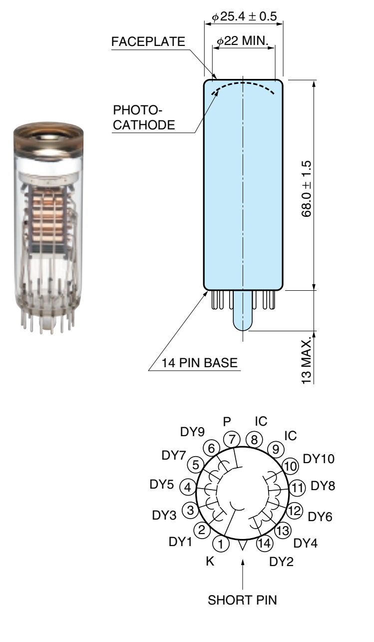


	R2078	R1288A
A	0.8	0.5
B	φ21	φ22

2 R9800

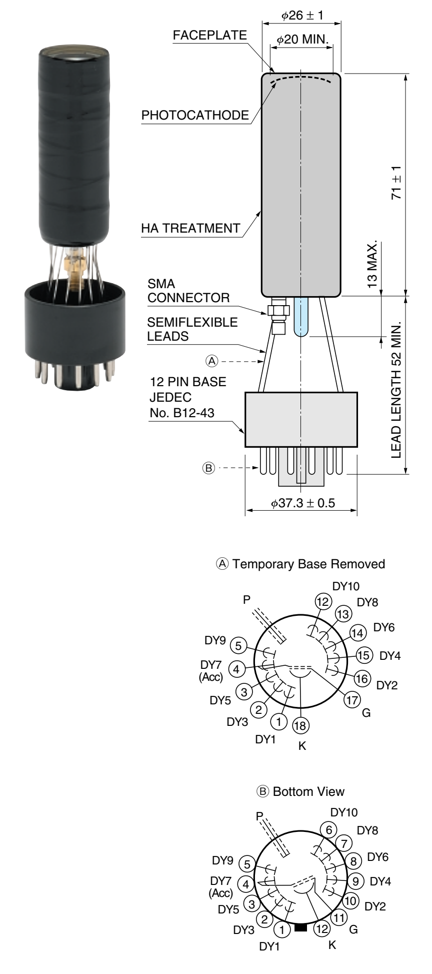


3 R7899



Cathode Characteristics					Anode Characteristics (M)										(at 25 °C)
Luminous		Blue Sensitivity Index (CS 5-58)	Red / White Ratio (R-68)	(K) Radiant	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	(A) Type No.
Min. (μA/lm)	Typ. (μA/lm)	Typ.	Typ.	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
—	—	—	—	29 (b)	2×10^3 (A/W) (b)	—	1.5×10^4 (b)	5.0×10^5	0.015	0.1	1.5	14	Better solar-blind characteristics	**R2078**
70	95	11.0	—	88	20	100	9.3×10^4	1.1×10^6	5	50	1.0	11	UV glass type: R10560	**R9800***
70	95	11.0	—	88	—	190	1.7×10^5	2.0×10^6	2	15	1.6	17	Semiflexible leads: R7899-01	**R7899**
60	70	9.0	—	72	100	400	4.1×10^5	5.7×10^6	100	800	0.7	10	Assembly type: H6533 Silica glass window: R5320 Silica glass window assembly type: H6610	**R4998**
60	90	10.5	—	85	40	180	1.7×10^5	2.0×10^6	3	20	1.5	17	Photon counting: R1924P	**R1924A**
30	50	7.0	—	55	45	100	1.1×10^5	2.0×10^6	0.5	4	1.5	17	For photon counting: R3550P Maximum Temp.: +70 °C	**R3550A**
20	40	6.0	—	51	8	20	1.9×10^4	5.0×10^5	0.1	10	1.3	13	Button stem: R1288A-01 High temp. operation (Maximum Temp.: +175 °C)	**R1288A**
80	150	—	0.2	64	20	75	3.2×10^4	5.0×10^5	3	20	1.5	17	Silica glass window: R1926A	**R1925A**
130	230	—	0.1 (h)	65	20	100	2.8×10^4	4.3×10^5	3	20	2.2	19	Prism window	**R5070A**

❹ R4998



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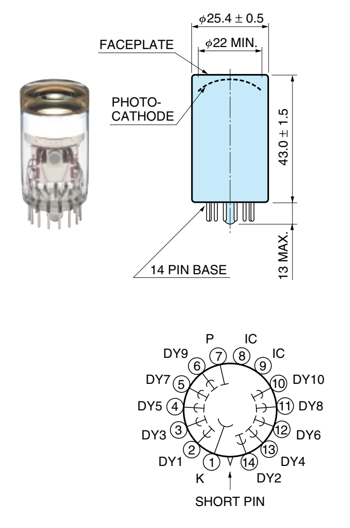
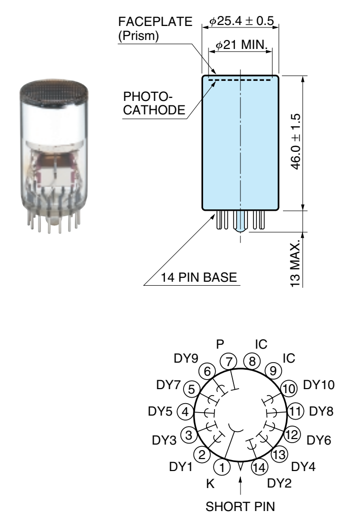
❺ R1924A, R3550A, R1925A



TPMHA0040EC

❻ R5070A



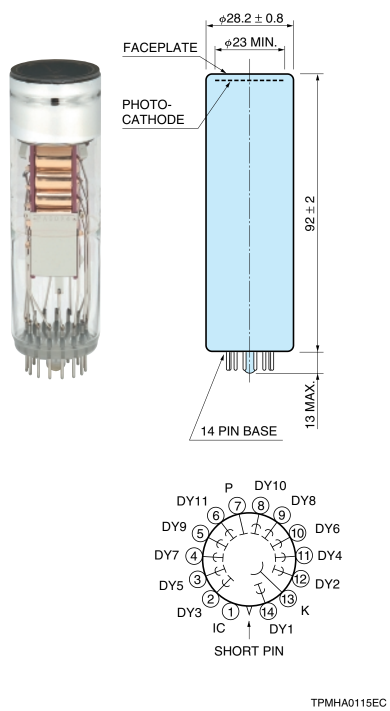
TPMHA0491EB

Head-on Type Photomultiplier Tubes

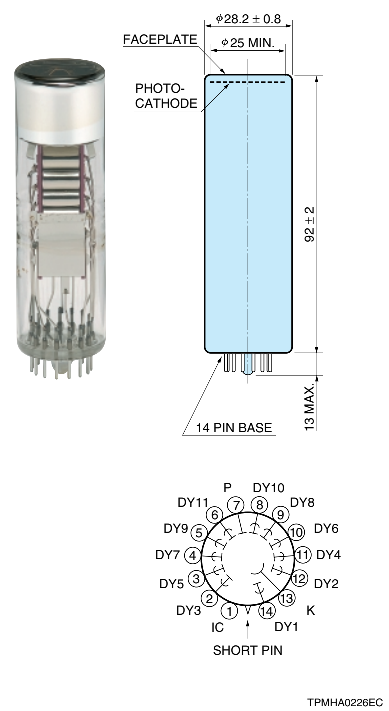
	Spectral Response				Remarks					Max. Ratings Ⓗ		
Ⓐ Type No.	Effective Area (mm) / ← Wavelength (nm) → (100 200 300 400 500 600 700 800 900 1000 1100 1200)	Spectral Response Range (nm)	Ⓑ Curve Code	Peak Wavelength (nm)	Ⓒ Photocathode Material	Ⓓ Window Material	Ⓔ Outline No.	Ⓕ Dynode Structure / Stages	Ⓖ Socket & Socket Assembly	Anode to Cathode Voltage (V)	Ⓙ Average Anode Current (mA)	Ⓛ Anode to Cathode Supply Voltage (V)
28 mm (1-1/8") Dia. Types												
R6835	φ23	115 to 200	100M	140	Cs-I	MF	❶	B+L/11	E678-14C*	2500	0.01	2000 ㉖
R6836	φ23	115 to 320	200M	240	Cs-Te	MF	❶	B+L/11	E678-14C*	1500	0.01	1000 ㉖
R6834	φ25	160 to 320	200S	240	Cs-Te	Q	❷	B+L/11	E678-14C* ㉔㉕㉖	1500	0.01	1000 ㉖
R6095	φ25	300 to 650	400K	420	BA	K	❸	B+L/11	E678-14C* ㉔㉕㉖	1500	0.1	1000 ㉖
R6094	φ25	300 to 650	400K	420	BA	K	❹	B+L/11	E678-14C* ㉔㉕㉖	1500	0.1	1000 ㉖
R6427	φ25	300 to 650	400K	420	BA	K	❺	L/10	E678-14C* ㉗㉘㉙	2000	0.1	1500 ⑳
R374	φ25	185 to 850	500U	420	MA	U	❸	B/11	E678-14C* ㉔㉕㉖	1500	0.1	1000 ㉖

Dimensional Outlines (Unit: mm)

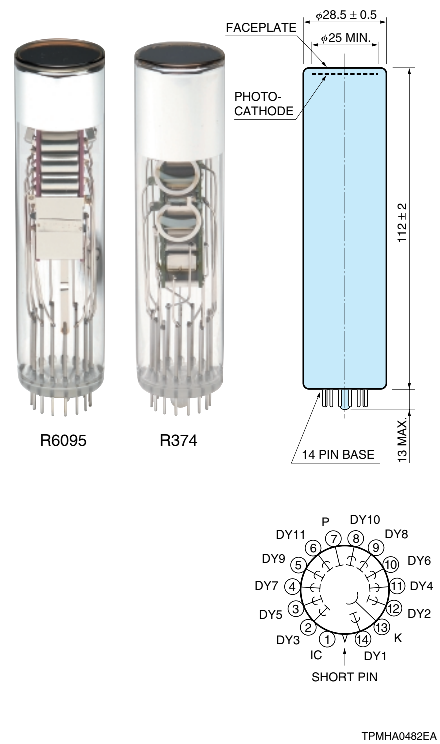
❶ R6835, R6836



❷ R6834



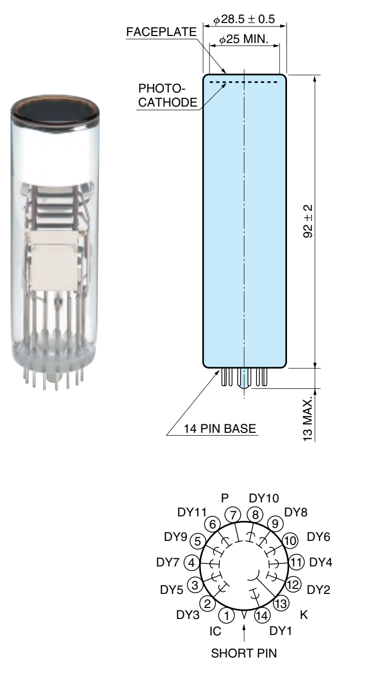
❸ R6095, R374



(at 25 °C)

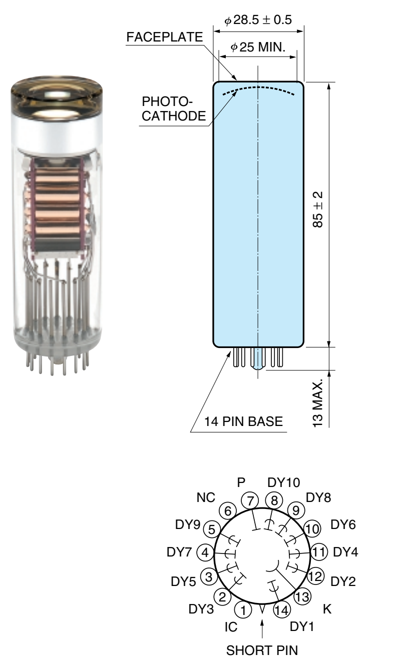
Cathode Characteristics: Luminous Min. (µA/lm)	Cathode Characteristics: Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	(K) Radiant Typ. (mA/W)	Anode Characteristics (M): Luminous Min. (A/lm)	Anode Characteristics: Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	(A) Type No.
—	—	—	—	12 (a)	—	—	1.2×10^3 (a)	1.0×10^5	0.03	0.05	2.8	22		R6835
—	—	—	—	28 (b)	4×10^3 (A/W) (b)	—	1.4×10^4 (b)	5.0×10^5	0.3	1	4.0	30		R6836
—	—	—	—	28 (b)	4×10^3 (A/W) (b)	—	1.4×10^4 (b)	5.0×10^5	0.3	1	4.0	30		R6834
60	95	11.0	—	88	50	200	1.8×10^5	2.1×10^6	2	10	4.0	30	For photon counting: R6095P-01	R6095
60	95	11.0	—	88	50	200	1.8×10^5	2.1×10^6	2	10	4.0	30	For photon counting: R6094P-01	R6094
70	100	11.0	—	88	100	500	4.4×10^5	5.0×10^6	10	200	1.7	16	UV glass window: R7056	R6427
80	150	—	0.2	64	20	80	3.4×10^4	5.3×10^5	3	15	15	60	High gain: R1104	R374

4 R6094



TPMHA0493EA

5 R6427



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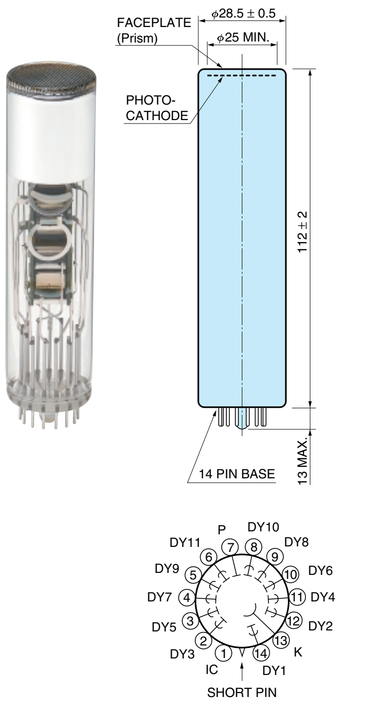
Head-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings (H): Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
28 mm (1-1/8") Dia. Types												
R5929	φ25	300 to 900	502K	420	MA	K	❶	B/11	E678-14C* ㉔㉕㉖	1500	0.1	1000 ㉖
R2228	φ25	300 to 900	501K	600	EMA	K	❶	B/11	E678-14C* ㉔㉕㉖	1500	0.1	1000 ㉖
R7205-01	φ10	300 to 650	400K	420	BA	K	❷	B+L/11	E678-14C* ㉚	1500	0.01	1000 ㉘
R7206-01	φ10	300 to 850	500K	420	MA	K	❷	B+L/11	E678-14C* ㉚	1500	0.01	1000 ㉘
R3998-02	φ25	300 to 650	400K	420	BA	K	❸	B+L/9	E678-14C* ㉛	1500	0.1	1000 ⑩
R7111	φ25	300 to 650	400K	420	BA	K	❹	C+L/10	E678-14C* ㉑㉒㉓	1250	0.1	1000 ⑰

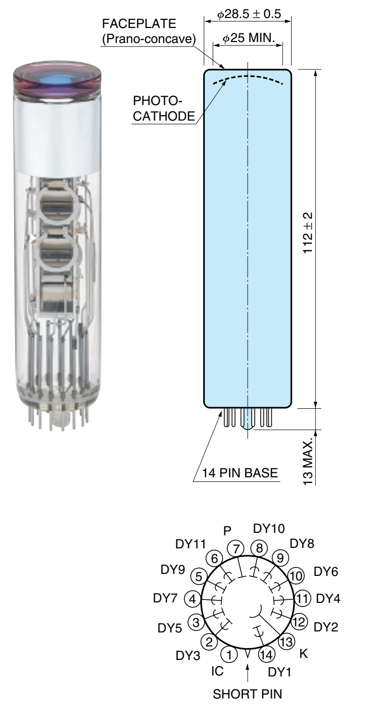
Dimensional Outlines (Unit: mm)

❶ R5929



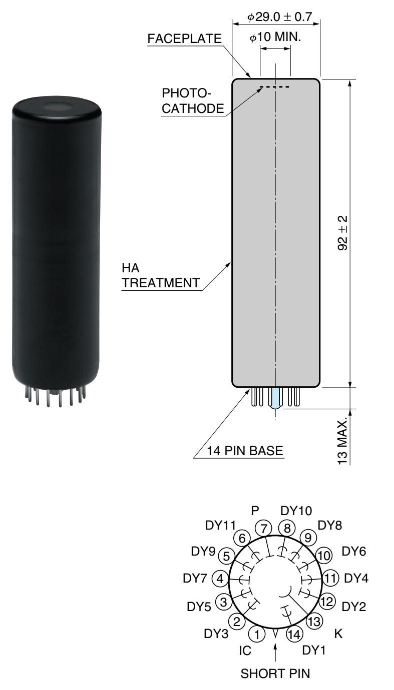
TPMHA0532EA

❷ R2228



TPMHA0533EA

❸ R7205-01, R7206-01

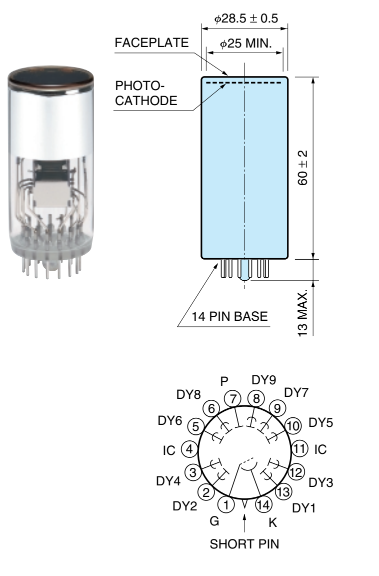


TPMHA0412EC

(at 25 °C)

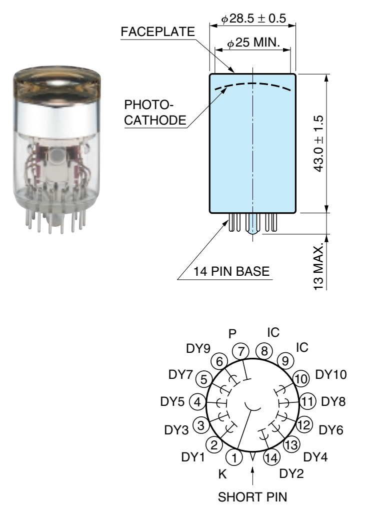
Cathode Characteristics: Luminous Min. (µA/lm)	Cathode: Luminous Typ. (µA/lm)	Cathode: Blue Sensitivity Index (CS 5-58) Typ.	Cathode: Red / White Ratio (R-68) Typ.	Cathode: Radiant Ⓚ Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Min. (A/lm)	Anode: Luminous Typ. (A/lm)	Anode: Radiant Typ. (A/W)	Anode: Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	Type No. Ⓐ
130	230	—	0.25	65	30	180	5.1×10^4	7.8×10^5	5	25	15	60	Prism window	R5929
100	200	—	0.3	40	20	150	3.0×10^4	7.5×10^5	8	30	15	60		R2228
40	70	9.0	—	72	200	700	7.5×10^5	1.0×10^7	10ⓕ	30ⓕ	1.7	26	Silica glass window: R7207-01	R7205-01
80	150	—	0.2	64	200	1500	6.4×10^5	1.0×10^7	300ⓕ	1000ⓕ	1.7	26		R7206-01
60	90	10.5	—	85	50	120	1.1×10^5	1.3×10^6	2	10	3.4	23		R3998-02
60	90	10.5	—	85	40	180	1.7×10^5	2.0×10^6	3	20	1.6	18		R7111

❹ R3998-02



TPMHA0114EA

❺ R7111



TPMHA0395EB

Head-on Type Photomultiplier Tubes

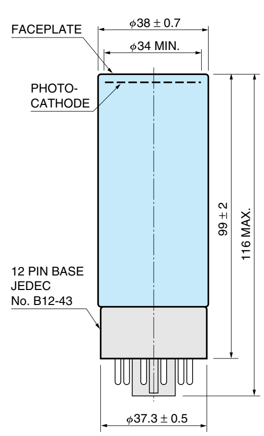
	Spectral Response				Remarks					Max. Ratings Ⓗ		
Ⓐ Type No.	Effective Area (mm) / ← Wavelength (nm) → (100 200 300 400 500 600 700 800 900 1000 1100 1200)	Spectral Response Range (nm)	Ⓑ Curve Code	Peak Wavelength (nm)	Ⓒ Photocathode Material	Ⓓ Window Material	Ⓔ Outline No.	Ⓕ Dynode Structure / Stages	Ⓖ Socket & Socket Assembly	Anode to Cathode Voltage (V)	Ⓙ Average Anode Current (mA)	Ⓛ Anode to Cathode Supply Voltage (V)
38 mm (1-1/2") Dia. Types												
*R11102	ϕ34	300 to 650	400K	420	BA	K	❶	C+L/10	E678-12A ㉜㉝	1250	0.1	1000 ⑮
*R3886A	ϕ34	300 to 650	400K	420	BA	K	❷	C+L/10	E678-12A* ㉜㉝	1250	0.1	1000 ⑮
*R9420	ϕ34	300 to 650	400K	420	BA	K	❸	L/8	E678-12A*	1500	0.1	1300 ⑧
R580	ϕ34	300 to 650	400K	420	BA	K	❹	L/10	E678-12A* ㉜㉝	1750	0.1	1250 ⑮
*R9722A	ϕ34	300 to 650	401K	375	HBA	K	❺	C+L/10	E678-12R* ㉜㉝	1800	0.02	1500 ⑮
R2066	ϕ34	300 to 900	501K	600	EMA	K	❶	CC/10	E678-12A* ㉜㉝	1500	0.2	1000 ⑮

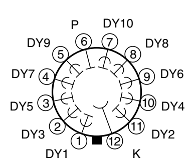
Dimensional Outlines (Unit: mm)

❶ R11102, R2066

R11102

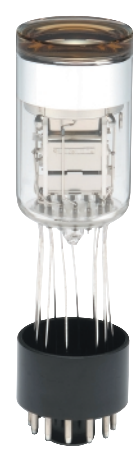
R2066 (Plano-concave faceplate)

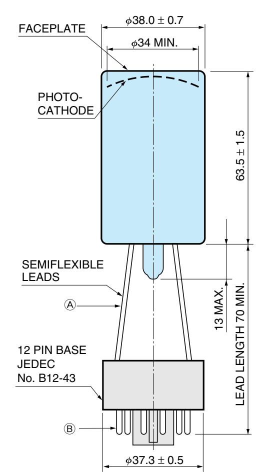




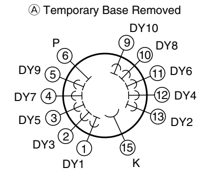
TPMHA0228EA

❷ R3886A

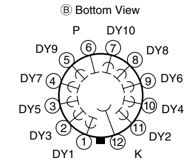




Ⓐ Temporary Base Removed



Ⓑ Bottom View

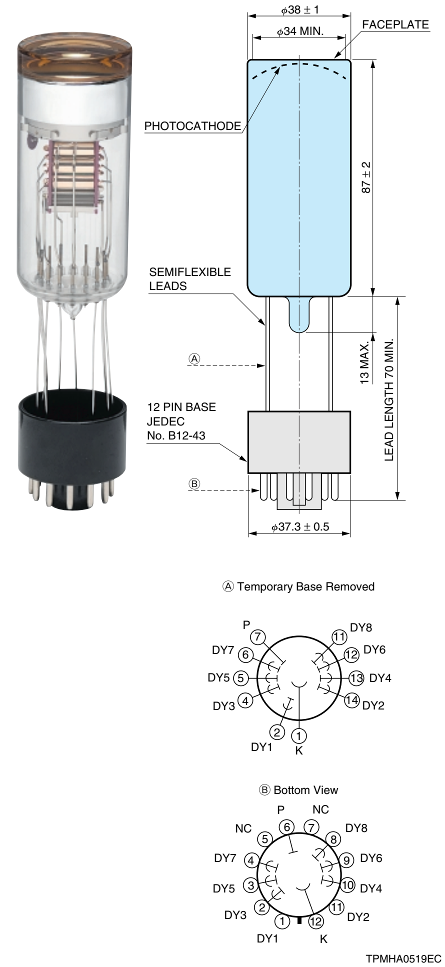


TPMHA0104EA

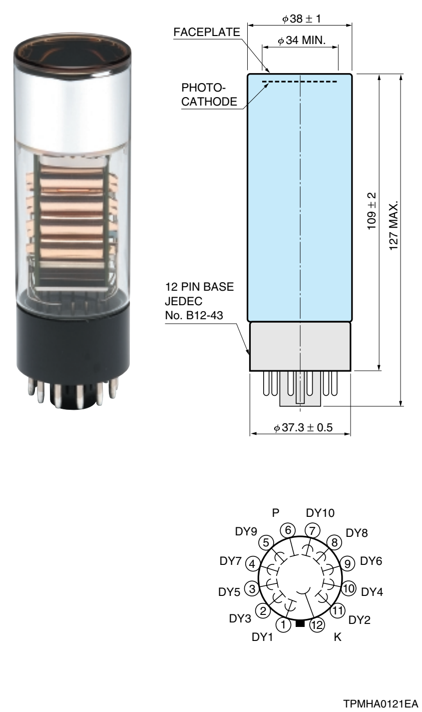
(at 25 °C)

Cathode Characteristics: Luminous Min. (µA/lm)	Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	(K) Radiant Typ. (mA/W)	Anode Characteristics (M): Luminous Min. (A/lm)	Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current Max. (nA)	Time Response: Rise Time Typ. (ns)	Transit Time Typ. (ns)	Notes	(A) Type No.
80	120	11.5	—	89	10	120	8.9×10^4	1.0×10^6	2	20	3.2	34		**R11102***
60	90	10.5	—	85	40	180	4.3×10^4	2.0×10^6	3	20	2.6	30		**R3886A***
70	95	11.0	—	88	5	47	4.4×10^4	5.0×10^5	10	100	1.6	17		**R9420***
70	95	11.0	—	88	10	100	9.7×10^4	1.1×10^6	3	20	2.7	37		**R580**
20	40	6.0	—	51	5	20	2.5×10^4	5.0×10^5	0.5	10	2.2	26	High temp. operation (Maximum Temp.: +175 °C)	**R9722A***
120	200	—	0.3	40	20	50	1.0×10^4	2.5×10^5	8	30	2.8	40		**R2066**

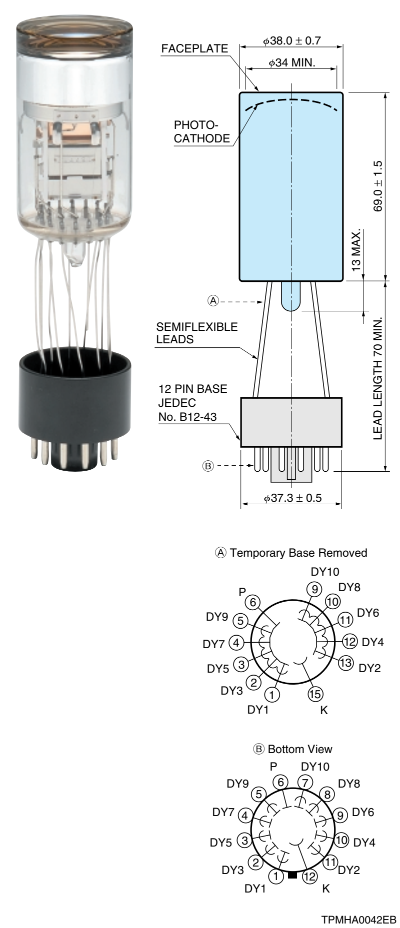
3 R9420



4 R580



5 R9722A

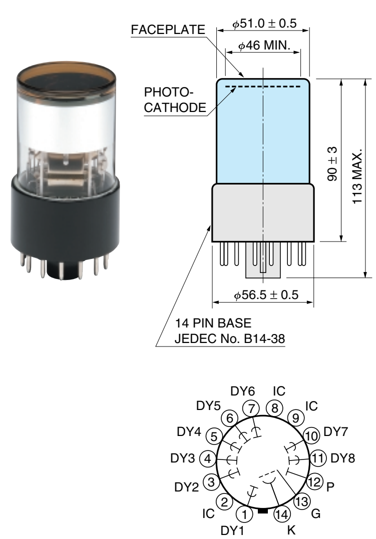


Head-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wave-length (nm)	Photo-cathode Material (C)	Win-dow Mate-rial (D)	Out-line No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings (H): Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
51 mm (2") Dia. Types with Plastic Base												
R6231	φ46	300 to 650	400K	420	BA	K	❶	B+L/8	E678-14W 34 35	1500	0.1	1000 ⑦
R1306	φ46	300 to 650	400K	420	BA	K	❷	B/8	E678-14W 36 37	1500	0.1	1000 ②
*R878	φ46	300 to 650	400K	420	BA	K	❸	B/10	E678-14W 40 41 42 43	1500	0.1	1250 ⑬
*R9779	φ46	300 to 650	400K	420	BA	K	❹	L/8	E678-20B*	1750	0.1	1500 ④
R2154-02	φ46	300 to 650	400K	420	BA	K	❺	L/10	E678-14W 38	1750	0.1	1250 ⑮
R1828-01	φ46	300 to 650	400K	420	BA	K	❻	L/12	E678-20B* 39	3000	0.2	2500 ㉙
R550	φ46	300 to 850	500K	420	MA	K	❸	B/10	E678-14W 40 41 42 43	1500	0.3	1000 ⑬

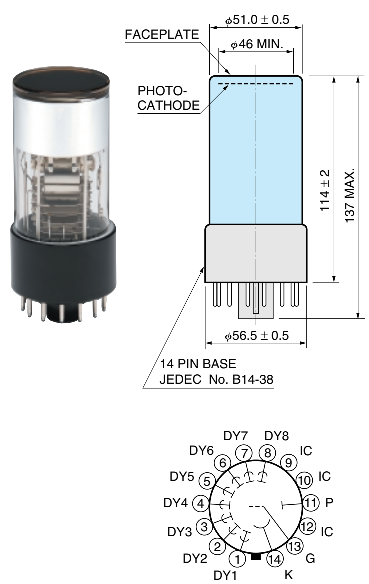
Dimensional Outlines (Unit: mm)

❶ R6231



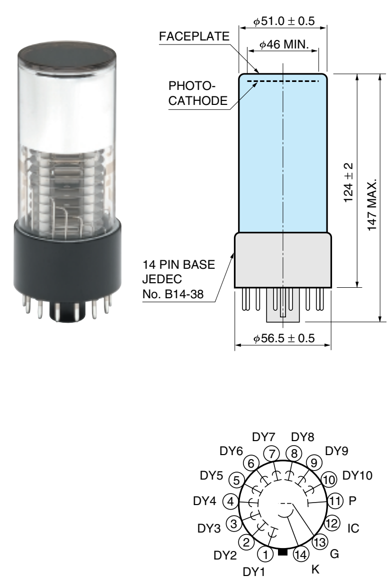
TPMHA0388EB

❷ R1306



TPMHA0089EC

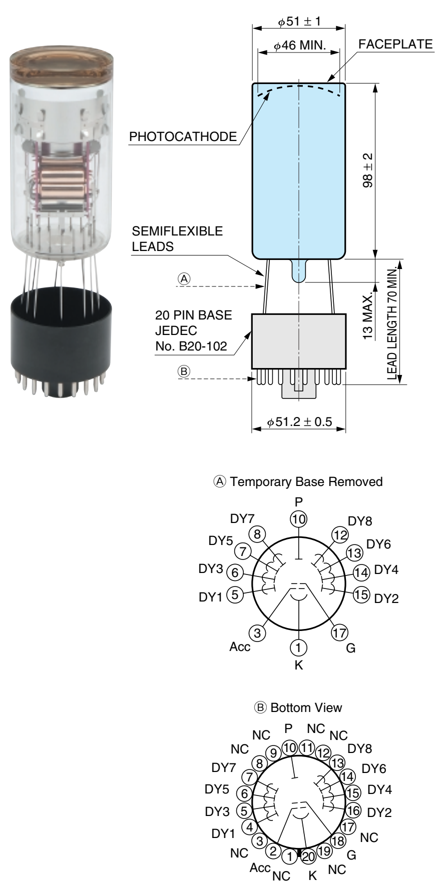
❸ R878, R550



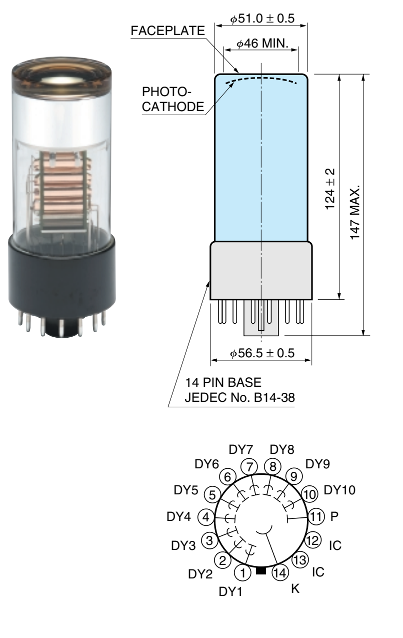
TPMHA0210EB

Cathode Characteristics					Anode Characteristics Ⓜ									(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58)	Red / White Ratio (R-68)	Ⓚ Radiant	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Ⓐ Type No.
Min. (µA/lm)	Typ. (µA/lm)	Typ.	Typ.	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	8.5	48	Semiflexible lead: R6231-01	R6231
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	7.0	60		R1306
60	100	11.5	—	90	20	100	9.0×10^4	1.0×10^6	5	50	7.0	70		R878*
70	95	11.0	—	88	10	47.5	4.6×10^4	5.0×10^5	15	100	1.8	20		R9779*
60	90	10.5	—	85	20	90	8.5×10^4	1.0×10^6	5	20	3.4	31	Multialkali photocathode: R3256	R2154-02
60	90	10.5	—	85	200	1800	1.7×10^6	2.0×10^7	50	400	1.3	28	Silica glass window: R2059	R1828-01
100	150	—	0.2	64	20	100	4.3×10^4	6.7×10^5	10	30	9.0	70		R550

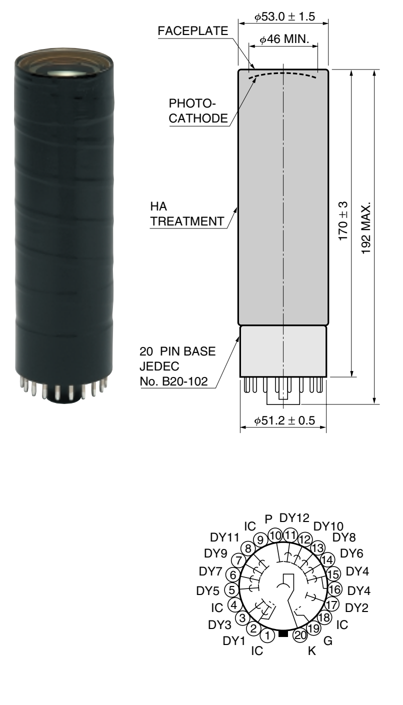
❹ R9779



❺ R2154-02



❻ R1828-01

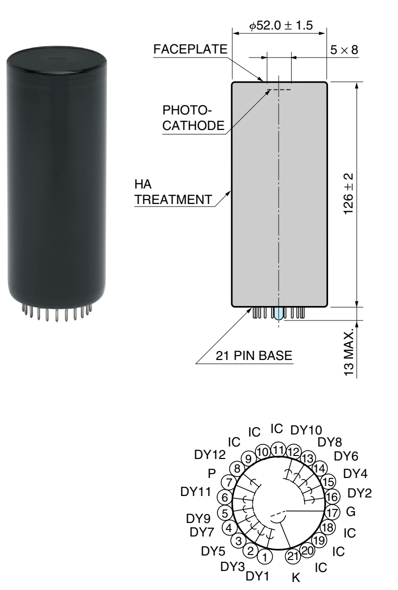


Head-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wave-length (nm)	Remarks: Photo-cathode Material (C)	Win-dow Mate-rial (D)	Out-line No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Average Anode Current (J) (mA)	Anode to Cathode Supply Voltage (L) (V)
51 mm (2") Dia. Types with Glass Base												
R464	5 × 8	300 to 650	400K	420	BA	K	1	B/12	E678-21C* (44)	1500	0.01	1000 (31)
*R7724	φ46	300 to 650	400K	420	BA	K	2	L/10	E678-21C* (45)	2000	0.2	1750 (21)
R329-02	φ46	300 to 650	400K	420	BA	K	3	L/12	E678-21C* (46)(47)(48)	2700	0.2	1500 (30)
R331-05	φ46	300 to 650	400K	420	BA	K	4	L/12	E678-21C* (46)(47)(48)	2500	0.2	1500 (30)
R2083	φ46	300 to 650	400K	420	BA	K	5	L/8	E678-19J*	3500	0.2	3000 (3)
*R4607A-01	φ46	300 to 650	401K	375	HBA	K	6	C+L/10	E678-15C*	1800	0.02	1500 (15)
R649	5 × 8	300 to 850	500K	420	MA	K	1	B/12	E678-21C* (44)	1500	0.01	1000 (31)

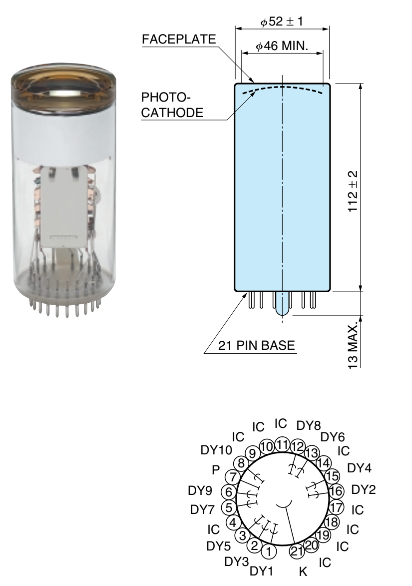
Dimensional Outlines (Unit: mm)

1 R464, R649



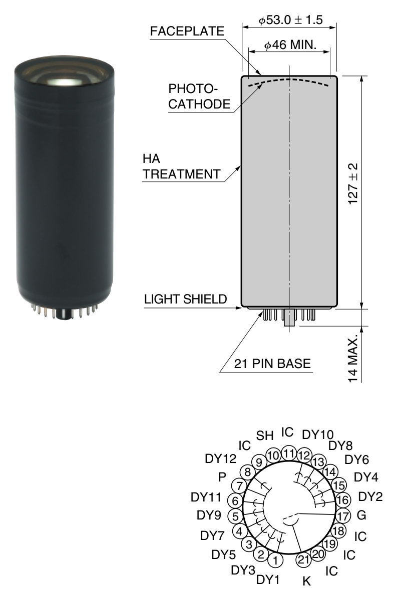
TPMHA0216EC

2 R7724



TPMHA0509EC

3 R329-02

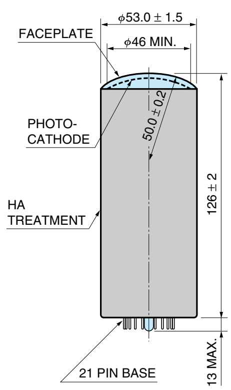


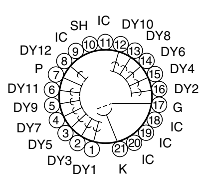
TPMHA0123EE

(at 25 °C)

Cathode Characteristics: Luminous Min. (µA/lm)	Cathode: Luminous Typ. (µA/lm)	Cathode: Blue Sensitivity Index (CS 5-58) Typ.	Cathode: Red / White Ratio (R-68) Typ.	Cathode: Ⓚ Radiant Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Min. (A/lm)	Anode: Luminous Typ. (A/lm)	Anode: Radiant Typ. (A/W)	Anode: Gain Typ.	Anode: Dark Current (After 30 min.) Typ. (nA)	Anode: Dark Current (After 30 min.) Max. (nA)	Anode: Time Response Rise Time Typ. (ns)	Anode: Time Response Transit Time Typ. (ns)	Notes	Ⓐ Type No.
30	50	—	—	50	100	300	3.0×10^5	6.0×10^6	5ⓕ	15ⓕ	13	70	Silica glass window: R585	**R464**
60	90	10.5	—	85	30	300	2.8×10^5	3.3×10^6	6	40	2.1	29		**R7724** *
60	90	10.5	—	85	30	100	9.4×10^4	1.1×10^6	6	40	2.6	48	UV glass window: R5113-02 Silica glass window: R2256-02	**R329-02**
60	90	10.5	—	85	30	120	1.1×10^5	1.3×10^6	1000ⓕ	2000ⓕ	2.6	48	Silica glass window: R331	**R331-05**
60	80	10.0	—	80	50	200	2.0×10^5	2.5×10^6	100	800	0.7	16	Assembly type: H2431-50 Recommended Silica glass window: R3377 Silica glass window assembly type: H3378-50	**R2083**
20	40	6.0	—	51	5	20	2.5×10^4	5.0×10^5	3	50	2.6	28	High temp. operation (Maximum Temp.: +175 °C)	**R4607A-01** *
80	120	—	0.2	51	100	800	3.4×10^5	6.7×10^6	200ⓕ	350ⓕ	13	70		**R649**

❹ R331-05

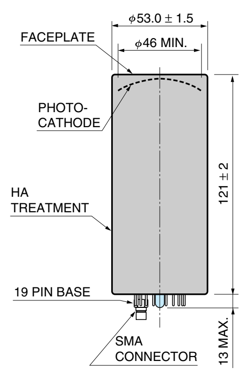


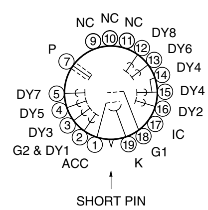


*CONNECT SH TO DY5

TPMHA0072EC

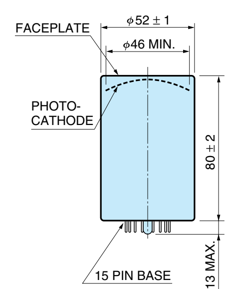
❺ R2083

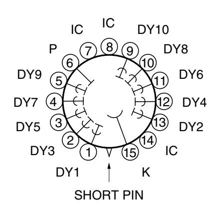




TPMHA0185EC

❻ R4607A-01





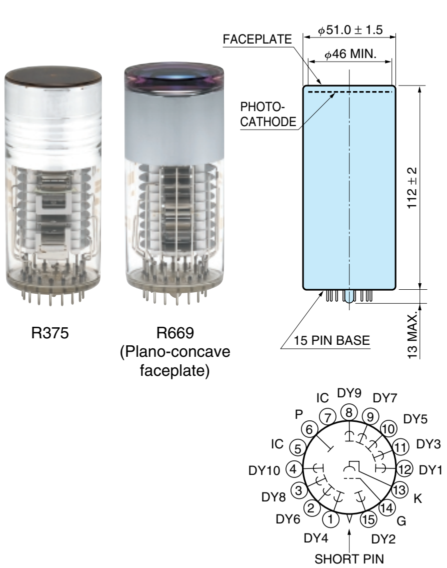
TPMHA0003EC

Head-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) (100 – 1200)	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Remarks: Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
51 mm (2") Dia. Types with Glass Base												
R375	ϕ46	160 to 850	500S	420	MA	Q	❶	B/10	E678-15C* (49)	1500	0.1	1000 (13)
R669	ϕ46	300 to 900	501K	600	EMA	K	❶	B/10	E678-15C* (49)	1500	0.1	1000 (13)
R943-02	□10	160 to 930	650S	300-800	GaAs	Q	❷	L/10	E678-21C*	2200	0.001	1500 (19)
R2257	ϕ46	300 to 900	501K	600	EMA	K	❸	L/12	E678-21C* (46)(47)(48)	2700	0.2	1500 (30)

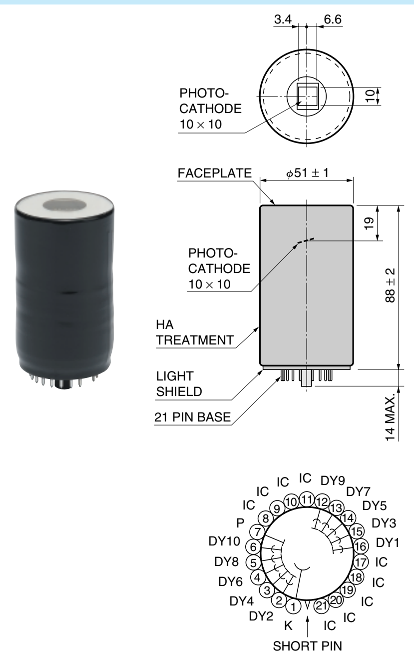
Dimensional Outlines (Unit: mm)

❶ R375, R669



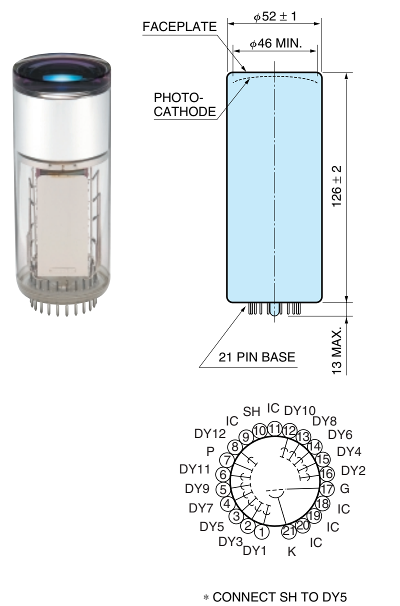
TPMHA0211EA

❷ R943-02



TPMHA0021EF

❸ R2257



TPMHA0359EB

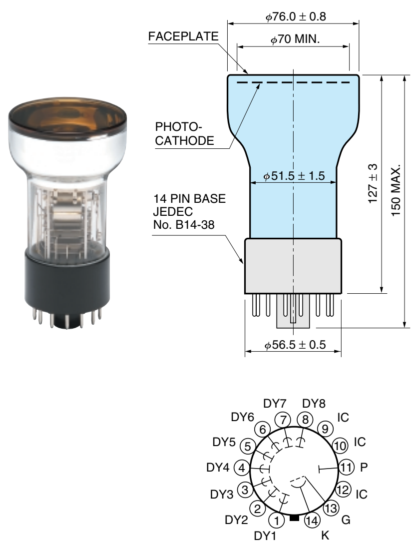
Cathode Characteristics					Anode Characteristics Ⓜ									(at 25 °C)
Luminous		Blue Sensitivity Index (CS 5-58)	Red / White Ratio (R-68)	Ⓚ Radiant	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Ⓐ Type No.
Min. (µA/lm)	Typ. (µA/lm)	Typ.	Typ.	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
80	150	—	0.2	64	20	80	3.4×10^4	5.3×10^5	5	20	9.0	70		R375
140	230	—	0.35	50	20	75	1.7×10^4	3.3×10^5	7	15	9.0	70		R669
300	600	—	0.58	71	150	300	3.6×10^4	5.0×10^5	20ⓖ	50ⓖ	3.0	23	For photon counting	R943-02
140	230	—	0.35	50	15	100	2.2×10^4	4.3×10^5	30	100	2.6	48		R2257

Head-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wave-length (nm)	Photo-cathode Material (C)	Win-dow Mate-rial (D)	Out-line No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings: Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
76 mm (3") Dia. Types												
R1307	φ70	300 to 650	400K	420	BA	K	1	B/8	E678-14W 36 37	1500	0.1	1000 (2)
R6233	φ70	300 to 650	400K	420	BA	K	2	B+L/8	E678-14W 34 35	1500	0.1	1000 (7)
*R594	φ70	300 to 650	400K	420	BA	K	3	B/10	E678-14W 40 41 42 43	2000	0.1	1500 (13)
R4143	φ65	300 to 650	400K	420	BA	K	4	L/12	E678-20B*	3000	0.2	2500 (32)
R6091	φ65	300 to 650	400K	420	BA	K	5	L/12	E678-21C* 46 47 48	2500	0.2	1500 (30)

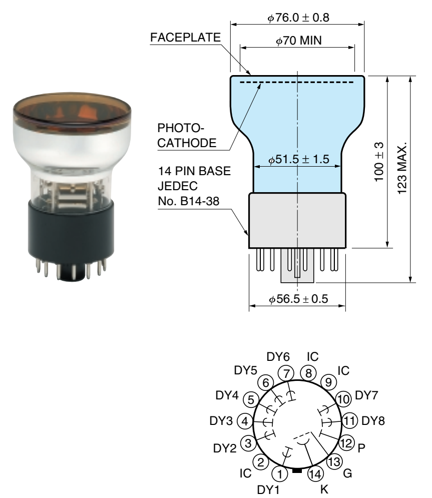
Dimensional Outlines (Unit: mm)

1 R1307



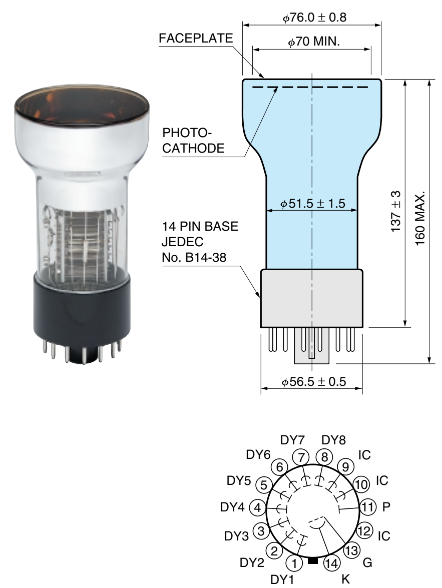
TPMHA0078EA

2 R6233



TPMHA0389EB

3 R594

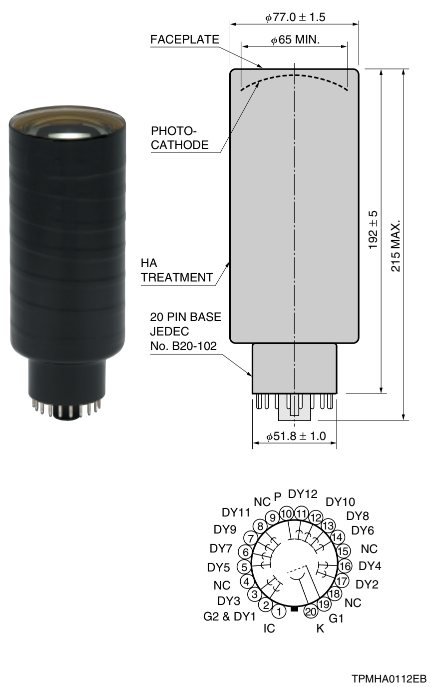


TPMHA0557EA

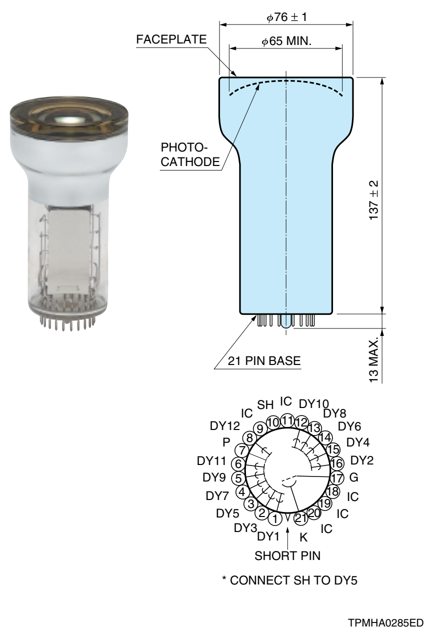
(at 25 °C)

Cathode Characteristics: Luminous Min. (µA/lm)	Cathode Characteristics: Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	K Radiant Typ. (mA/W)	Anode Characteristics M: Luminous Min. (A/lm)	Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	A Type No.
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	8.0	64	Semiflexible lead: R1307-01	R1307
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	9.5	52	Semiflexible lead: R6233-01	R6233
70	95	11.5	—	90	10	70	6.7×10^4	7.4×10^5	5	70	7.0	65		R594*
60	80	9.5	—	76	100	400	3.8×10^5	5.0×10^6	50	500	1.8	32		R4143
60	90	10.5	—	85	50	450	4.3×10^5	5.0×10^6	10	60	2.6	48		R6091

❹ R4143



❺ R6091



Head-on Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm)	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Remarks: Photocathode Material (C)	Remarks: Window Material (D)	Remarks: Outline No. (E)	Remarks: Dynode Structure / Stages (F)	Remarks: Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings (H): Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
127 mm (5") Dia. Types												
R877	ϕ111	300 to 650	400K	420	BA	K	❶	B/10	E678-14W ㊵㊶㊷㊸	1500	0.1	1250 ⑬
R1513	ϕ111	300 to 850	500K	420	MA	K	❶	VB/10	E678-14W ㊵㊶㊷㊸	2000	0.1	1500 ⑬
R1250	ϕ120	300 to 650	400K	420	BA	K	❷	L/14	E678-20B* ㊿	3000	0.2	2000 ㊳
R1584	ϕ120	185 to 650	400U	420	BA	U	❸	L/14	E678-20B* ㊿	3000	0.2	2000 ㊳

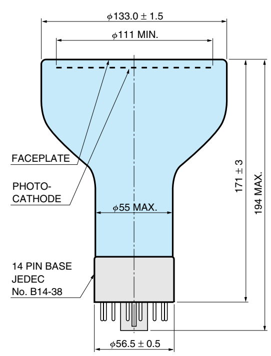
Wavelength scale (nm): 100 200 300 400 500 600 700 800 900 1000 1100 1200

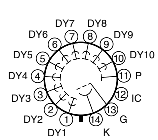
Dimensional Outlines (Unit: mm)

❶ R877, R1513


R877

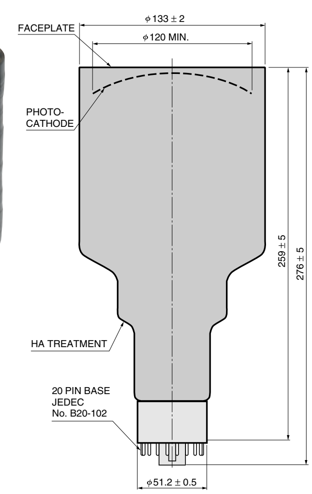

R1513

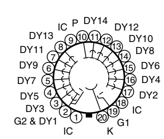




TPMHA0074EC

❷ R1250



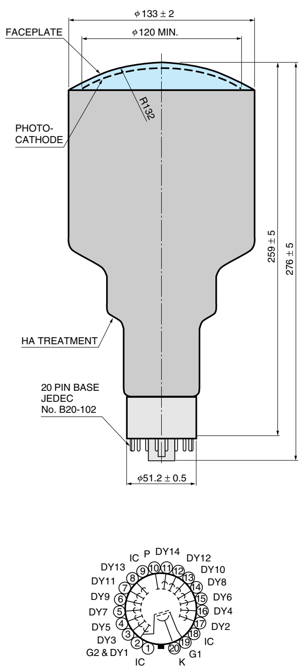


TPMHA0018EC

(at 25 °C)

Cathode Characteristics: Luminous Min. (µA/lm)	Cathode Characteristics: Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	K Radiant Typ. (mA/W)	Anode Characteristics M: Luminous Min. (A/lm)	Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	A Type No.
60	95	11.0	—	88	20	40	3.7×10^4	4.2×10^5	10	50	20	115	K-free borosilicate glass: R877-01	R877
100	150	—	0.2	64	10	50	2.1×10^4	3.3×10^5	30	150	15	82		R1513
55	70	9.0	—	72	300	1000	1.0×10^6	1.4×10^7	50	300	2.5	54		R1250
55	70	9.0	—	72	300	1000	1.0×10^6	1.4×10^7	50	300	2.5	54		R1584

❸ R1584



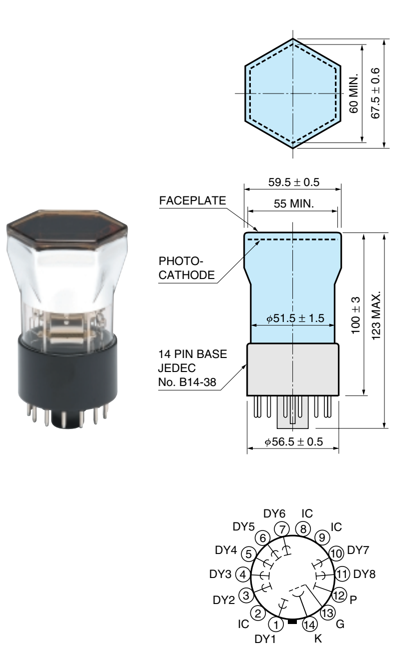
TPMHA0187EC

Hexagonal Type, Rectangular Type Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Remarks: Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
Hexagonal Types												
R6234	55 (6)	300 to 650	400K	420	BA	K	❶	B+L/8	E678-14W ㉞㉟	1500	0.1	1000 ⑦
R6235	70 (6)	300 to 650	400K	420	BA	K	❷	B+L/8	E678-14W ㉞㉟	1500	0.1	1000 ⑦
Rectangular Types												
R6236	□54	300 to 650	400K	420	BA	K	❸	B+L/8	E678-14W ㉞㉟	1500	0.1	1000 ⑦
R6237	□70	300 to 650	400K	420	BA	K	❹	B+L/8	E678-14W ㉞㉟	1500	0.1	1000 ⑦
R2248	□8	300 to 650	400K	420	BA	K	❺	L/8	E678-11N* ⑥	1500	0.03	1250 ①
R1548-07	8 × 18 × (2)	300 to 650	400K	420	BA	K	❻	L/10	E678-17A*	1750	0.1	1250 ⑳

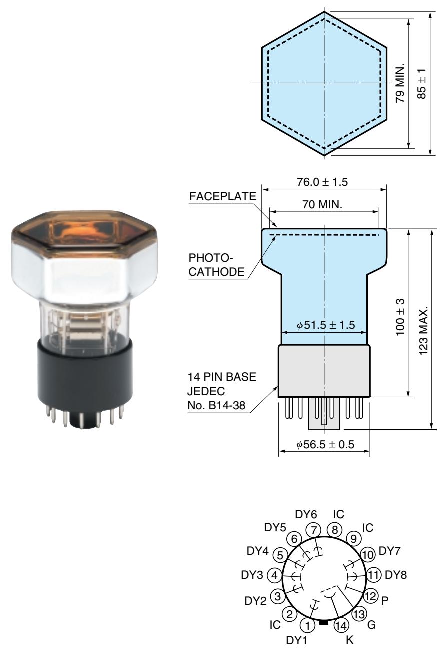
Dimensional Outlines (Unit: mm)

❶ R6234



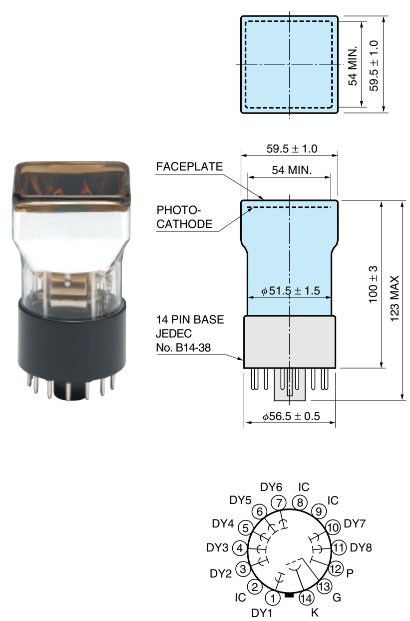
TPMHA0390EB

❷ R6235



TPMHA0391EB

❸ R6236

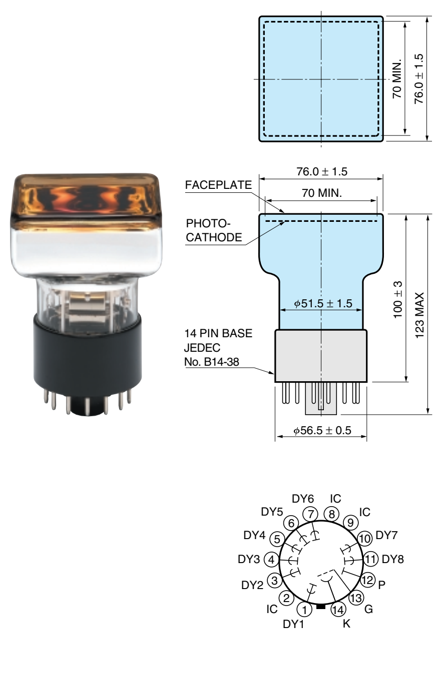


TPMHA0392EB

(at 25 °C)

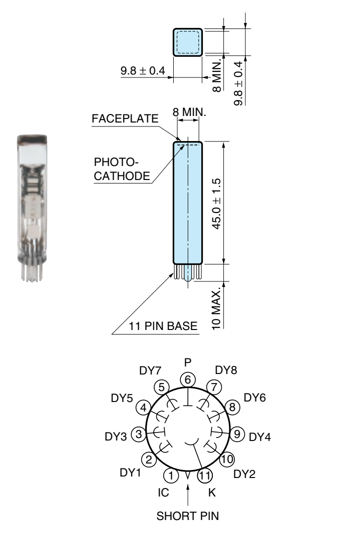
Cathode Characteristics: Luminous Min. (µA/lm)	Cathode Characteristics: Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Ⓚ Radiant Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Min. (A/lm)	Anode Characteristics Ⓜ: Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	Ⓐ Type No.
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	9.5	52	Semiflexible lead: R6234-01	R6234
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	9.5	52	Semiflexible lead: R6235-01	R6235
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	9.5	52	Semiflexible lead: R6236-01	R6236
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	9.5	52	Semiflexible lead: R6237-01	R6237
60	95	9.5	—	76	30	100	8.0×10^4	1.1×10^6	1	50	0.9	9		R2248
60	80	9.5	—	76	50	200	1.9×10^5	2.5×10^6	20	250	1.8	20	Rectangular dual type	R1548-07

❹ R6237



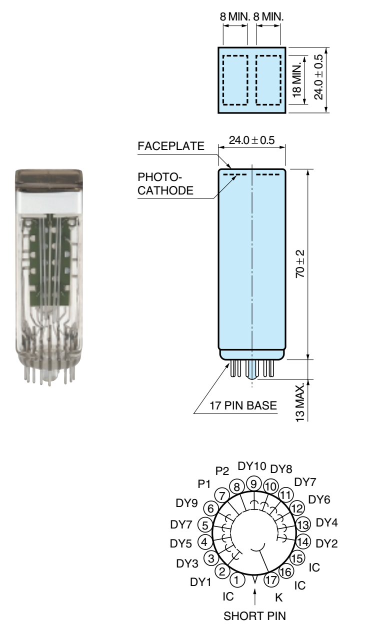
TPMHA0393EB

❺ R2248



TPMHA0098EB

❻ R1548-07



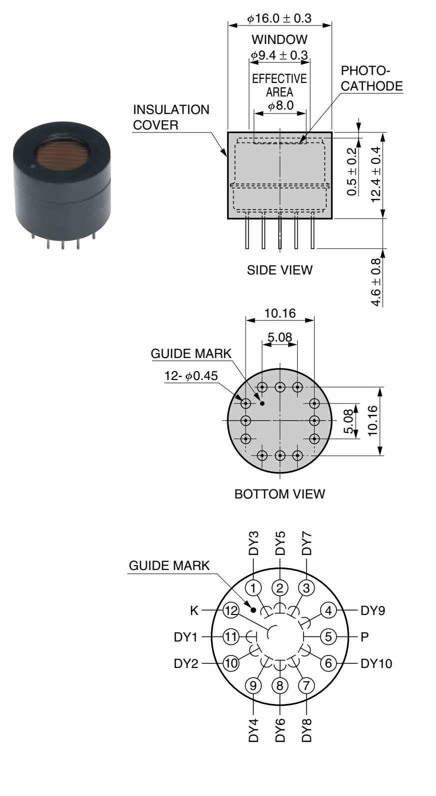
TPMHA0223EA

Metal Package Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) (100 – 1200)	Spectral Response Range (nm)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings (H): Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
*R9880U-01	φ8	230 to 870	400	MA	K	❶	MC/10	E678-12-01	1100	0.1	1000 ⑪
*R9880U-20	φ8	230 to 920	630	MA	K	❶	MC/10	E678-12-01	1100	0.1	1000 ⑪

Dimensional Outlines (Unit: mm)

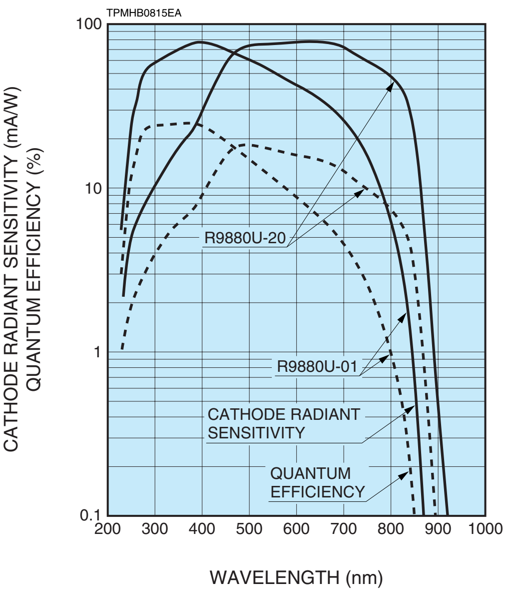
❶ R9880U, -01, -20



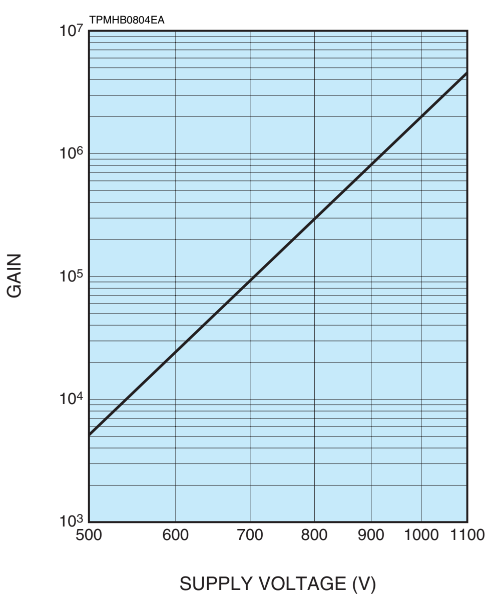
(at 25 °C)

Cathode Characteristics: Luminous Min. (µA/lm)	Cathode Characteristics: Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Ⓚ Radiant Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Min. (A/lm)	Anode Characteristics Ⓜ: Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	Ⓐ Type No.
100	200	—	0.2	77	100	400	1.5 × 10^5	2.0 × 10^6	1	10	0.57	2.7		R9880U-01*
350	500	—	0.45	78	350	1000	1.5 × 10^5	2.0 × 10^6	10	100	0.57	2.7		R9880U-20*

■Spectral Response



■Gain



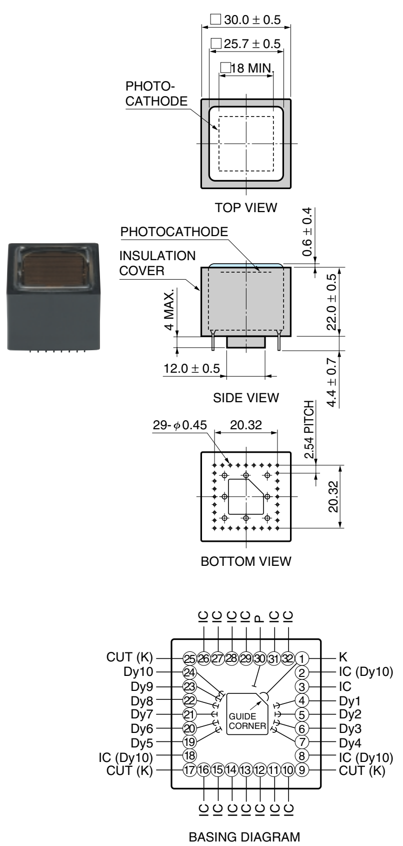
Metal Package Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Peak Wave-length (nm)	(C) Photo-cathode Material	(D) Win-dow Mate-rial	(E) Out-line No.	(F) Dynode Structure / Stages	(G) Socket & Socket Assembly	Max. Ratings (H): Anode to Cathode Voltage (V)	(J) Average Anode Current (mA)	(L) Anode to Cathode Supply Voltage (V)
R7600U	□18	300 to 650	420	BA	K	❶	MC/10	E678-32B (52)	900	0.1	800 (24)
*R7600U-01	□18	300 to 850	400	MA	K	❶	MC/10	E678-32B (52)	900	0.1	800 (24)
*R7600U-20	□18	300 to 920	530	MA	K	❶	MC/10	E678-32B (52)	900	0.1	800 (24)
R7600U-00-M4	□18 (M4 ch)	300 to 650	420	BA	K	❷	MC/10	E678-32B (53)	900	0.1	800 (24)
*R7600U-01-M4	□18 (M4 ch)	300 to 850	400	MA	K	❷	MC/10	E678-32B (53)	900	0.1	800 (24)
*R7600U-20-M4	□18 (M4 ch)	300 to 920	530	MA	K	❷	MC/10	E678-32B (53)	900	0.1	800 (24)
R5900U-00-L16	0.8 × 16 × (L16 ch)	300 to 650	420	BA	K	❸	MC/10	E678-32B (54)	900	0.1	800 (12)
R5900U-01-L16	0.8 × 16 × (L16 ch)	300 to 880	420	MA	K	❸	MC/10	E678-32B (54)	900	0.1	800 (12)
R5900U-20-L16	0.8 × 16 × (L16 ch)	300 to 920	630	MA	K	❸	MC/10	E678-32B (54)	900	0.1	800 (12)

Multianode photomultiplier tubes R7600-00-M16 and R7600-00-M64 are listed in the group of photomultiplier tube assemblies on page 78.

Dimensional Outlines (Unit: mm)

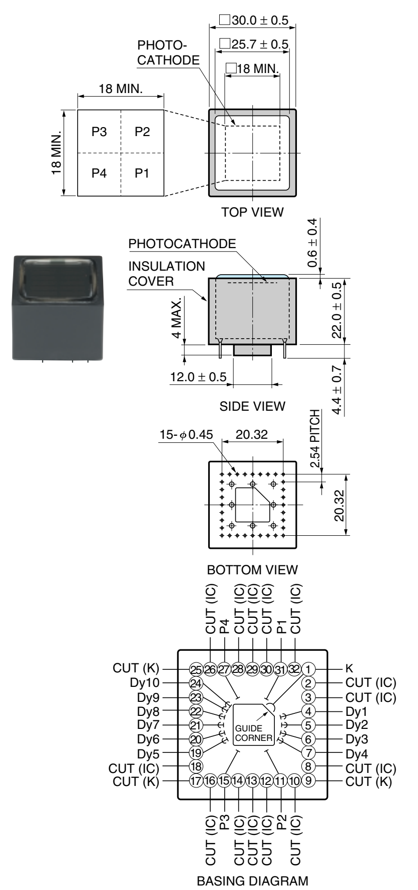
❶ R7600U, R7600U-01, R7600U-20



K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Do not Use)

TPMHA0278EI

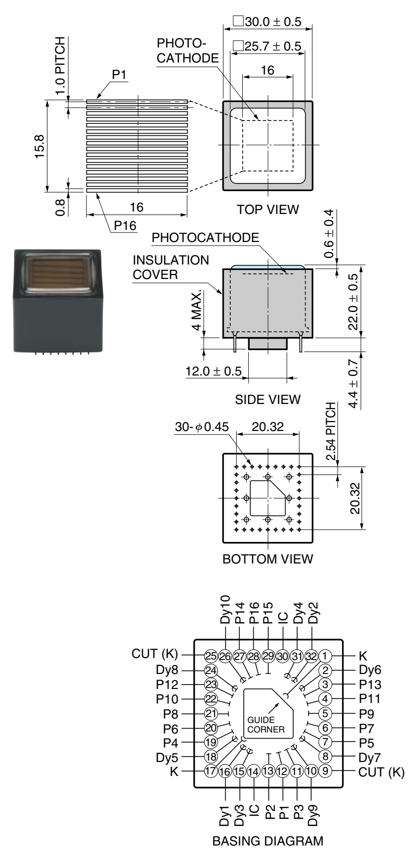
❷ R7600U-00-M4, R7600U-01-M4, R7600U-20-M4



K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Do not Use)

TPMHA0297EI

❸ R5900U-00-L16, R5900U-01-L16, R5900U-20-L16



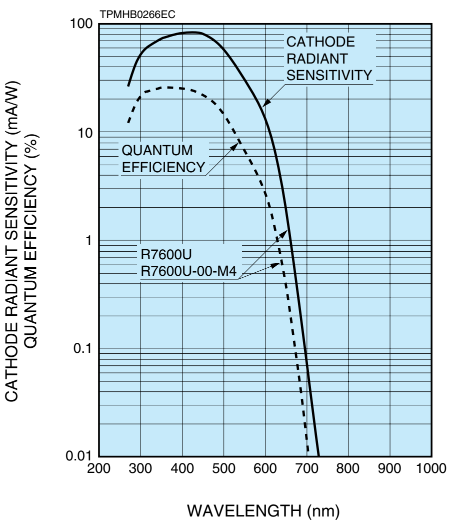
K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Do not Use)

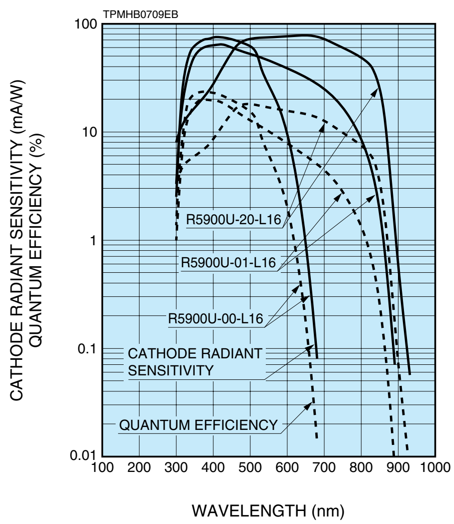
TPMHA0298EG

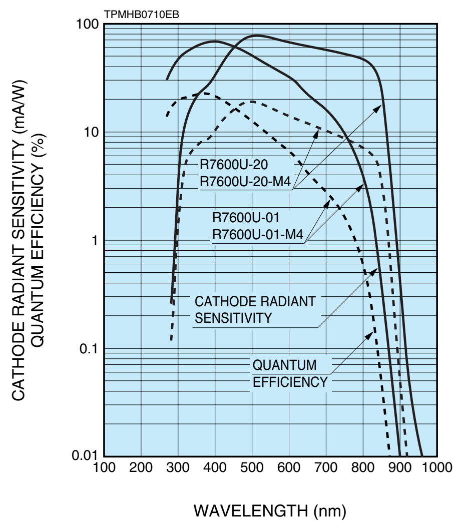
(at 25 °C)

Cathode Characteristics: Luminous Min. (µA/lm)	Cathode: Luminous Typ. (µA/lm)	Cathode: Blue Sensitivity Index (CS 5-58) Typ.	Cathode: Red / White Ratio (R-68) Typ.	Cathode: Radiant (K) Typ. (mA/W)	Anode Characteristics (M): Luminous Min. (A/lm)	Anode: Luminous Typ. (A/lm)	Anode: Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	(A) Type No.
60	80	9.5	—	80	40	160	1.4×10^5	2.0×10^6	2	20	1.4	9.6	UV glass window: R7600U-03 For photon counting: R7600P	R7600U
150	200	—	0.2	65	50	200	7.0×10^4	1.0×10^6	10	50	1.4	9.6	UV glass window: R7600U-04	R7600U-01*
350	500	—	0.4	78	100	500	6.5×10^4	1.0×10^6	20	50	1.4	9.6		R7600U-20*
60	80	9.5	—	80	25	140	1.4×10^5	1.8×10^6	0.5/ch	5/ch	1.2	9.5	UV glass window: R7600U-03-M4	R7600U-00-M4
150	200	—	0.2	65	50	200	7.0×10^4	1.0×10^6	2.5/ch	12.5/ch	1.2	9.5	UV glass window: R7600U-04-M4	R7600U-01-M4*
350	500	—	0.4	78	100	500	6.5×10^4	1.0×10^6	2.5/ch	12.5/ch	1.2	9.5		R7600U-20-M4*
50	70	8.5	—	72	50	280	2.9×10^5	4.0×10^6	0.2/ch	2/ch	0.6	7.4	UV glass window: R5900U-03-L16 Silica glass window: R5900U-06-L16	R5900U-00-L16
150	250	—	0.3	65	75	250	6.5×10^4	1.0×10^6	0.5/ch	5/ch	0.6	7.4	UV glass window: R5900U-04-L16 Silica glass window: R5900U-07-L16	R5900U-01-L16
350	500	—	0.45	78	175	500	7.8×10^4	1.0×10^6	1/ch	10/ch	0.6	7.4		R5900U-20-L16

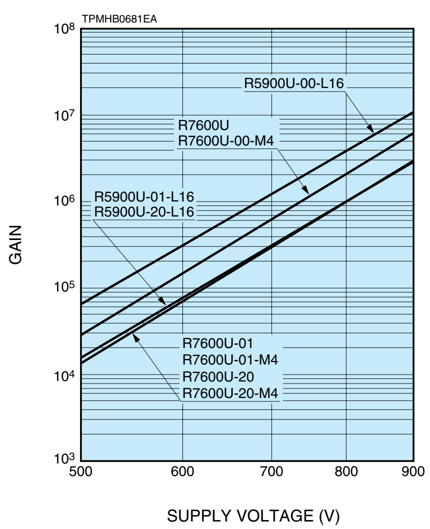
■Spectral Response







■Gain

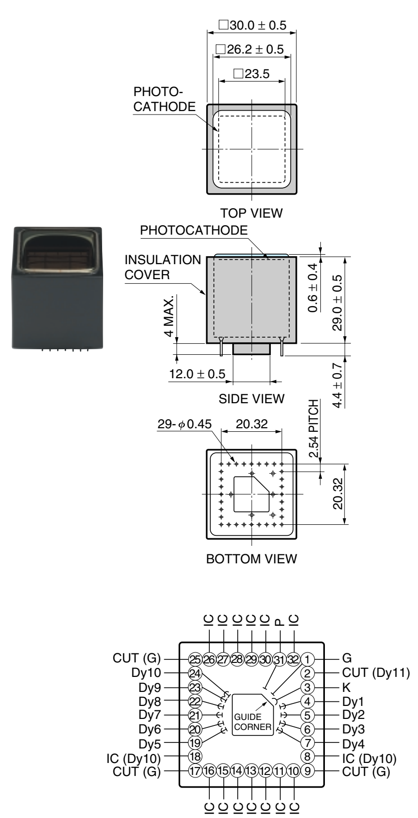


Metal Package Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Peak Wave-length (nm)	Photo-cathode Material (C)	Win-dow Mate-rial (D)	Out-line No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings (H): Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
R8900U	□23.5	300 to 650	420	BA	K	1	MC/10	E678-32B (55)	900	0.1	800 (25)
R8900U-00-M4	□23.5 (M4 ch)	300 to 650	420	BA	K	2	MC/10	E678-32B	900	0.1	800 (25)
R8900-00-M16	□23.5 (M16 ch)	300 to 650	420	BA	K	3	MC/12	— (56)	1000	0.1	800 (35)
R8900U-00-C12	□23.5	300 to 650	420	BA	K	4	MC/11	E678-32B (57)	1000	0.1	800 (27)

Dimensional Outlines (Unit: mm)

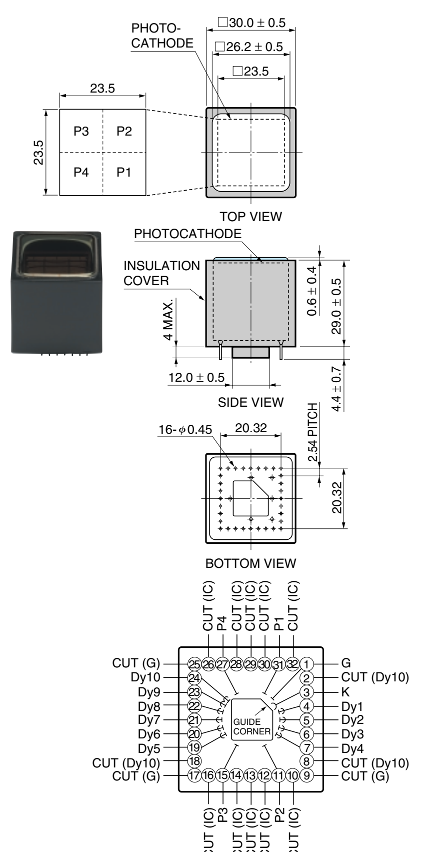
1 R8900U



G : Grid
K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Do not Use)

TPMHA0529EA

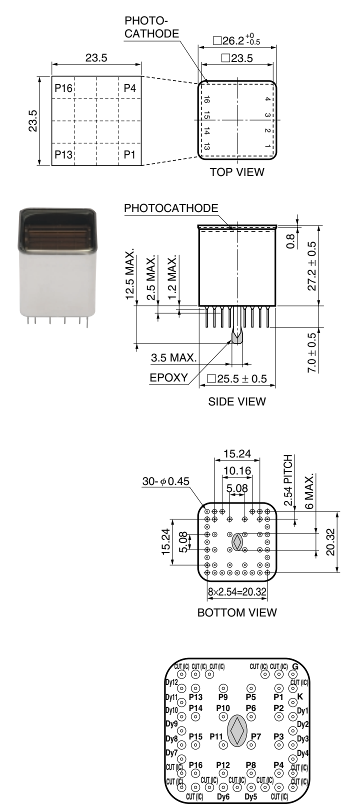
2 R8900U-00-M4



G : Grid
K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Do not Use)

TPMHA0530EA

3 R8900-00-M16



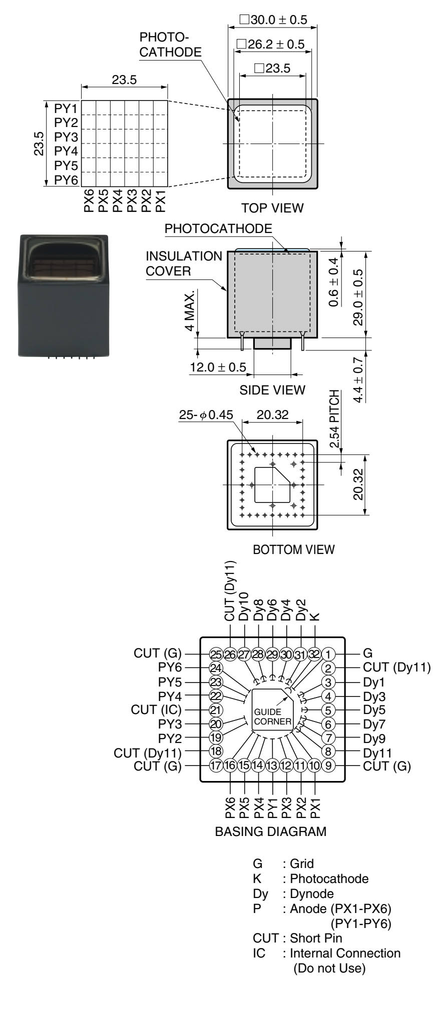
G : Grid
K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Don't Use)

Precautions must be taken to avoid electrical shock during use because the metal package is connected to the cathode.

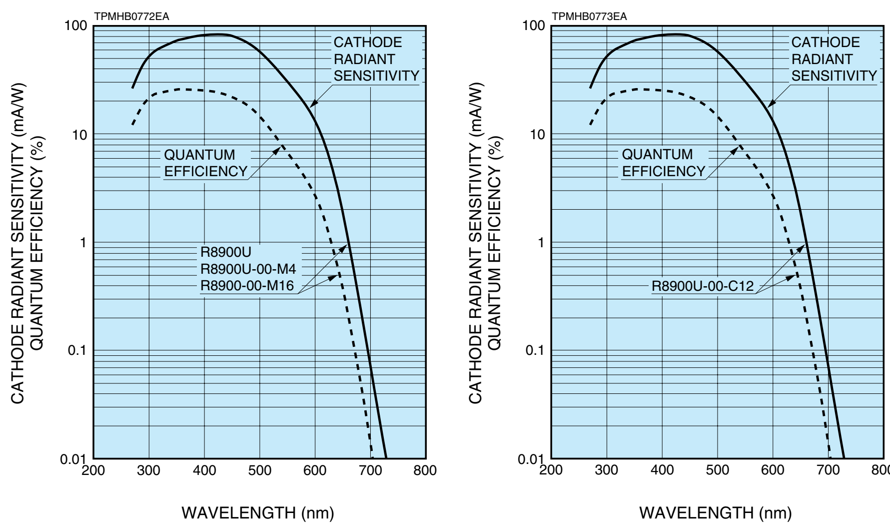
TPMHA0531EC

Cathode Characteristics					Anode Characteristics									(at 25 °C)
Luminous		Blue Sensitivity Index (CS 5-58)	Red / White Ratio (R-68)	Radiant	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Type No.
Min. (µA/lm)	Typ. (µA/lm)	Typ.	Typ.	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
60	80	9.5	—	80	20	80	7.2×10^4	1.0×10^6	2	20	1.8	12.4		R8900U
60	80	9.5	—	80	20	80	7.2×10^4	1.0×10^6	1/ch	5/ch	1.4	11.4		R8900U-00-M4
60	80	9.5	—	80	20	80	7.2×10^4	1.0×10^6	0.8/ch	4/ch	1.3	13		R8900-00-M16
50	85	10.0	—	82	15	60	7.4×10^4	0.7×10^6	2	10	2.2	11.9		R8900U-00-C12

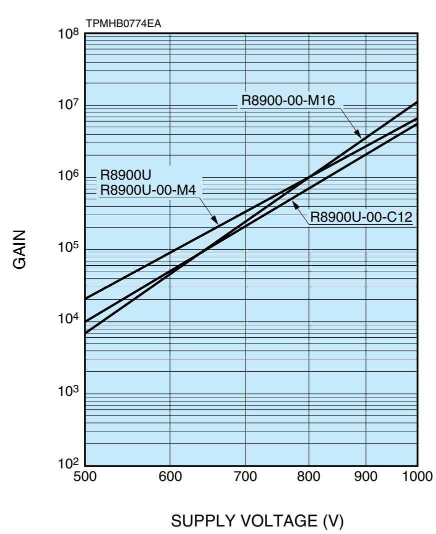
❹ R8900U-00-C12



■Spectral Response



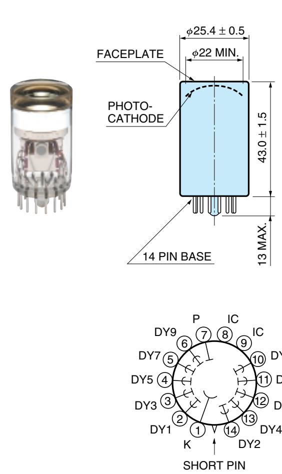
■Gain



Ⓐ Type No.	Spectral Response: Effective Area (mm) / ← Wavelength (nm) → (100 200 300 400 500 600 700 800 900 1000 1100 1200)	Spectral Response Range (nm)	Ⓑ Curve Code	QE Peak Wave-length (nm)	Ⓒ Photo-cathode Material	Ⓓ Win-dow Mate-rial	Ⓔ Out-line No.	Ⓕ Dynode Structure / Stages	Ⓖ Socket & Socket Assembly	Max. Ratings Ⓗ: Anode to Cathode Voltage (V)	Ⓙ Average Anode Current (mA)	Ⓛ Anode to Cathode Supply Voltage (V)
Head-on Types												
*R1924A-100	φ22	300 to 650	440K	350	SBA	K	❶	C+L/10	E678-14C* ㉑㉒㉓	1250	0.1	1000 ⑰
*R3998-100-02	φ25	300 to 650	440K	350	SBA	K	❷	B+L/9	E678-14C* ㉛	1500	0.1	1000 ⑩
*R9420-100	φ34	300 to 650	440K	350	SBA	K	❸	L/8	E678-12A*	1500	0.1	1300 ⑧
*R6231-100	φ46	300 to 650	440K	350	SBA	K	❹	B+L/8	E678-14W ㉞㉟	1500	0.1	1000 ⑦
*R6233-100	φ70	300 to 650	440K	350	SBA	K	❺	B+L/8	E678-14W ㉞㉟	1500	0.1	1000 ⑦
*R877-100	φ111	300 to 650	440K	350	SBA	K	❻	B/10	E678-14W ㊵㊶	1500	0.1	1250 ⑬

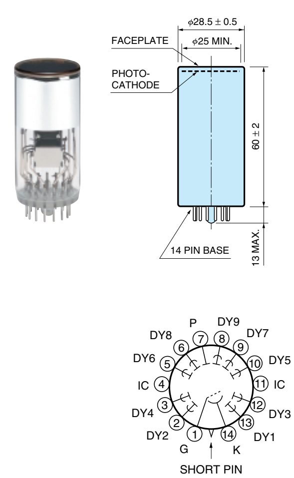
Dimensional Outlines (Unit: mm)

❶ R1924A-100



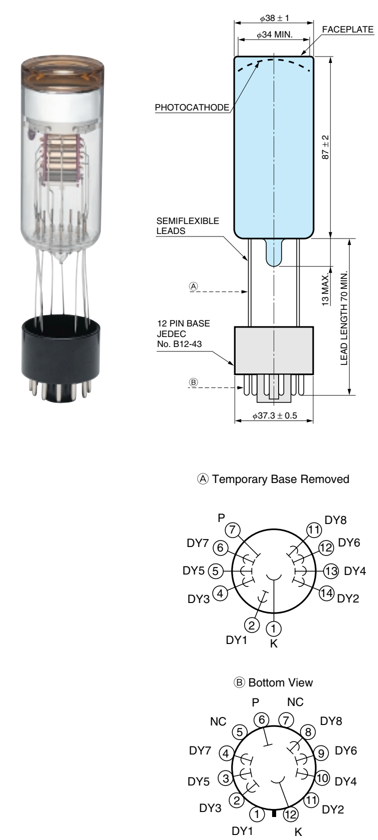
TPMHA0040EC

❷ R3998-100-02



TPMHA0114EA

❸ R9420-100



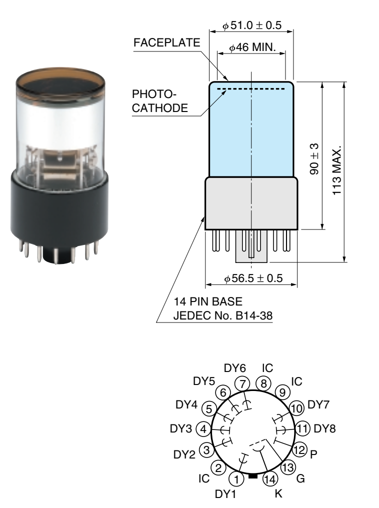
TPMHA0519EC

(at 25 °C)

Cathode Characteristics					Anode Characteristics Ⓜ									
Luminous		Blue Sensitivity Index (CS 5-58)	Quantum Efficiency	Ⓚ Radiant	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Ⓐ Type No.
Min. (µA/lm)	Typ. (µA/lm)	Typ.	Typ. (%)	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
100	130	13.5	35	110	50	260	2.2×10^5	2.0×10^6	5	25	1.5	17		R1924A-100*
100	135	13.5	35	110	50	130	1.1×10^5	1.0×10^6	5	25	3.4	23		R3998-100-02*
100	135	13.5	35	110	5	48	5.5×10^4	3.7×10^5	10	100	1.6	17		R9420-100*
110	135	13.5	35	110	3	30	2.5×10^4	2.3×10^5	10	30	8.5	48		R6231-100*
110	135	13.5	35	110	3	30	2.5×10^4	2.3×10^5	10	30	9.5	52		R6233-100*
90	105	13.5	35	110	20	40	4.2×10^4	3.8×10^5	20	100	20	115		R877-100*

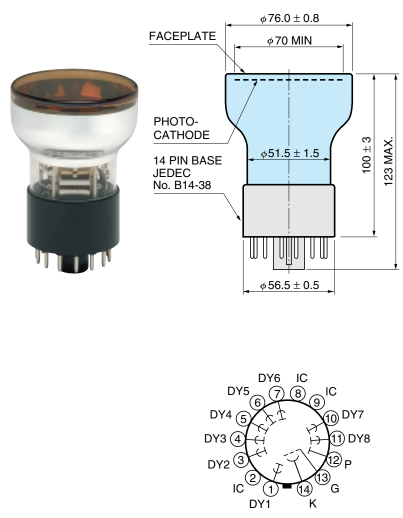
Quantum efficiency is measured at the peak wavelength (350 nm).
Cathode radiant sensitivity is measured at the peak wavelength (400 nm).

❹ R6231-100



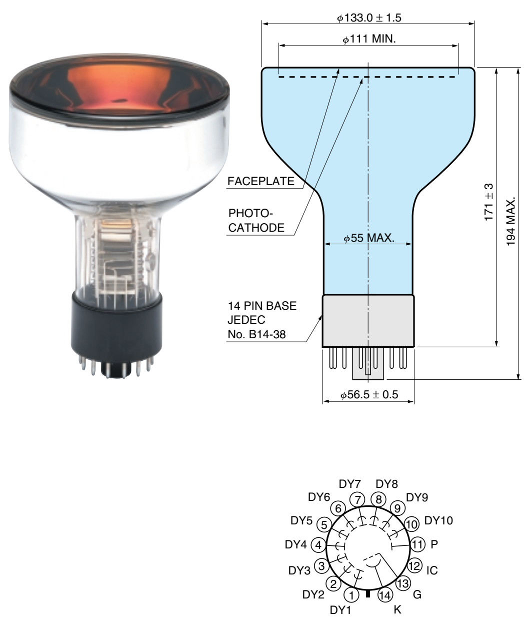
TPMHA0388EB

❺ R6233-100



TPMHA0389EB

❻ R877-100



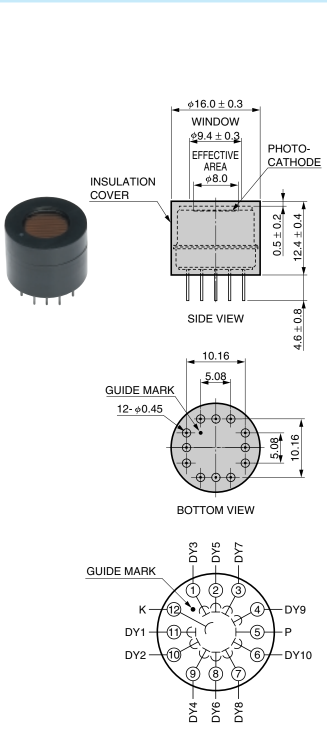
TPMHA0074EC

UBA (Ultra Bialkali), SBA (Super Bialkali) Photomultiplier Tubes

Type No. (A)	Spectral Response: Effective Area (mm)	Spectral Response Range (nm)	(B) Curve Code	QE Peak Wavelength (nm)	(C) Photocathode Material	(D) Window Material	(E) Outline No.	(F) Dynode Structure / Stages	(G) Socket & Socket Assembly	Max. Ratings (H) Anode to Cathode Voltage (V)	(J) Average Anode Current (mA)	(L) Anode to Cathode Supply Voltage (V)
Metal Package Types												
*R9880U-110	φ8	230 to 700	442K	350	SBA	K	❶	MC/10	E678-12-01 (51)	1100	0.1	1000 (11)
*R9880U-210	φ8	230 to 700	443K	350	UBA	K	❶	MC/10	E678-12-01 (51)	1100	0.1	1000 (11)
*R7600U-100	□18	300 to 650	440K	350	SBA	K	❷	MC/10	E678-32B (52)	900	0.1	800 (24)
*R7600U-200	□18	300 to 650	441K	350	UBA	K	❷	MC/10	E678-32B (52)	900	0.1	800 (24)
*R7600U-100-M4	□18 (M4 ch)	300 to 650	440K	350	SBA	K	❸	MC/10	E678-32B (53)	900	0.1	800 (24)
*R7600U-200-M4	□18 (M4 ch)	300 to 650	441K	350	UBA	K	❸	MC/10	E678-32B (53)	900	0.1	800 (24)
*R5900U-100-L16	0.8 x 16 x (L16 ch)	300 to 650	440K	350	SBA	K	❹	MC/10	E678-32B (54)	900	0.1	800 (12)
*R5900U-200-L16	0.8 x 16 x (L16 ch)	300 to 650	441K	350	UBA	K	❹	MC/10	E678-32B (54)	900	0.1	800 (12)
*R8900U-100	□23.5	300 to 650	440K	350	SBA	K	❺	MC/10	E678-32B (55)	900	0.1	800 (25)
*R8900U-100-M4	□23.5 (M4 ch)	300 to 650	440K	350	SBA	K	❻	MC/10	E678-32B	900	0.1	800 (25)
*R8900-100-M16	□23.5 (M16 ch)	300 to 650	440K	350	SBA	K	❼	MC/12	— (56)	1000	0.1	800 (35)
*R8900U-100-C12	□23.5	300 to 650	440K	350	SBA	K	❽	MC/11	E678-32B (57)	1000	0.1	800 (27)
*H8711-100	□18.1 (M16 ch)	300 to 650	440K	350	SBA	K	P83 (20)	MC/12	—	-1000	0.017	-800 (36)
*H8711-200	□18.1 (M16 ch)	300 to 650	441K	350	UBA	K	P83 (20)	MC/12	—	-1000	0.017	-800 (36)
*H7546B-100	□18.1 (M64 ch)	300 to 650	440K	350	SBA	K	P84 (21)	MC/12	—	-1000	0.023	-800 (37)
*H7546B-200	□18.1 (M64 ch)	300 to 650	441K	350	UBA	K	P84 (21)	MC/12	—	-1000	0.023	-800 (37)
*H7260-100	0.8 x 7 x (L32 ch)	300 to 650	440K	350	SBA	K	P84 (22)	MC/10	—	-900	0.1	-800 (12)
*H7260-200	0.8 x 7 x (L32 ch)	300 to 650	441K	350	UBA	K	P84 (22)	MC/10	—	-900	0.1	-800 (12)

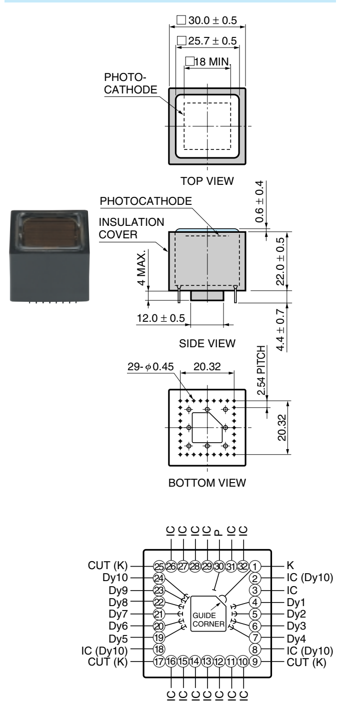
Dimensional Outlines (Unit: mm)

❶ R9880U-110, R9880U-200



TPMHA0539ED

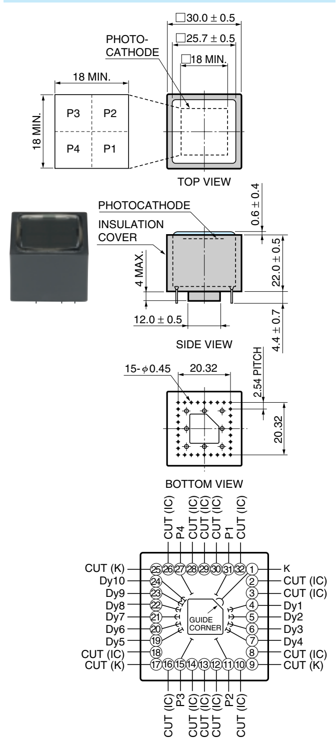
❷ R7600U-100, R7600U-200



K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Do not Use)

TPMHA0278EI

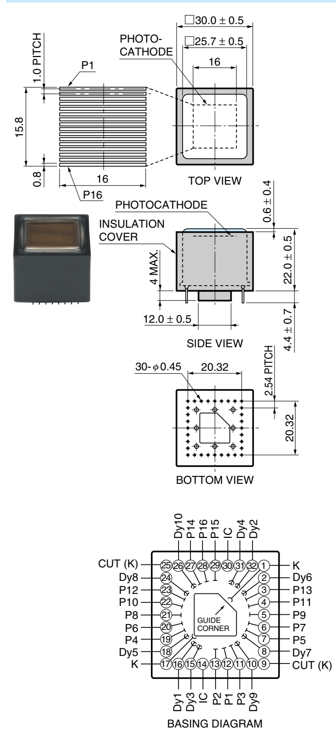
❸ R7600U-100-M4, R7600U-200-M4



K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Do not Use)

TPMHA0297EI

❹ R5900U-100-L16, R5900U-200-L16



K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection (Do not Use)

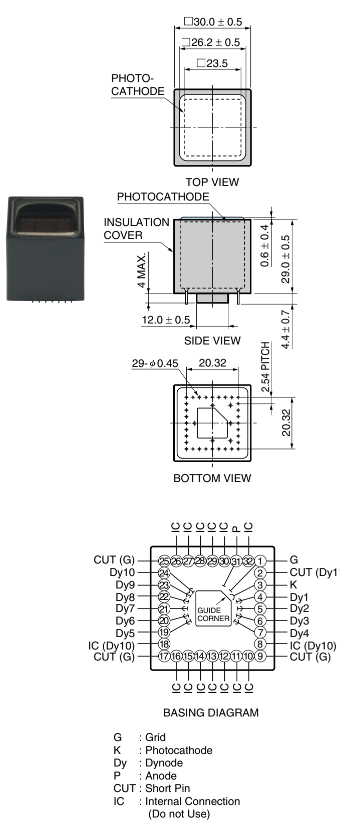
TPMHA0298EG

(at 25 °C)

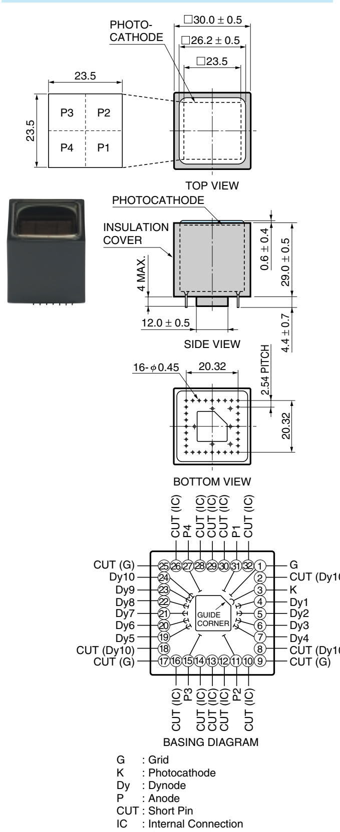
Cathode Characteristics: Luminous Min. (µA/lm)	Luminous Typ. (µA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Quantum Efficiency Typ. (%)	Ⓚ Radiant Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Min. (A/lm)	Luminous Typ. (A/lm)	Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.) Typ. (nA)	Dark Current (After 30 min.) Max. (nA)	Time Response: Rise Time Typ. (ns)	Time Response: Transit Time Typ. (ns)	Notes	Ⓐ Type No.
80	105	13.5	35	110	80	210	2.2×10^5	2.0×10^6	1	10	0.57	2.7		R9880U-110*
100	135	15.5	43	130	100	270	2.6×10^5	2.0×10^6	1	10	0.57	2.7		R9880U-210*
90	105	13.5	35	110	40	105	1.1×10^5	1.0×10^6	2	20	1.6	9.6		R7600U-100*
110	135	15.5	43	130	50	135	1.3×10^5	1.0×10^6	2	20	1.6	9.6		R7600U-200*
90	105	13.5	35	110	25	140	1.4×10^5	1.3×10^6	0.5/ch	5/ch	1.2	9.5		R7600U-100-M4*
110	135	15.5	43	130	25	175	1.7×10^5	1.3×10^6	0.5/ch	5/ch	1.2	9.5		R7600U-200-M4*
90	105	13.5	35	110	90	315	3.3×10^5	3.0×10^6	0.2/ch	2/ch	0.6	7.4		R5900U-100-L16*
110	135	15.5	43	130	110	405	3.9×10^5	3.0×10^6	0.2/ch	2/ch	0.6	7.4		R5900U-200-L16*
90	105	13.5	35	110	45	105	1.1×10^5	1.0×10^6	2	20	1.8	12.4		R8900U-100*
90	105	13.5	35	110	—	105	1.1×10^5	1.0×10^6	1/ch	5/ch	1.4	11.4		R8900U-100-M4*
90	105	13.5	35	110	—	105	1.1×10^5	1.0×10^6	0.8/ch	8/ch	1.3	13		R8900-100-M16*
90	105	13.5	35	110	20	70	6.5×10^4	6.7×10^5	2	20	2.2	11.9		R8900U-100-C12*
90	105	13.5	35	110	50	210	2.2×10^5	2.0×10^6	0.8/ch	4/ch	0.83	12		H8711-100*
110	135	15.5	43	130	50	270	2.6×10^5	2.0×10^6	0.8/ch	4/ch	0.83	12		H8711-200*
90	105	13.5	35	110	8	30	3.3×10^4	3.0×10^5	0.2/ch	2/ch	1.0	12		H7546B-100*
110	135	15.5	43	130	8	40	3.9×10^4	3.0×10^5	0.2/ch	2/ch	1.0	12		H7546B-200*
90	105	13.5	35	110	90	210	2.2×10^5	2.0×10^6	0.2/ch	2/ch	0.6	6.8		H7260-100*
110	135	15.5	43	130	110	270	2.6×10^5	2.0×10^6	0.2/ch	2/ch	0.6	6.8		H7260-200*

Quantum efficiency is measured at the peak sensitivity wavelength (350 nm). Cathode radiant sensitivity is measured at the peak sensitivity wavelength (400 nm).

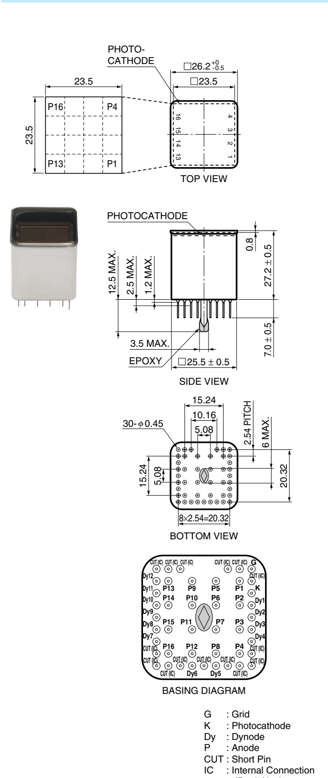
❺ R8900U-100



❻ R8900U-100-M4



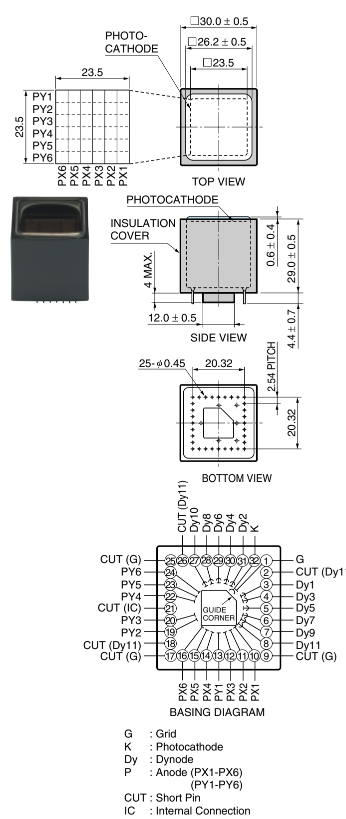
❼ R8900-100-M16



Precautions must be taken to avoid electrical shock during use because the metal package is connected to the cathode.

TPMHA0531EC

❽ R8900U-100-C12

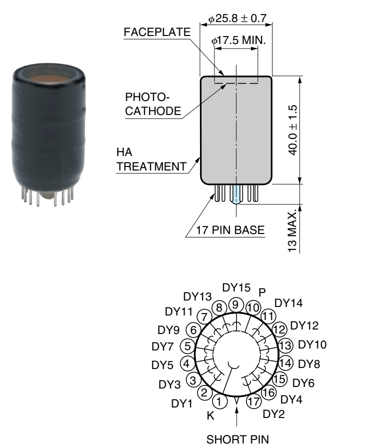


Photomultiplier Tubes for High Magnetic Environments

Type No. (A)	Tube Diameter mm (inch)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	Dynode Structure / Stages (F)	Socket & Socket Assembly (G)	Max. Ratings (H): Anode to Cathode Voltage (V)	Max. Ratings (H): Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
R5505-70	25 (1)	φ17.5	300 to 650	420	BA	K	❶	FM / 15	E678-17A* 58	+2300	0.01	+2000 39
R7761-70	38 (1-1/2)	φ27	300 to 650	420	BA	K	❷	FM / 19	—	+2300	0.01	+2000 40
R5924-70	51 (2)	φ39	300 to 650	420	BA	K	❸	FM / 19	—	+2300	0.1	+2000 40

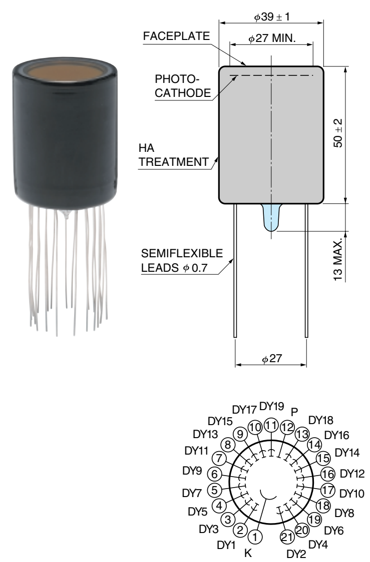
Dimensional Outlines (Unit: mm)

❶ R5505-70



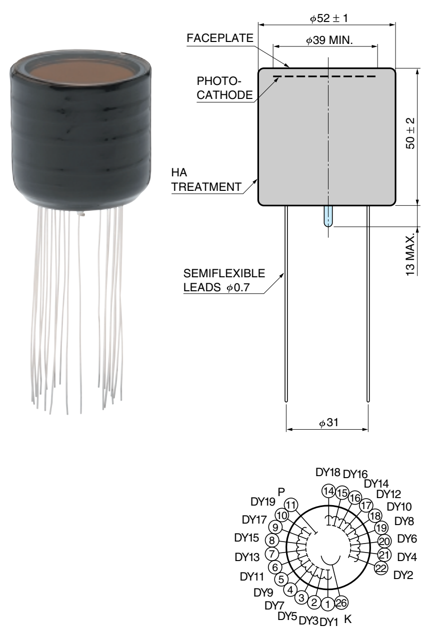
TPMHA0236EA

❷ R7761-70



TPMHA0469EB

❸ R5924-70

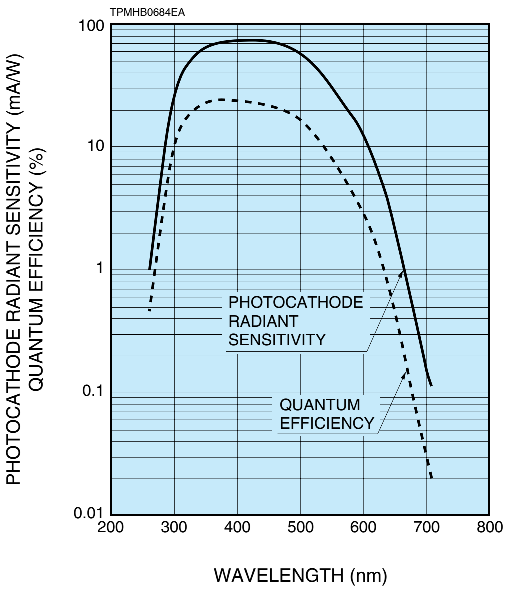


TPMHA0490EA

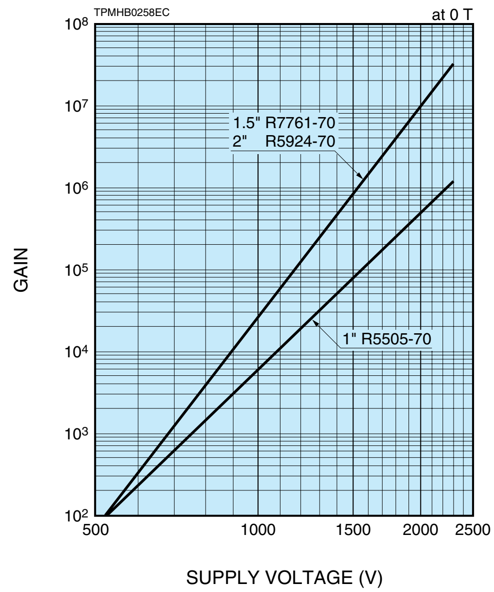
(at 25 °C)

Cathode Characteristics: Luminous Typ. (µA/lm)	Cathode: Blue Sensitivity Index (CS 5-58) Typ.	Cathode: Radiant Ⓚ Typ. (mA/W)	Anode Characteristics Ⓜ: Luminous Typ. (A/lm)	Anode: Gain at 0 T Typ.	Anode: Gain at 0.5 T Typ.	Anode: Gain at 1.0 T Typ.	Anode: Dark Current (After 30 min.) Typ. (nA)	Anode: Dark Current (After 30 min.) Max. (nA)	Anode: Time Response Rise Time Typ. (ns)	Anode: Time Response Transit Time Typ. (ns)	Notes	Ⓐ Type No.
80	9.5	76	40	5.0×10^5	2.3×10^5	1.8×10^4	5	30	1.5	5.6	(For +HV operation) Assembly type: H6152-70 Recommended	R5505-70
80	9.5	76	800	1.0×10^7	3.0×10^6	1.5×10^5	15	100	2.1	7.5	(For +HV operation) Assembly type: H8409-70 Recommended	R7761-70
70	9.0	72	700	1.0×10^7	4.1×10^6	2.5×10^5	30	200	2.5	9.5	(For +HV operation) Assembly type: H6614-70 Recommended	R5924-70

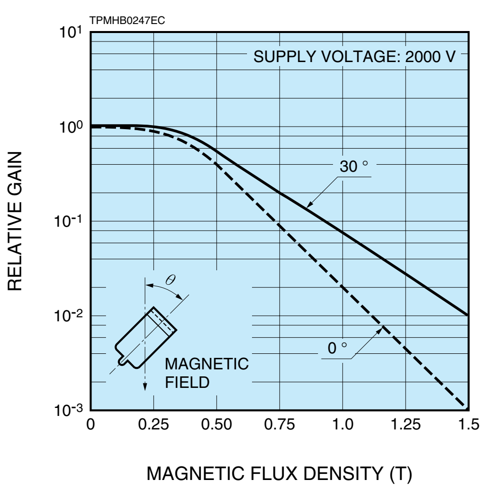
■Spectral Response



■Gain



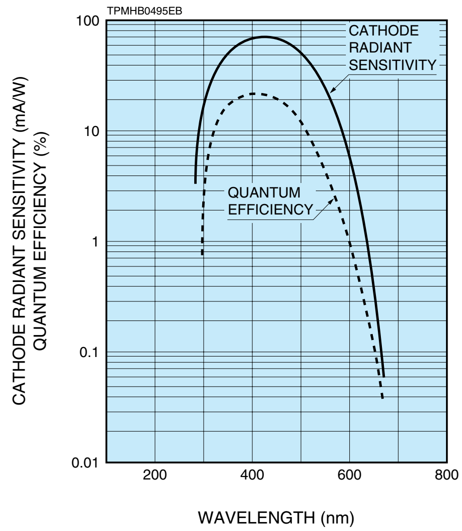
■R5924-70 Relative Gain in Magnetic Fields



Position Sensitive Type Photomultiplier Tubes

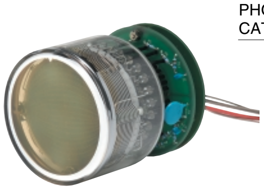
Type No. (A)	Spectral Response: Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Peak Wave-length (nm)	Photo-cathode Material (C)	Win-dow Mate-rial (D)	Remarks: Anode Matrixes	Out-line No. (E)	Dynode Structure / Stages (F)	Max. Ratings (H): Anode to Cathode Voltage (V)	Average Anode Current (mA) (J)	Anode to Cathode Supply Voltage (V) (L)
R2486-02	φ50	300 to 650	420	BA	K	16(X) + 16(Y)	1	CM / 12	-1300	0.015	-1250 (34)
R3292-02	φ100	300 to 650	420	BA	K	28(X) + 28(Y)	2	CM / 12	-1300	0.015	-1250 (34)

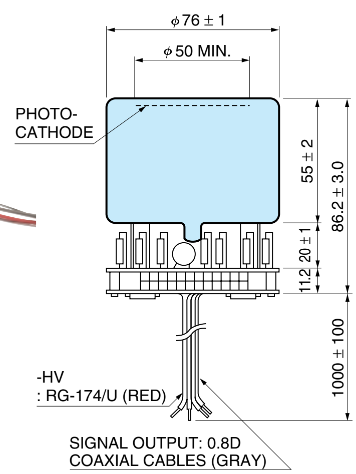
■Spectral Response

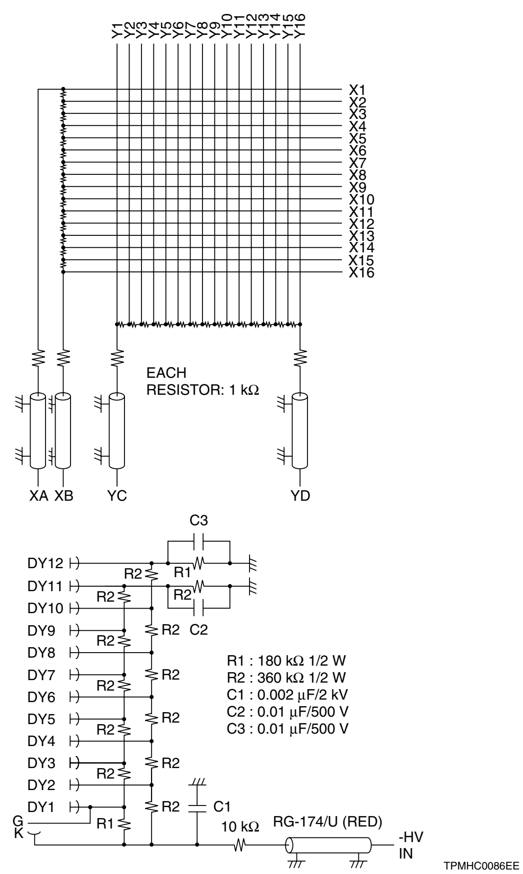


Dimensional Outlines (Unit: mm)

1 R2486-02

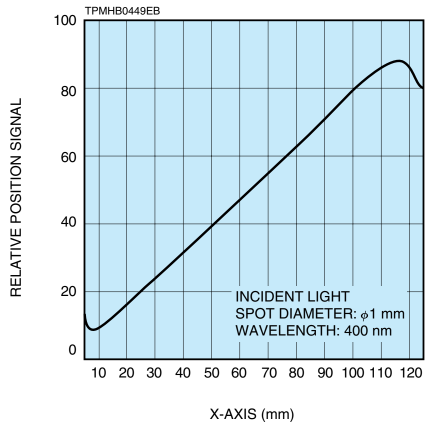


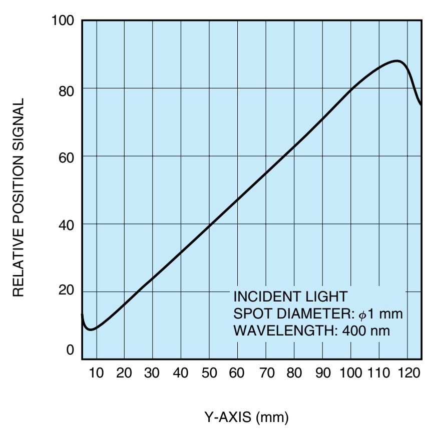




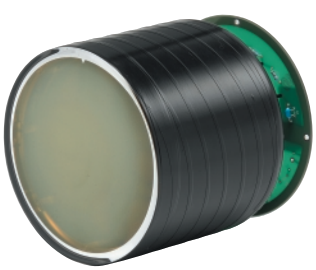
Cathode Characteristics					Anode Characteristics Ⓜ									(at 25 °C)
Luminous		Blue Sensitivity Index (CS 5-58)	Red / White Ratio (R-68)	Ⓚ Radiant	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Ⓐ Type No.
Min. (µA/lm)	Typ. (µA/lm)	Typ.	Typ.	Typ. (mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
50	80	9.0	—	72	5.0	40	3.6×10^4	5.0×10^5	20	50	5.5	17		R2486-02
50	80	9.0	—	72	5.0	10	9.4×10^3	1.3×10^5	40	150	6.0	20		R3292-02

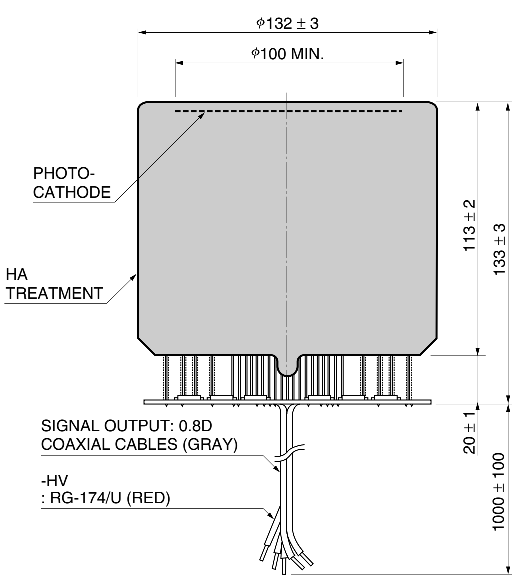
R3292-02 Position Signal Linearity

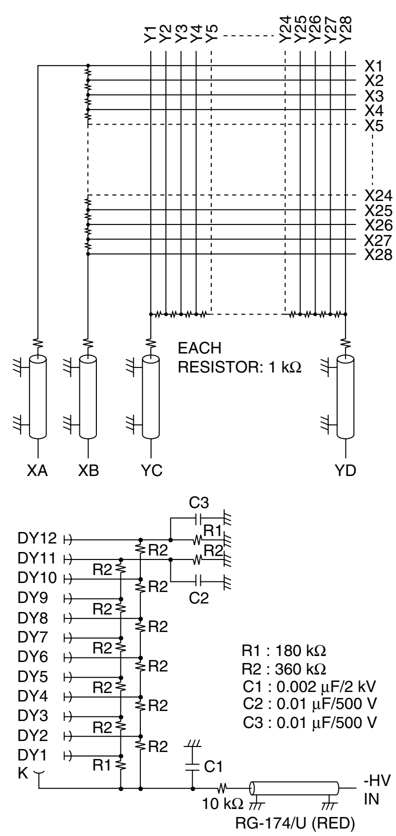




❷ R3292-02







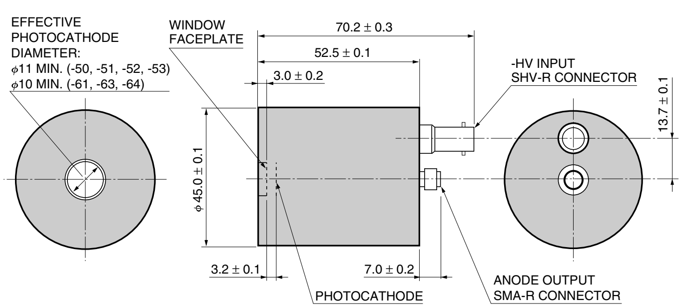
TPMHA0162EF TPMHC0088EE

Type No. (A)	Effective Area (mm) / Wavelength (nm) 100–1200	Spectral Response Range (nm)	Curve Code (B)	Peak Wavelength (nm)	Photocathode Material (C)	Window Material (D)	Outline No. (E)	No. of MCP Stage	-HV Input Terminals	Signal Output Terminals	Max. Ratings (H): Anode to Cathode Voltage (V)	Anode Current: Continuous (nA)	Anode Current: Pulsed Peak (mA)
Standard Types													
R3809U-50	φ11	160 to 850	500S	430	MA	Q	❶	2	SHV-R	SMA-R	-3400	100	350
R3809U-51	φ11	160 to 910	501S	600	EMA	Q	❶	2	SHV-R	SMA-R	-3400	100	350
R3809U-52	φ11	160 to 650	403K	400	BA	Q	❶	2	SHV-R	SMA-R	-3400	100	350
*R3809U-53	φ11	160 to 320	200S	230-250	Cs-Te	Q	❶	2	SHV-R	SMA-R	-3400	100	350
*R3809U-61	φ10	370 to 920	602K	700-850	GaAs	K	❶	2	SHV-R	SMA-R	-3400	100	350
*R3809U-63	φ10	280 to 820	601K	550-650	Extended Red GaAsP	K	❶	2	SHV-R	SMA-R	-3400	100	350
*R3809U-64	φ10	280 to 720	600K	550-650	GaAsP	K	❶	2	SHV-R	SMA-R	-3400	100	350
Gated Types													
R5916U-50	φ10	160 to 850	500S	430	MA	Q	❷	2	SHV-R	SMA-R	-3400	100	350
R5916U-51	φ10	160 to 910	501S	600	EMA	Q	❷	2	SHV-R	SMA-R	-3400	100	350
R5916U-52	φ10	160 to 650	403K	400	BA	Q	❷	2	SHV-R	SMA-R	-3400	100	350
*R5916U-53	φ10	160 to 320	200S	230-250	Cs-Te	Q	❷	2	SHV-R	SMA-R	-3400	100	350

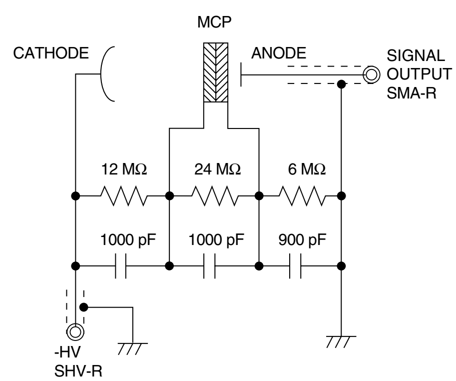
The R5916 series can be gated by input of a +10 V to +50 V gate signal. Standard types are normally OFF, but normally ON types are also available.
Gate operation is 5 ns, though this depends on the gate signal input pulse.
Consult us regarding the R5916U series with a GaAs or GaAsP photocathode.

Dimensional Outlines (Unit: mm)

❶ R3809U Series



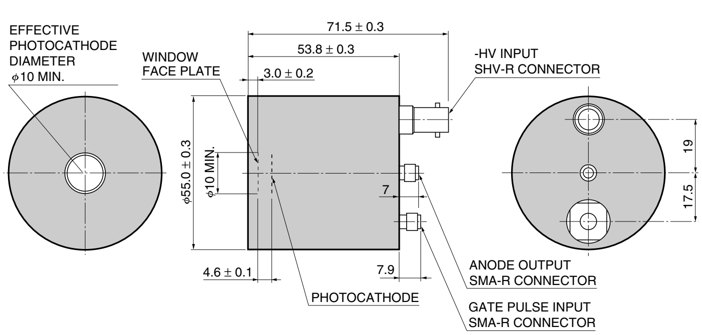
TPMHA0352EB



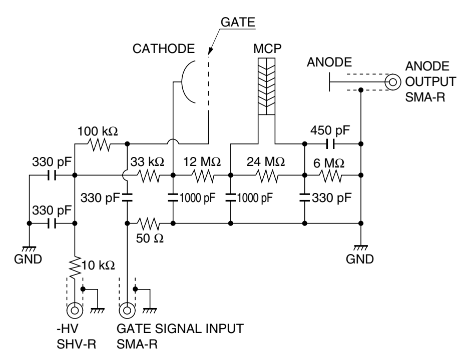
* Actual resistor values may slightly differ from the above.

TPMHC0089EC

❷ R5916U Series



TPMHA0348EC

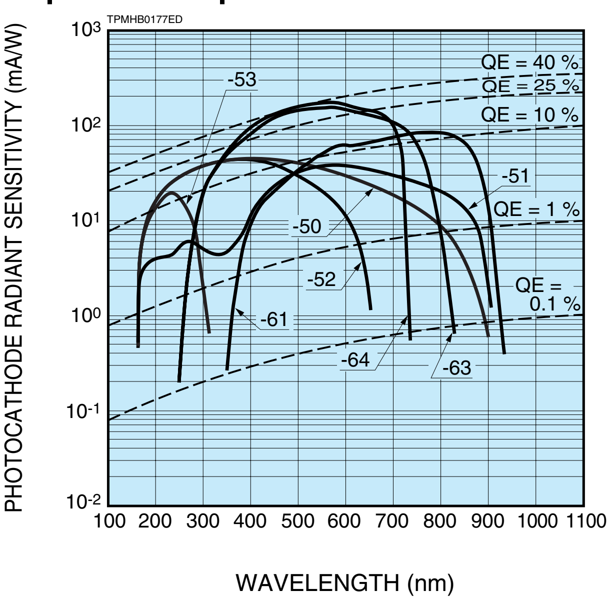


* Actual resistor values may slightly differ from the above.

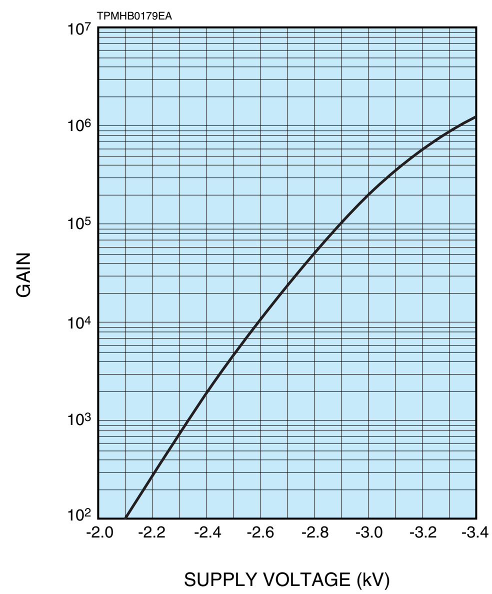
TPMHC0090ED

	Cathode Characteristics			Anode Characteristics Ⓜ							(at 25 °C)
Anode to Cathode Supply Voltage (V)	Luminous Min. (µA/lm)	Luminous Typ. (µA/lm)	Ⓚ Radiant Typ. (mA/W)	Luminous Typ. (A/lm)	Gain Typ.	Dark Current (After 30 min.) Max. (nA)	Time Response Rise Time Typ. (ns)	Time Response Transit Time Typ. (ns)	Time Response Transit Time Spread Typ. (ns)	Notes	Ⓐ Type No.
-3000	100	150	70	30	2.0×10^5	10	0.15	0.55	0.025		R3809U-50
-3000	240	350	40	70	2.0×10^5	10	0.15	0.55	0.025		R3809U-51
-3000	20	50	65	10	2.0×10^5	0.5	0.15	0.55	0.025		R3809U-52
-3000	—	—	30	—	2.0×10^5	0.1	0.15	0.55	0.025		R3809U-53*
-3000	400	700	77	140	2.0×10^5	25	0.2	0.55	0.15		R3809U-61*
-3000	450	750	160	150	2.0×10^5	15	0.18	0.55	0.06		R3809U-63*
-3000	400	700	180	140	2.0×10^5	15	0.18	0.55	0.06		R3809U-64*
-3000	100	150	52	30	2.0×10^5	10	0.18	1.0	0.09		R5916U-50
-3000	200	300	36	60	2.0×10^5	10	0.18	1.0	0.09		R5916U-51
-3000	20	45	48	9	2.0×10^5	0.5	0.18	1.0	0.09		R5916U-52
-3000	—	—	30	—	2.0×10^5	0.1	0.18	1.0	0.09		R5916U-53*

■Spectral Response

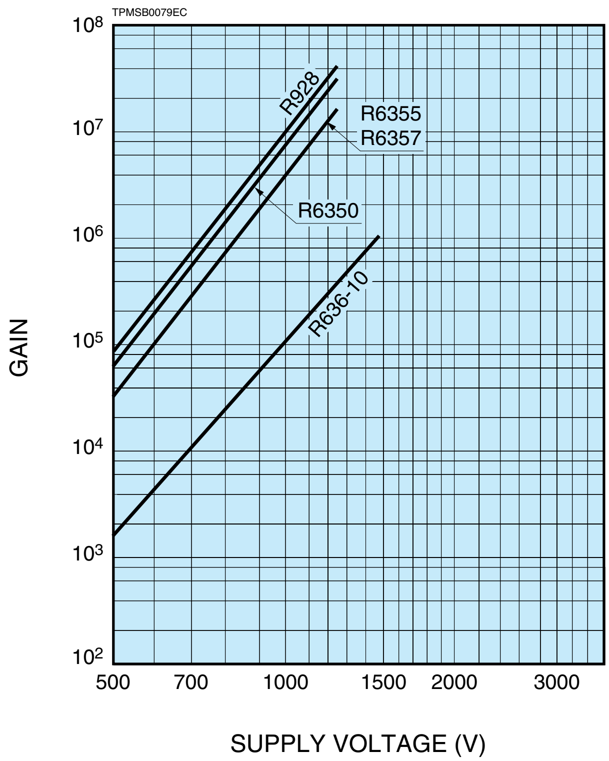


■Gain

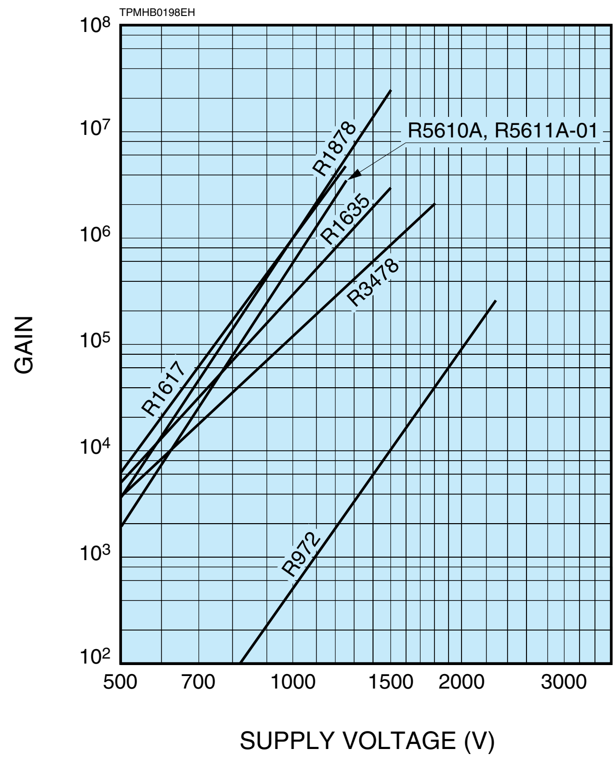


For tubes not listed here, please consult our sales office.

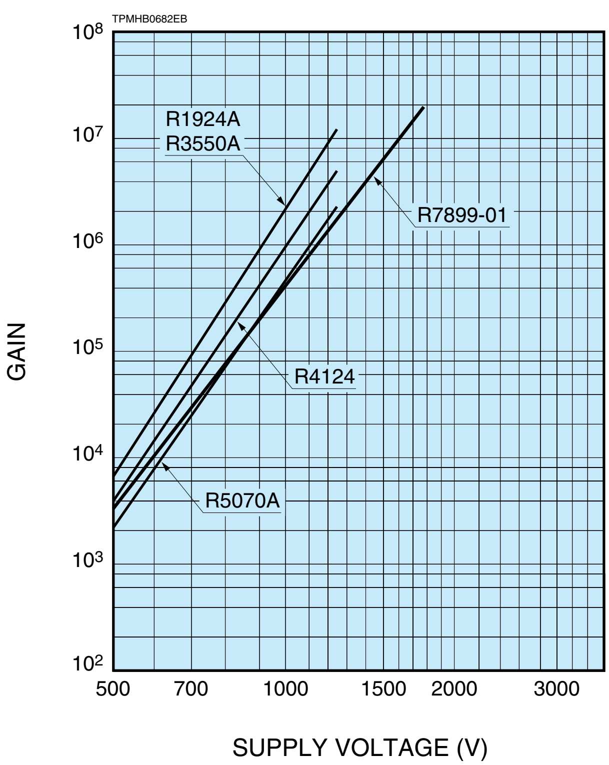
Side-on Types



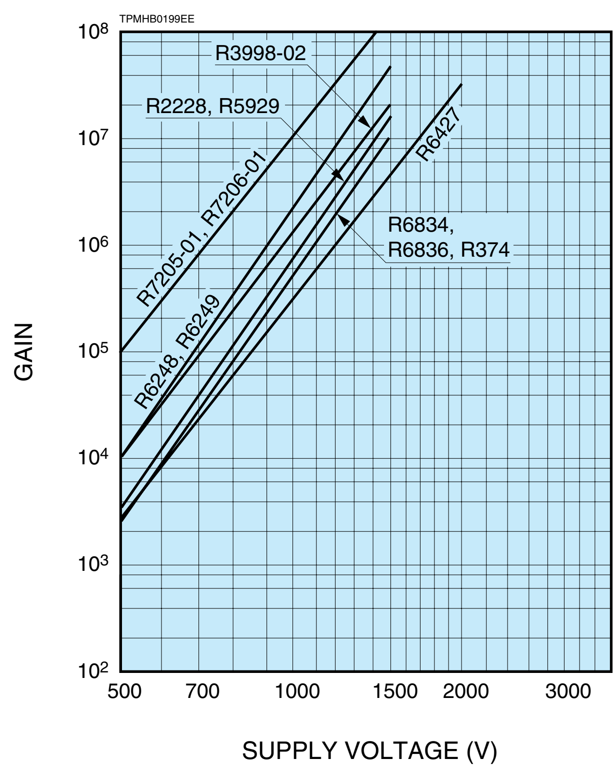
Head-on Types (10 mm and 19 mm Dia.)



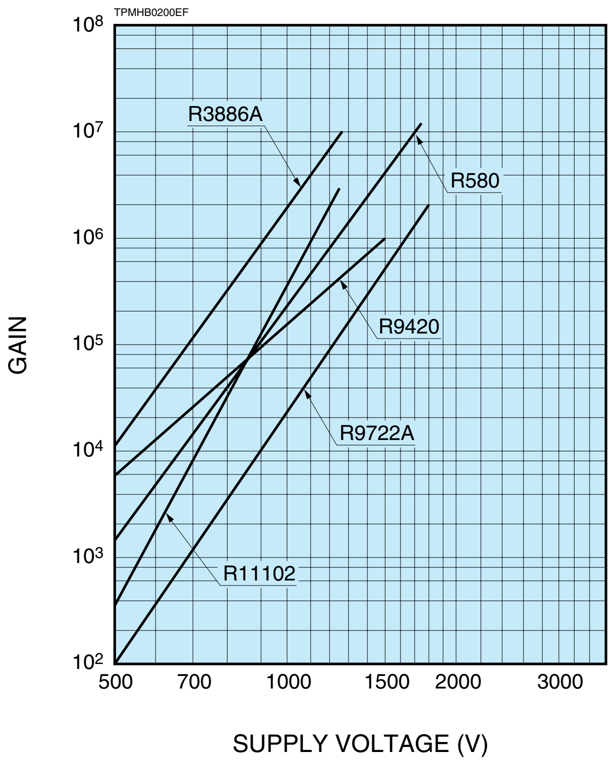
Head-on Types (13 mm and 25 mm Dia.)



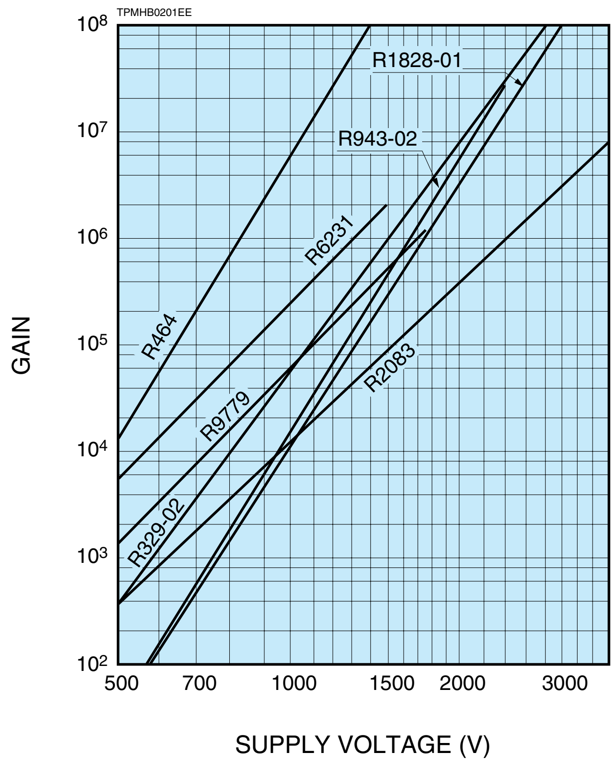
Head-on Types (28 mm Dia.)



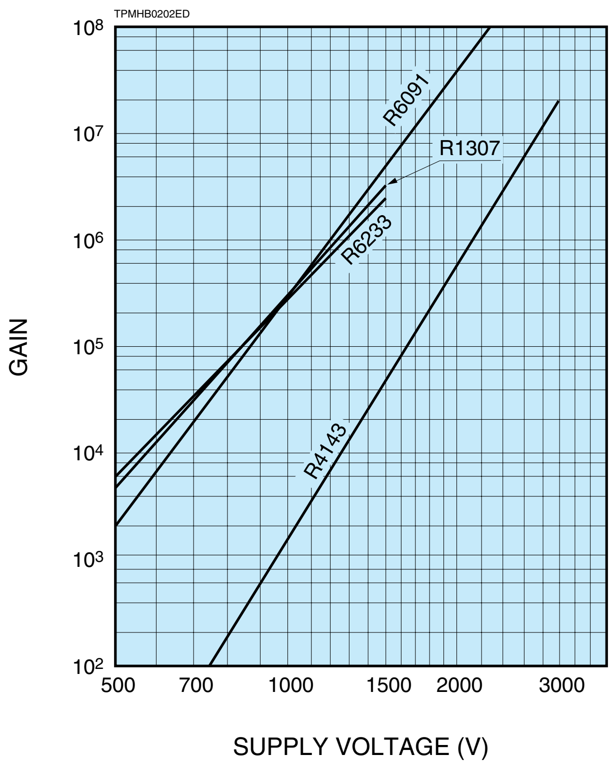
Head-on Types (38 mm Dia.)



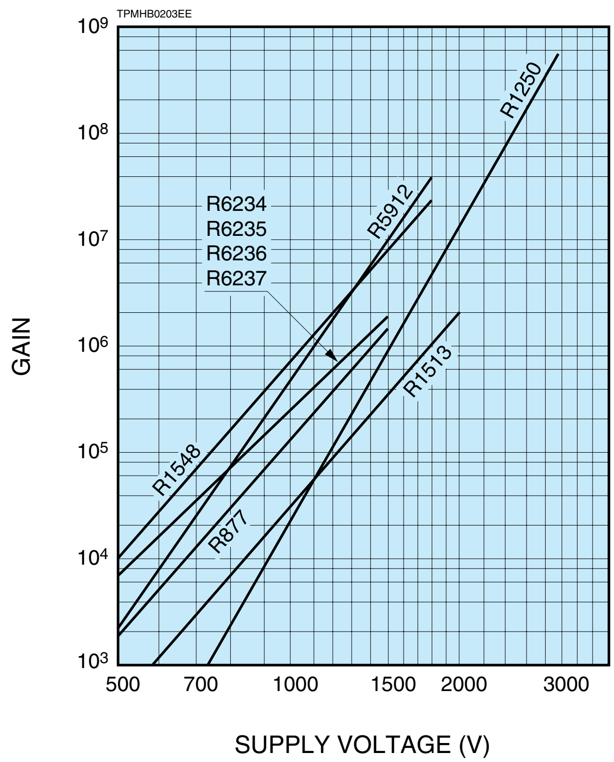
Head-on Types (51 mm Dia.)



Head-on Types (76 mm Dia.)



Head-on Types (127 mm Dia.) and Special Types



Voltage Distribution Ratio

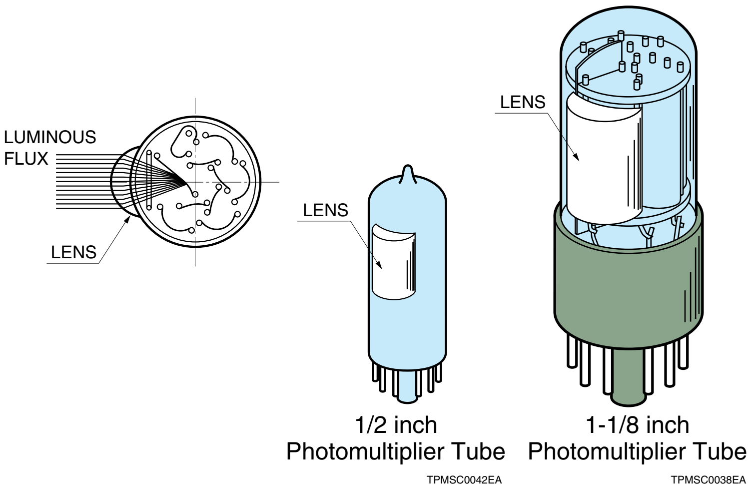
The characteristic values tabulated in the catalog for the individual tube types are measured with the voltage-divider networks having the voltage distribution ratio shown below.

Distribution Ratio Codes	Number of Stage	Voltage Distribution Ratio K: Photocathode Dy: Dynode P: Anode G: Grid F: Focus																	
	8	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Acc	Dy7	Dy8	P						
①		2	—	2	1	1	1	1	1	—	1	1							
②		1	1	1	1	1	1	1	1	—	1	1							
③		1.3	4.8	1.2	1.8	1	1	1	1	0.5	3	2.5							
④		1.3	4.8	1.5	1.5	1	1	1	1	—	1	1							
⑤		3	—	1.5	1.5	1	1	1	1	—	1	1							
⑥		7	—	1	1.5	1	1	1	1	—	1	1							
⑦		2	2	1	1	1	1	1	1	—	1	1							
⑧		4	—	1.5	1.5	1	1	1	1	—	1	1							
	9	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	P						
⑨		1	—	1	1	1	1	1	1	1	1	1							
⑩		3	1	1	1	1	1	1.5	1	1	1	1							
	10	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P					
⑪		1	—	1	1	1	1	1	1	1	1	1	0.5						
⑫		1	—	1	1	1	1	1	1	1	1	1	1						
⑬		1	1	1	1	1	1	1	1	1	1	1	1						
⑭		1.5	—	1	1	1	1	1	1	1	1	1	1						
⑮		2	—	1	1	1	1	1	1	1	1	1	1						
⑯		2	—	1	1.5	1	1	1	1	1	1	1	0.75						
⑰		3	—	1	1	1	1	1	1	1	1	1	1						
⑱		3	—	1	1.5	1	1	1	1	1	1	1	1						
⑲		3	—	1.5	1	1	1	1	1	1	1	1	1						
⑳		4	—	1	1.5	1	1	1	1	1	1	1	1						
㉑		4	—	1	2	1	1	1	1	1	1	2	1						
㉒		1.3	4.8	1.2	1.8	1	1	1	1	1	1.5	3	2.5						
㉓		1.5	—	1.5	1.5	1	1	1	1	1	1	1	0.5						
㉔		1.5	—	1.5	1.5	1	1	1	1	1	1	1	1						
㉕		0.5	1.5	2	1	1	1	1	1	1	1	1	0.5						
	11	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	P				
㉖		1	—	1	1	1	1	1	1	1	1	1	1	1					
㉗		0.5	1.5	2	1	1	1	1	1	1	1	1	1	0.5					
㉘		2	—	1	1	1	1	1	1	1	1	1	1	1					
	12	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	P			
㉙		1.2	2.8	1.2	1.8	1	1	1	1	1	1	1.5	1.5	3	2.5				
㉚		4	0	1	1.4	1	1	1	1	1	1	1	1	1	1	(Note 1)			
㉛		4	0	2.5	1.5	1	1	1	1	1	1	1	1	1	1				
㉜		1	3	1.2	1.8	1	1	1	1	1	1	1.5	1.5	3	2.5				
㉝		4	0	1.2	1.8	1	1	1	1	1	1	1	1	1	1				
㉞		1	—	1	1	1	1	1	1	1	1	1	1	1	1				
㉟		0.6	1.8	2.4	1	1	1	1	1	1	1	1	1	1	1				
㊱		2	—	2	2	1	1	1	1	1	1	1	1	1	1				
㊲		3	—	2	2	1	1	1	1	1	1	1	1	2	5				
	14	K	G1	G2	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	Dy13	Dy14	P
㊳		2.5	7.5	0	1.2	1.8	1	1	1	1	1	1	1	1	1.5	1.5	3	2.5	
	15	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	Dy13	Dy14	Dy15	P	
㊴		2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
	19	K	Dy1	Dy2	Dy3	·	·	·	·	·	·	·	·	·		Dy17	Dy18	Dy19	P
㊵		2	1	1	1	·	·	·	·	·	·	·	·	·	1	1	1	1	

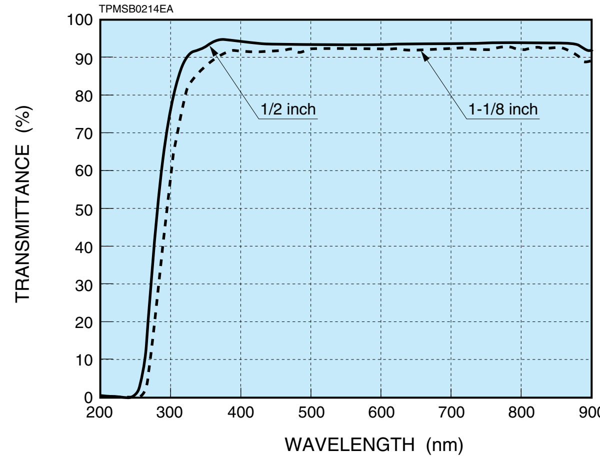
Note 1: The shield pin should be connected to Dy5.

Lens for Side-on Type Photomultiplier Tubes

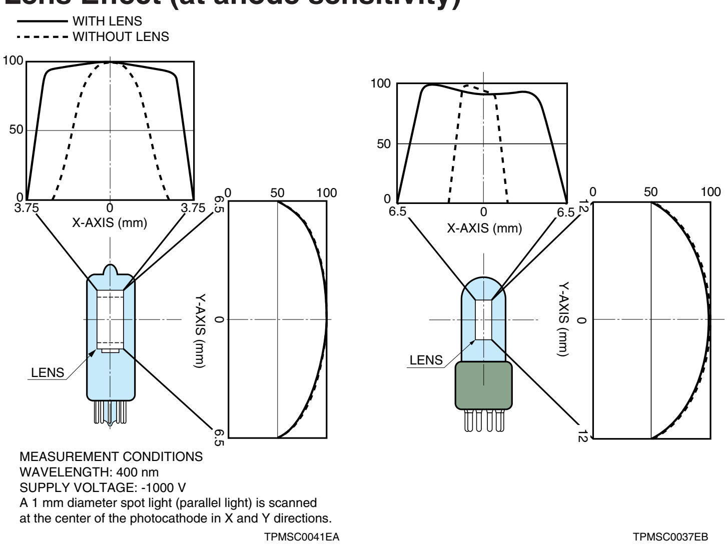
The optimized cylindrical lens which can be attached at the entrance window of 1-1/8 inch side-on photomultiplier tube. This lens helps the incident light reaches the photocathode efficiently.
With these lenses, the effective area widens by the factor of three in case of 1-1/8" PMT (13 mm width) or the factor of two in case of 1/2" PMT (7.5 mm width). The lens transmits above 300 nm light only.



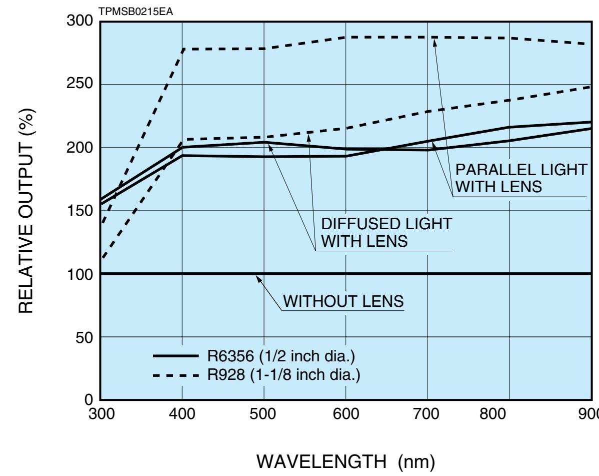
Transmittance of Lens



Lens Effect (at anode sensitivity)



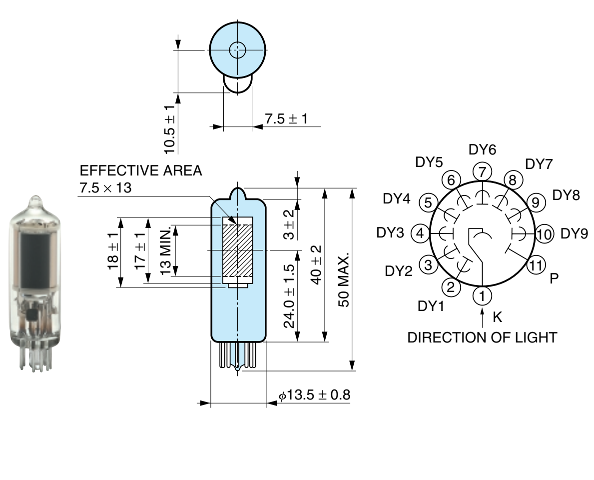
Lens Effect

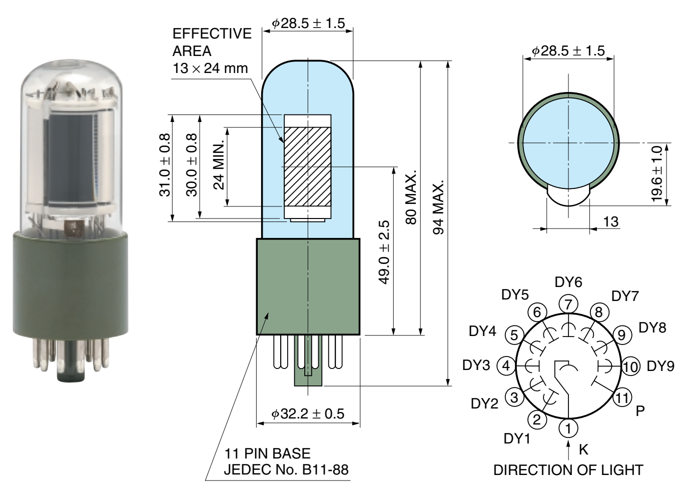


Parallel light:
Uniform and sufficiently large area, than the sensitive area size, of the parallel incident light (40 mm dia.) shall be given to the photomultiplier tube.

Diffused light:
Parallel light (40 mm dia.) is given to the photomultiplier tube through the diffuser, which locates 100 mm from the tube.

Dimensional Outlines (Unit: mm)

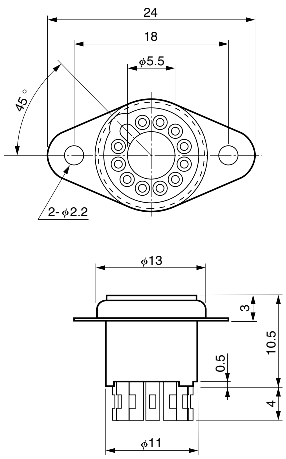




Photomultiplier Tube Socket

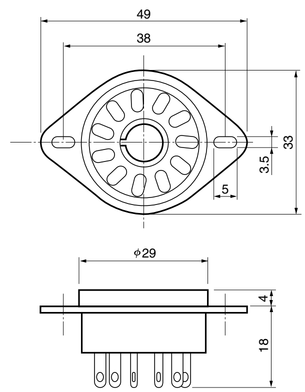
Dimensional Outline (Unit: mm)

E678-11U



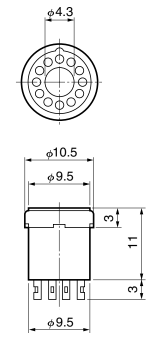
TACCA0181EC

E678-11A



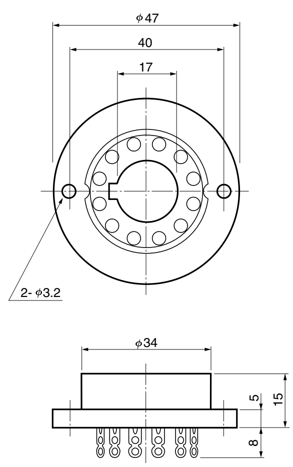
TACCA0064EA

E678-11N



TACCA0043EB

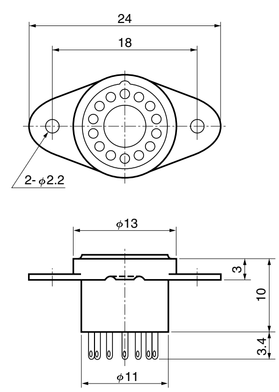
E678-12A, E678-12R*



* Gold Plating type

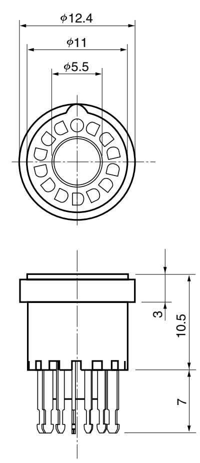
TACCA0009EB

E678-13F



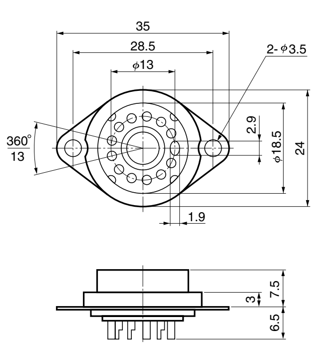
TACCA0005EA

E678-13E



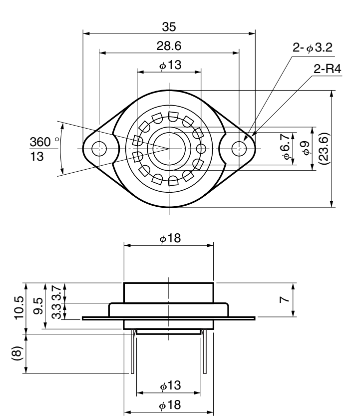
TACCA0013EB

E678-12T



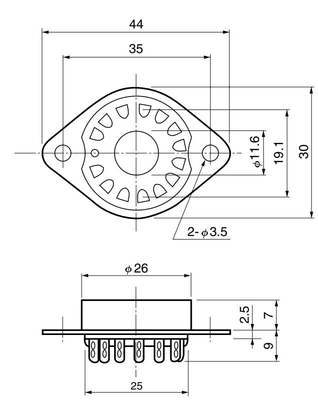
TACCA0275EA

E678-12L



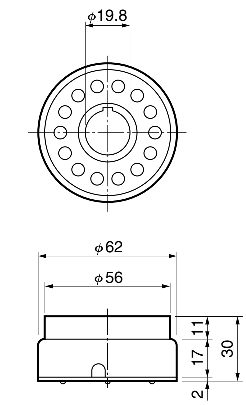
TACCA0047EA

E678-14C



TACCA0004EA

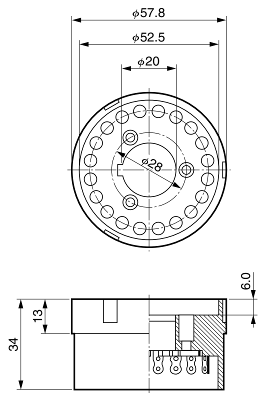
E678-14W



* Pins are housed in the socket.

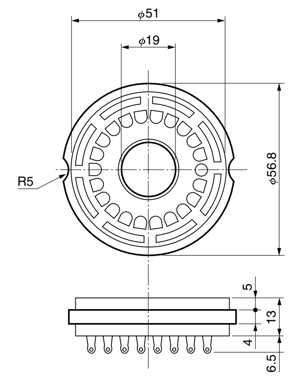
TACCA0200EA

E678-20B



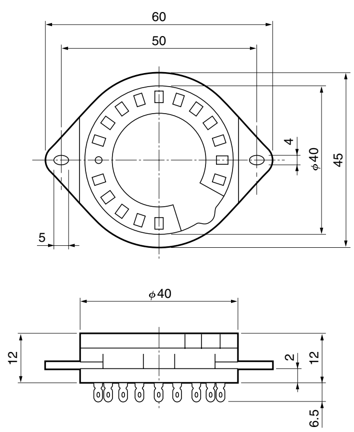
TACCA0309EA

E678-21C



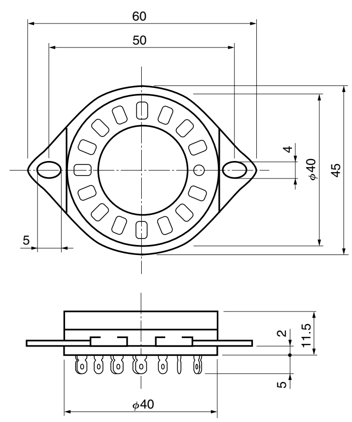
TACCA0066EC

E678-19J



TACCA0203EA

E678-15C



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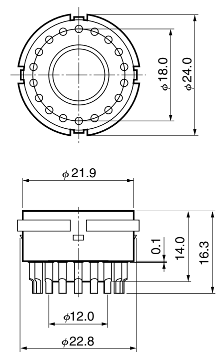

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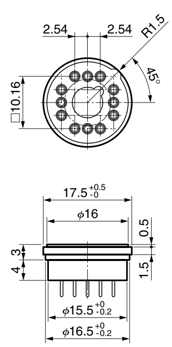

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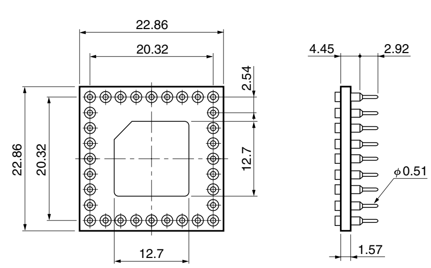
E678-32B



MATERIAL: Glass Epoxy

TACCA0094ED

TACCF0133

Photomultiplier Tube Assemblies

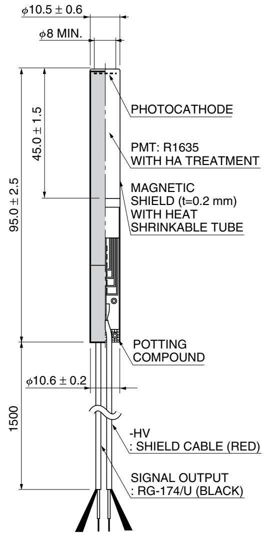
Photomultiplier tube assemblies are made up of a photomultiplier tube, a voltage-divider circuit and other components, all integrated into a single case.

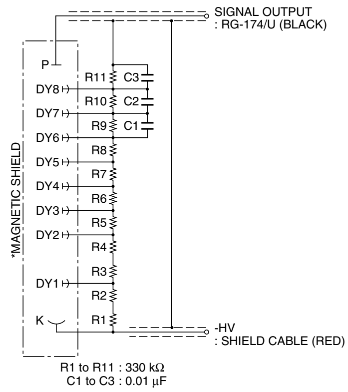
Type No.	Assembly Dia. (mm)	PMT Dia. mm (inch)	Built-in PMT	Curve Code	Wavelength (nm)	Out-line No.	Dynode Structure / Stages	Max. Rating: F Anode to Cathode Voltage Max. (V)	Max. Rating: Divider Current Max. (mA)	Anode to Cathode Supply Voltage (V)	Cathode Sensitivity: Luminous Typ. (μA/lm)	Cathode Sensitivity: Blue Sensitivity Index (CS 5-58) Typ.
H3164-10	φ10.5	10 (3/8)	R1635	400K	300 to 650	1	L/8	-1500	0.41	-1250	100	10.0
H3695-10	φ11.3	10 (3/8)	R2496	400S	160 to 650	2	L/8	-1500	0.37	-1250	100	10.0
H3165-10	φ14.3	13 (1/2)	R647-01	400K	300 to 650	3	L/10	-1250	0.34	-1000	110	10.0
H6520	φ23.5	19 (3/4)	R1166	400K	300 to 650	4	L/10	-1250	0.33	-1000	110	10.5
H6524	φ23.5	19 (3/4)	R1450	400K	300 to 650	5	L/10	-1800	0.43	-1500	115	11.0
H6612	φ23.5	19 (3/4)	R3478	400K	300 to 650	6	L/8	-1800	0.35	-1700	115	11.0
H6152-70	φ31.0	25 (1)	R5505-70	—	300 to 650	7	FM/15	+2300	0.41	+2000	80	9.5
H6533	φ31.0	25 (1)	R4998	400K	300 to 650	8	L/10	-2500	0.36	-2250	70	9.0
H7415	φ33.0	28 (1-1/8)	R6427	400K	300 to 650	9	L/10	-2000	0.41	-1500	95	11.0
H3178-51	φ47.0	38 (1-1/2)	R580	400K	300 to 650	10	L/10	-1750	0.63	-1500	95	11.0
H8409-70	φ45.0	38 (1-1/2)	R7761-70	—	300 to 650	11	FM/19	+2300	0.33	+2000	80	9.5
H1949-51	φ60.0	51 (2)	R1828-01	400K	300 to 650	12	L/12	-3000	0.70	-2500	90	10.5
H6410	φ60.0	51 (2)	R329-02	400K	300 to 650	13	L/12	-2700	0.67	-2000	90	10.5
H7195	φ60.0	51 (2)	R329-02	400K	300 to 650	14	L/12	-2700	1.23	-2000	90	10.5
H2431-50	φ60.0	51 (2)	R2083	400K	300 to 650	15	L/8	-3500	0.61	-3000	80	10.0
H6614-70	φ60.0	51 (2)	R5924-70	—	300 to 650	16	FM/19	+2300	0.33	+2000	70	9.0
H6559	φ83.0	76 (3)	R6091	400K	300 to 650	17	L/12	-2500	0.62	-2000	90	10.5
H6527	φ142.0	127 (5)	R1250	400K	300 to 650	18	L/14	-3000	1.02	-2000	70	9.0
H6528	φ142.0	127 (5)	R1584	400U	185 to 650	18	L/14	-3000	1.02	-2000	70	9.0
H9530-20	▭ 35 × 16	—	—	—	300 to 920	19	MC/12	-1200	0.42	-1000	500	—
H8711	□30	—	R7600-00-M16	—	300 to 650	20	MC/12	-1000	0.35	-800	80	9.5
H8711-20	□30	—	R7600-20-M16	—	300 to 920	20	MC/12	-1000	0.35	-800	500	—
H7546B	□30	—	R7600-00-M64	—	300 to 650	21	MC/12	-1000	0.45	-800	80	9.5
H7546B-20	□30	—	R7600-20-M64	—	300 to 920	21	MC/12	-1000	0.45	-800	500	—
H7260-20	▭ 52 × 24	—	R7259-20	—	300 to 920	22	MC/10	-900	0.37	-800	500	—
H8500C	□52	—	R10551-00-M64	—	300 to 650	23	MC/12	-1100	0.173	-1000	60	9.5
H9500	□52	—	R8400-00-M256	—	300 to 650	24	MC/12	-1100	0.18	-1000	60	9.5
H10966A	□52	—	R10552-00-M64	—	300 to 650	25	MC/8	-1100	0.245	-1000	60	9.5
H10515B-20	□30	—	R5900U-20-L16	—	300 to 920	26	MC/10	-900	0.37	-800	500	—

CAUTION: Photomultiplier tube assemblies listed in this catalog are not designed for use in a vacuum, please consult our sales office.
When using them in a vacuum or under low pressure conditions, please consult us.

Anode Characteristics										
Luminous	Gain	Dark Current		Time Response			Pulse Linearity		Notes	Type No.
				Rise Time	Transit Time	Transit Time Spread	2 %	5 %		
Typ. (A/lm)	Typ.	Typ. (nA)	Max. (nA)	Typ. (ns)	Typ. (ns)	Typ. (ns)	Typ. (mA)	Typ. (mA)		
100	1.0×10^6	1	50	0.8	9.0	0.5	3	7	H3164-11 (with 50 Ω)	H3164-10
100	1.0×10^6	2	50	0.7	9.0	0.5	3	7	H3695-11 (with 50 Ω)	H3695-10
150	1.4×10^6	1	2	2.1	22	2.0	3	7	H3165-11 (with 50 Ω)	H3165-10
110	1.0×10^6	1	5	2.5	27	2.8	4	7	H6520-01 (with 50 Ω)	H6520
200	1.7×10^6	3	50	1.8	19	0.76	4	8	H6524-01 (with 50 Ω)	H6524
200	1.7×10^6	10	300	1.3	14	0.36	4	8	H6612-01 (with 50 Ω)	H6612
40	5.0×10^5	5	30	1.5	5.6	0.35	180	250		H6152-70
400	5.7×10^6	100	800	0.7	10	0.16	40	70	H6610 (R5320)	H6533
475	5.0×10^6	10	200	1.7	16	0.5	10	30	H7415-01 (with 50 Ω) H7416 (R7056)	H7415
75	7.9×10^5	2	15	2.7	40	4.5	150	200		H3178-51
800	1.0×10^7	15	100	2.1	7.5	0.35	350	500		H8409-70
1800	1.0×10^7	50	400	1.3	28	0.55	100	200	H3177-51 (R2059)	H1949-51
270	3.0×10^6	10	100	2.7	40	1.1	100	200	H6521 (R2256) H6522 (R5113)	H6410
270	3.0×10^6	10	100	2.7	40	1.1	80	110		H7195
200	2.5×10^6	100	800	0.7	16	0.37	100	150	H3378-50 (R3377)	H2431-50
700	1.0×10^7	30	200	2.5	9.5	0.44	500	700		H6614-70
900	1.0×10^7	30	120	2.7	40	1.5	80	110		H6559
1000	1.4×10^7	50	300	2.5	54	1.2	100	150		H6527
1000	1.4×10^7	50	300	2.5	54	1.2	100	150		H6528
1500	3.0×10^6	1/ch	10/ch	0.7	6.0	0.25	0.9/ch	1/ch	8 Linearanode	H9530-20
280	3.5×10^6	0.8/ch	4/ch	0.83	12	0.33	0.5/ch	1/ch	16 Multianode H8711-10 (Taper Divider Type)	H8711
250	5.0×10^5	0.8/ch	4/ch	0.83	12	0.33	0.5/ch	1/ch		H8711-20
24	3.0×10^5	0.2/ch	2/ch	1.0	12	0.38	0.3/ch	0.6/ch	64 Multianode	H7546B
25	5.0×10^4	0.2/ch	2/ch	1.0	12	0.38	0.3/ch	0.6/ch		H7546B-20
500	1.0×10^6	1/ch	10/ch	0.6	6.8	0.18	0.6/ch	0.8/ch	32 Linearanode H7260A-20 (-HV Cable Input Type)	H7260-20
90	1.5×10^6	0.1/ch	—	0.8	6.0	0.4	1/ch	2/ch	H8500C-03 (UV Grass Type) H8500D (HV Pin Input Type)	H8500C
90	1.5×10^6	0.05/ch	—	0.8	6.0	0.4	0.2/ch	0.5/ch	H9500-03 (UV Grass Type)	H9500
20	3.3×10^5	0.1/ch	—	0.4	4.0	—	1.2/ch	3/ch	H10966B (HV Pin Input Type)	H10966A
500	1.0×10^6	1/ch	10/ch	0.6	7.4	0.18	0.8/ch	1/ch	16 Linearanode	H10515B-20

1 H3164-10

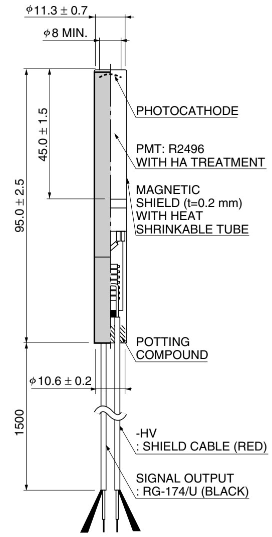


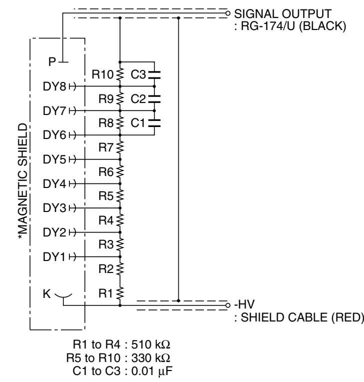


* MAGNETIC SHIELD IS CONNECTED TO -HV INSIDE OF THIS PRODUCT.
** HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0309EC

2 H3695-10

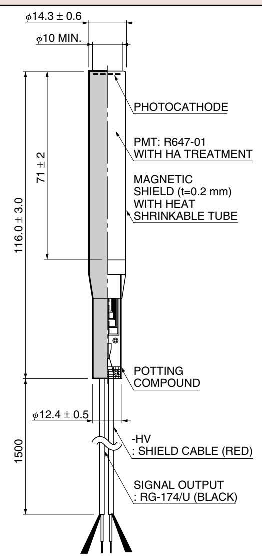


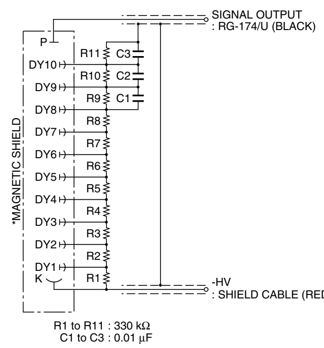


* MAGNETIC SHIELD IS CONNECTED TO -HV INSIDE OF THIS PRODUCT.
** HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0310EC

3 H3165-10





* MAGNETIC SHIELD IS CONNECTED TO -HV INSIDE OF THIS PRODUCT.
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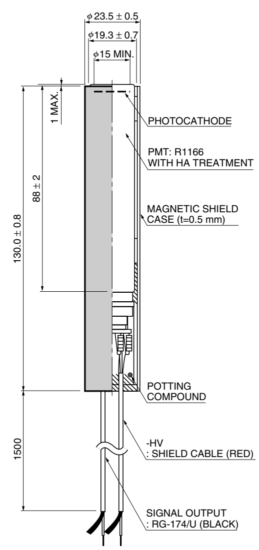
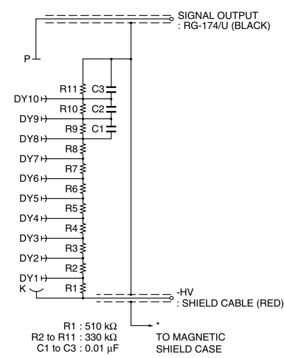
TPMHA0311EC

4 H6520

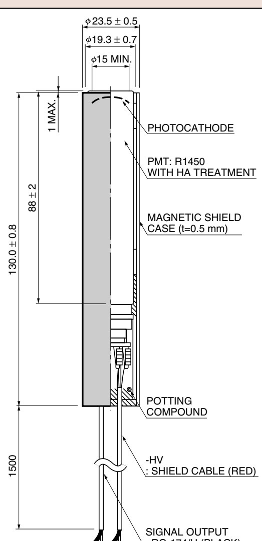


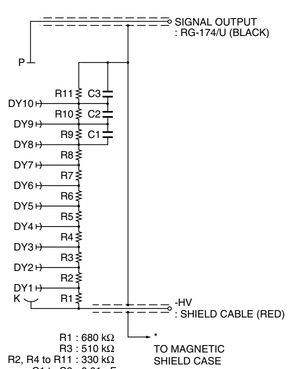


* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.
** HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0312EB

5 H6524

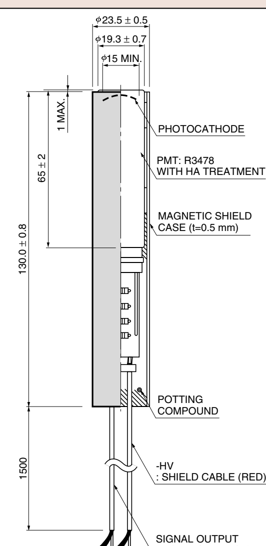


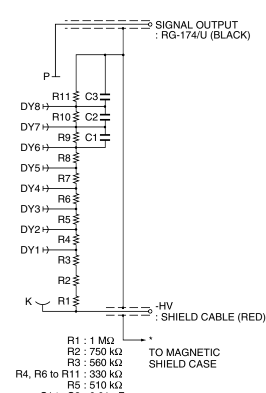


* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.
** HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0313EA

6 H6612

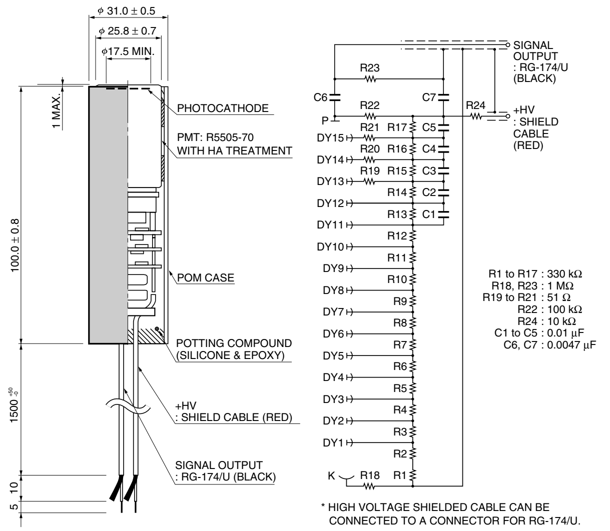




* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.
** HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0315EB

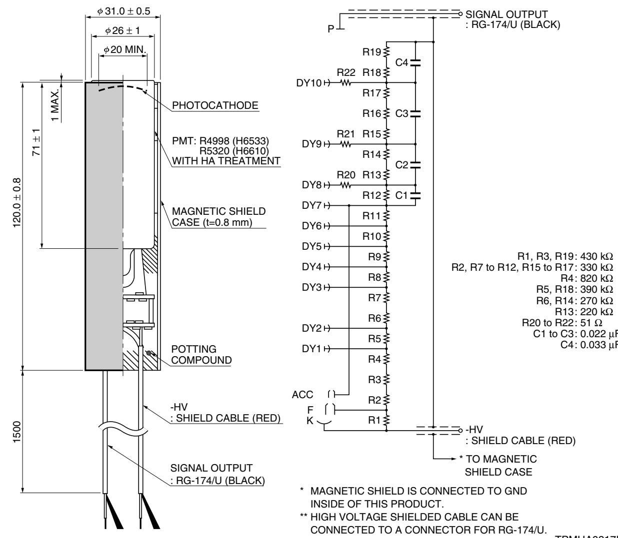
⑦ H6152-70



* HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0470EA

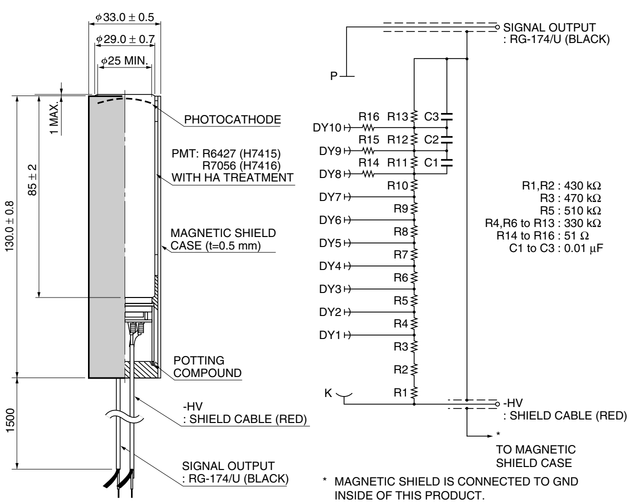
⑧ H6533



* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.
** HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0317EB

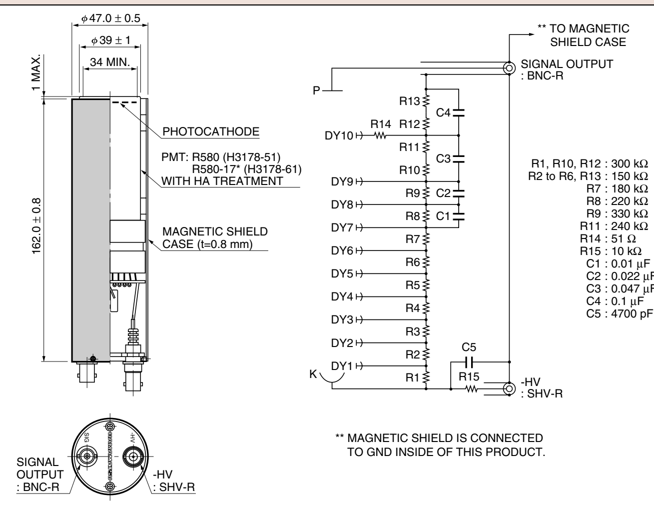
⑨ H7415



* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.
** HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0318EB

⑩ H3178-51

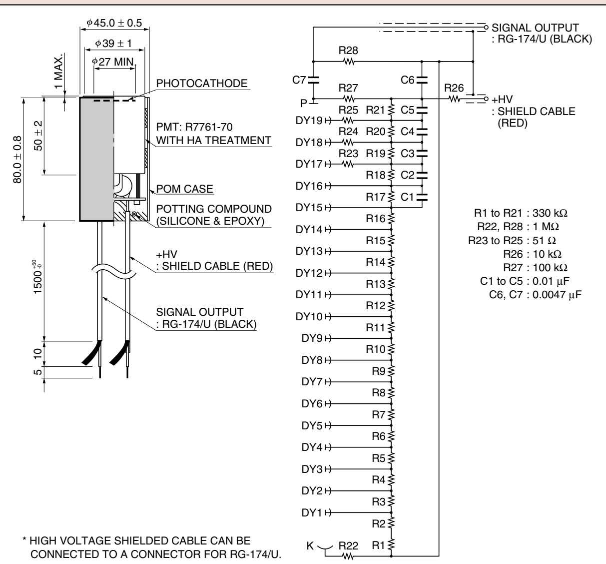


** MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

* R580-17 has a plano-concave face plate.

TPMHA0320EB

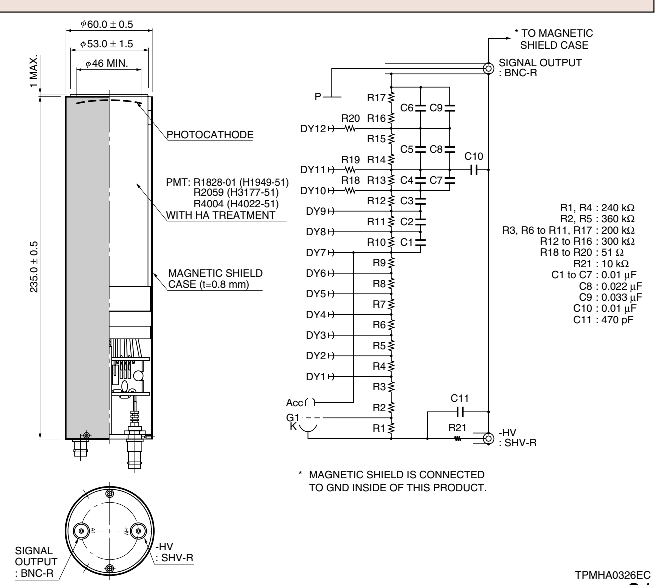
⑪ H8409-70



* HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0476EA

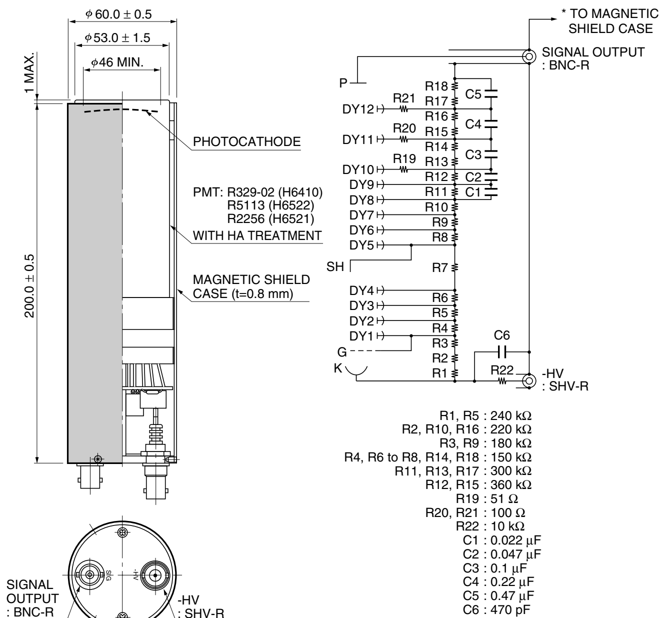
⑫ H1949-51



* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

TPMHA0326EC

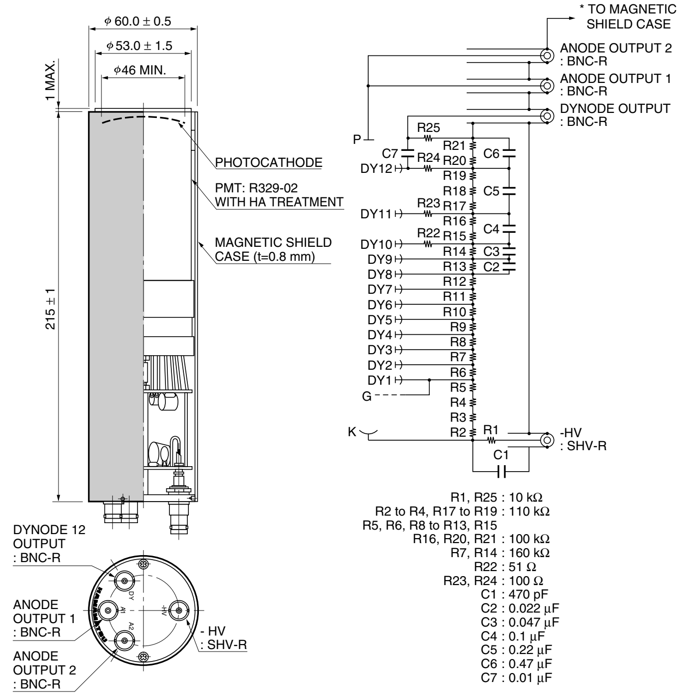
⑬ H6410



* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

TPMHA0324EB

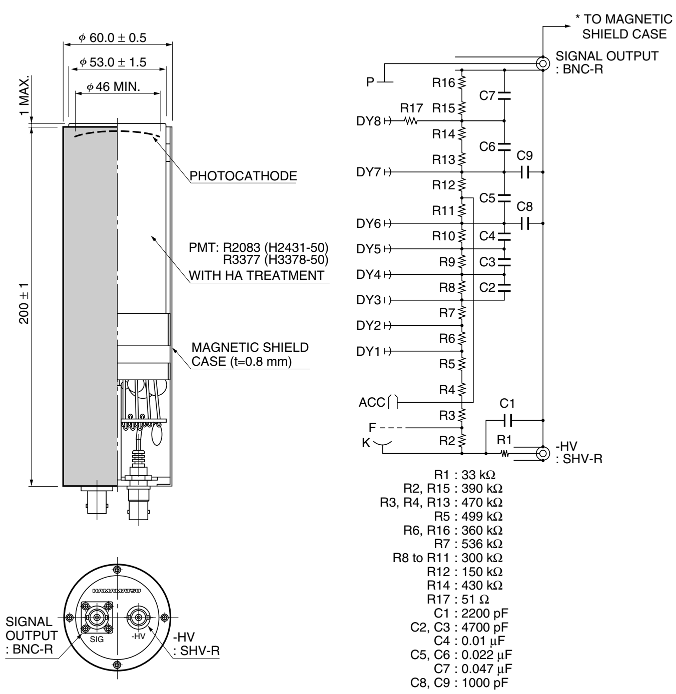
⑭ H7195



* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

TPMHA0323EB

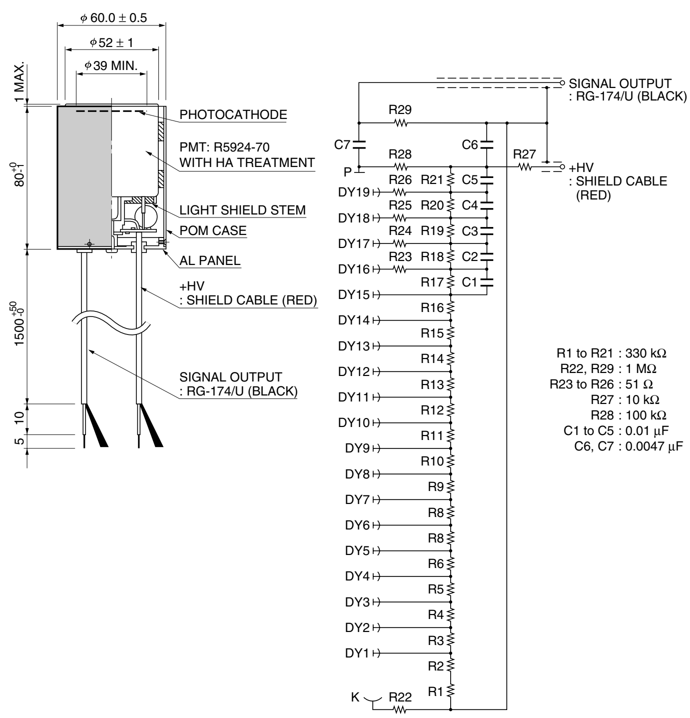
⑮ H2431-50



* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

TPMHA0327EB

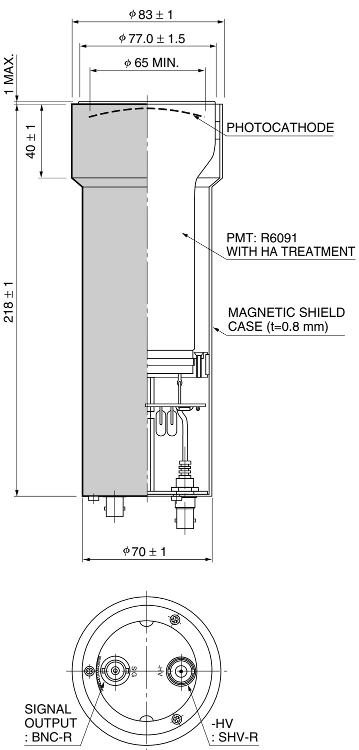
⑯ H6614-70

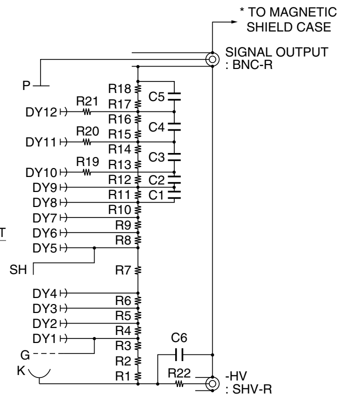


* HIGH VOLTAGE SHIELDED CABLE CAN BE CONNECTED TO A CONNECTOR FOR RG-174/U.

TPMHA0472EA

⑰ H6559



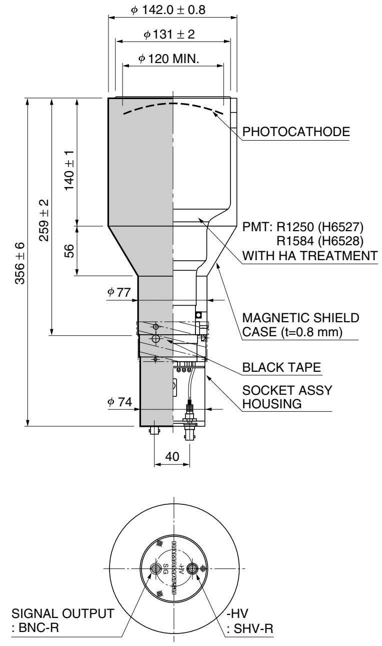


R1, R5 : 240 kΩ
R2, R10, R16 : 220 kΩ
R3, R9 : 180 kΩ
R4, R6 to R8, R14, R18 : 150 kΩ
R11, R13, R17 : 300 kΩ
R12, R15 : 360 kΩ
R19 : 51 Ω
R20, R21 : 100 Ω
R22 : 10 kΩ
C1 : 0.022 μF
C2 : 0.047 μF
C3 : 0.1 μF
C4 : 0.22 μF
C5 : 0.47 μF
C6 : 470 pF

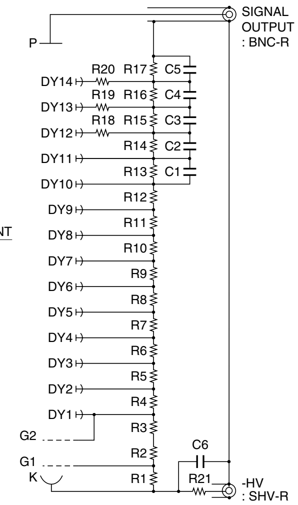
* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

TPMHA0331EA

⑱ H6527, H6528



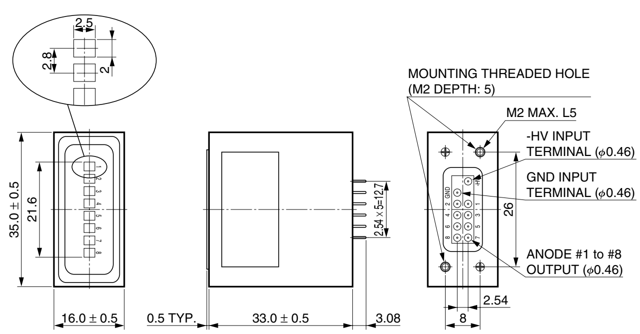
H6527=Flat window, Borosilicate
H6528=Curved window, UV glass

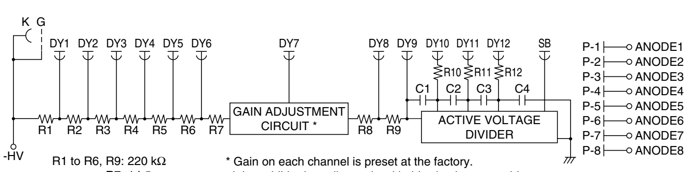


R1, R17 : 240 kΩ
R2 : 360 kΩ
R3 : 390 kΩ
R4 : 120 kΩ
R5 : 180 kΩ
R6 to R13 : 100 kΩ
R14, R15 : 150 kΩ
R16 : 300 kΩ
R18 : 51 Ω
R19, R20 : 100 Ω
R21 : 10 kΩ
C1 : 0.022 μF
C2 : 0.047 μF
C3 : 0.1 μF
C4 : 0.22 μF
C5 : 0.47 μF
C6 : 470 pF

TPMHA0332EA

⑲ H9530-20



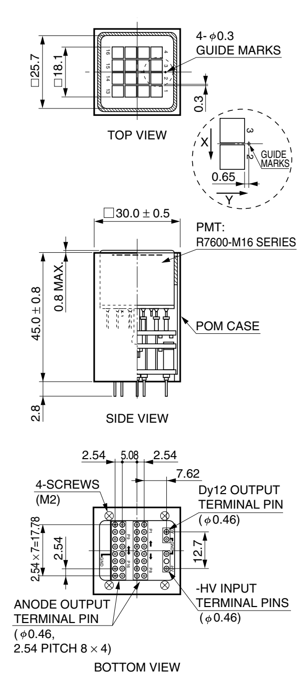


R1 to R6, R9: 220 kΩ
R7: 1 kΩ
R8: 200 kΩ
R10 to R12: 51 Ω
C1 to C4: 0.01 μF

* Gain on each channel is preset at the factory.
It is prohibited to adjust gain with this circuit at user side

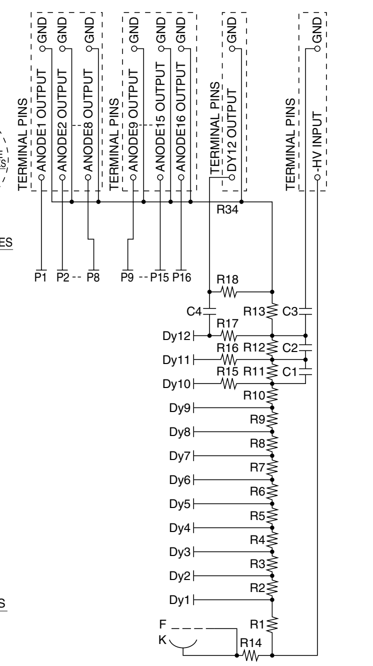
TPMHA0508EC

⑳ H8711, H8711-20, H8711-100, H8711-200



ANODE SIZE

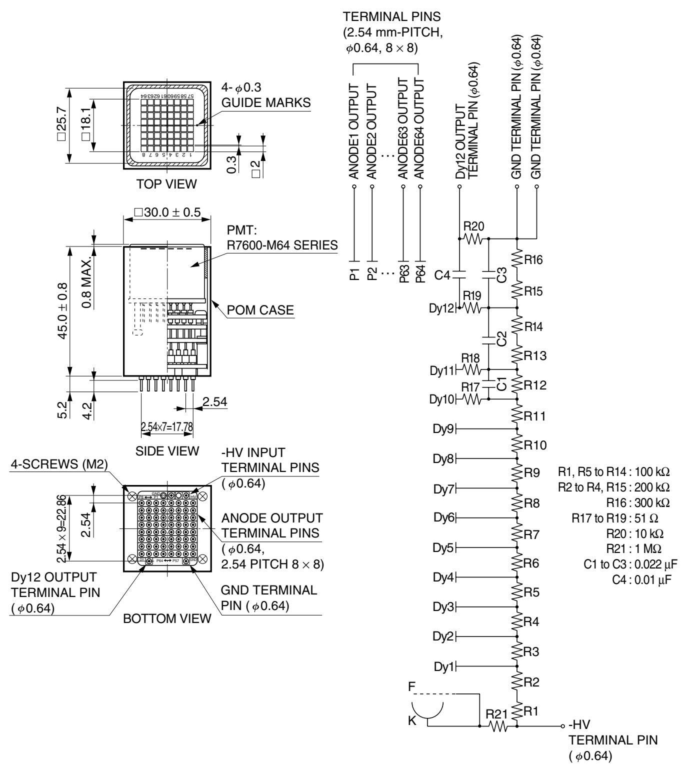
(X) × (Y)	ANODE
4.4 mm × 4.4 mm	P1, P4, P13, P16
4.2 mm × 4.4 mm	P2, P3, P14, P15
4.4 mm × 4.2 mm	P5, P8, P9, P12
4.2 mm × 4.2 mm	P6, P7, P10, P11



R1 to R3: 360 kΩ
R4 to R13: 180 kΩ
R14: 1 MΩ
R15 to R17: 51 Ω
R18: 10 kΩ
C1 to C4: 0.01 μF

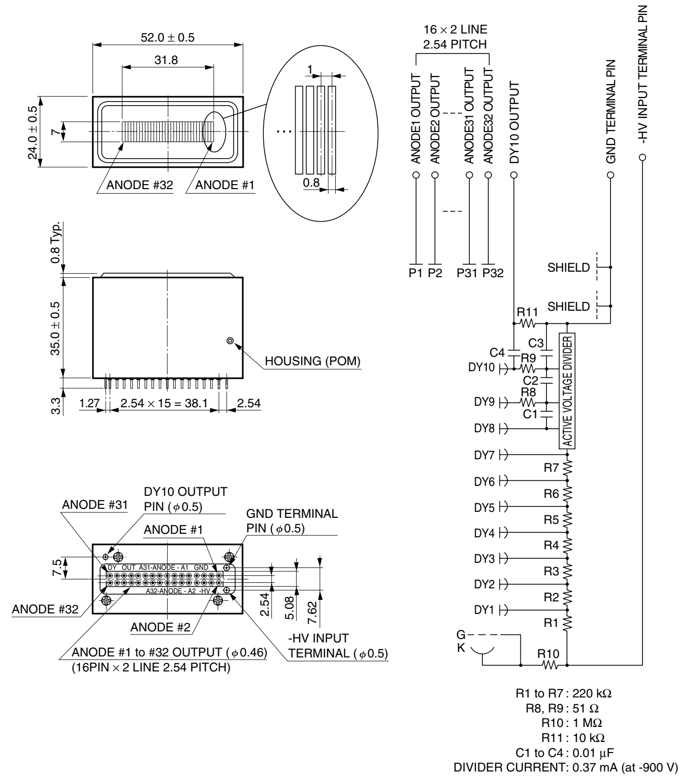
TPMHA0487ED

㉑ H7546B, H7546B-20, H7546B-100, H7546B-200



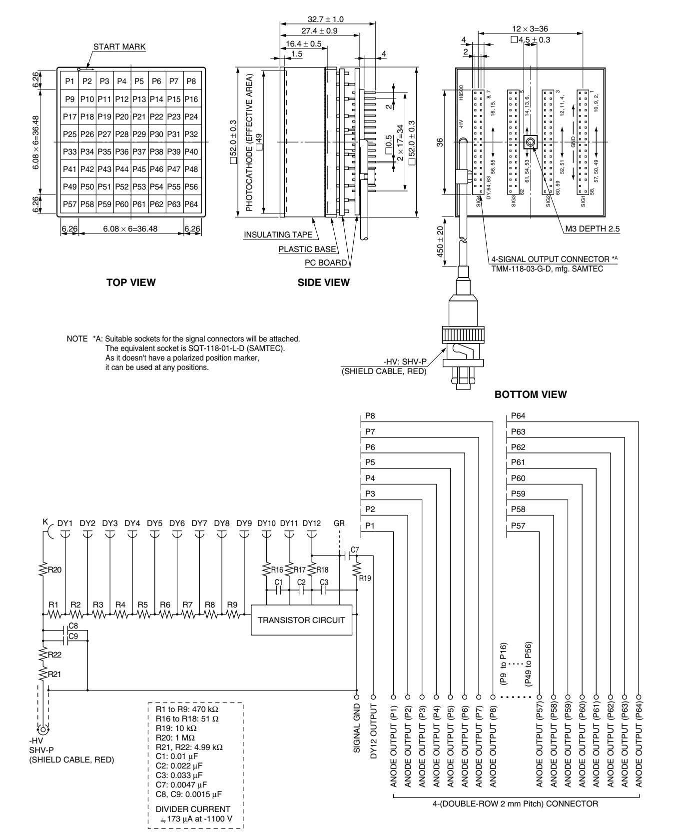
TPMHA0488EC

㉒ H7260-20, H7260-100, H7260-200



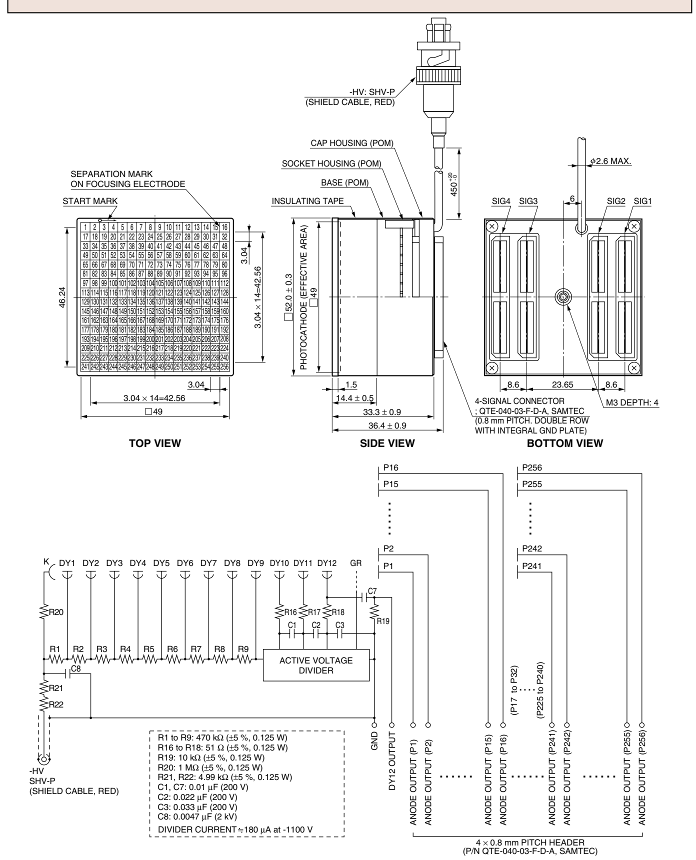
TPMHA0455EC TPMHA0192EA

㉓ H8500C



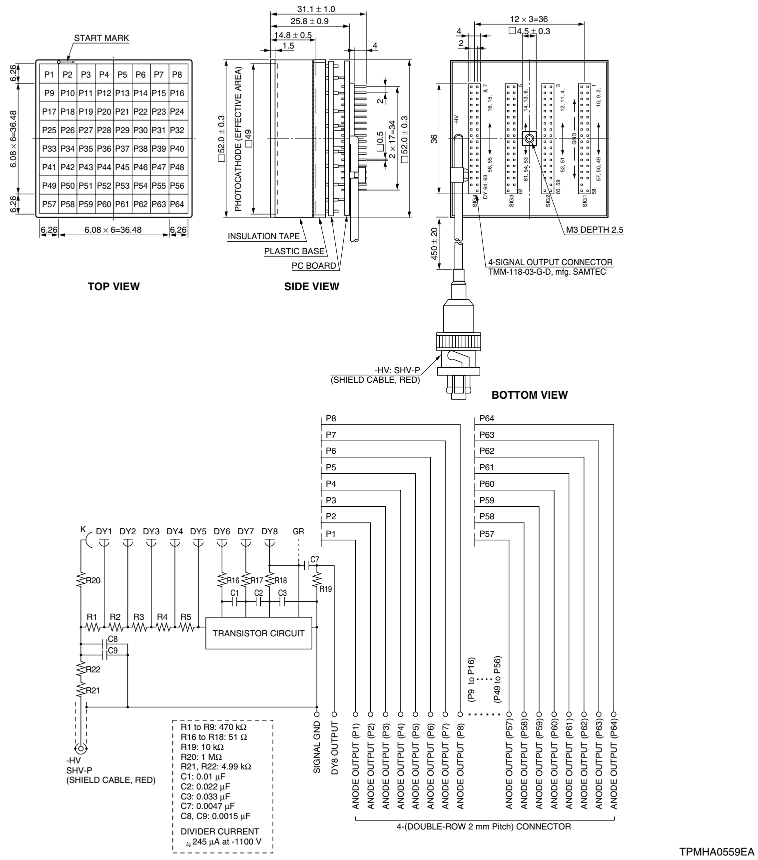
TPMHA0544EA

㉔ H9500



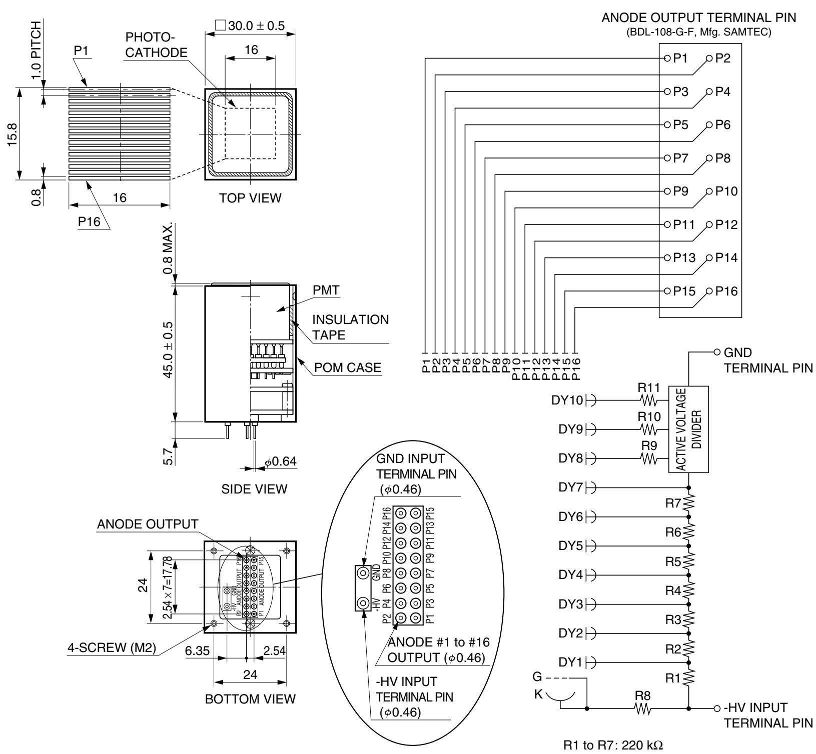
TPMHA0504EB

㉕ H10966A



TPMHA0559EA

㉖ H10515B-20



R1 to R7: 220 kΩ
R8: 1 MΩ
R9 to R11: 51 Ω
DIVIDER CURRENT: 0.37 mA (at -900 V)

TPMHA0534JA

TACCF0178

Photomultiplier Tube Socket Assemblies

Hamamatsu provides a wide variety of socket assemblies specifically designed for simple and reliable operation of photomultiplier tubes (often abbreviated as PMTs). These socket assemblies consist primarily of a high quality socket and voltage divider circuit integrated into a compact case. Variant types are available with internal current-to-voltage conversion amplifiers, gate circuits and high voltage power supply circuits.

Types of Socket Assemblies

The circuit elements used in Hamamatsu socket assemblies are represented by the three letters below. The socket assembly types are grouped according to the combination of these letters.

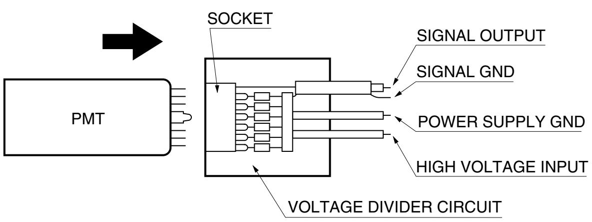
D : Voltage Divider
A : Amplifier
P : High Voltage Power Supply

D-Type Socket Assemblies (E717, E990 Series, etc.)

The D-type socket assemblies contain a voltage divider circuit along with a socket in a compact metallic or plastic case. Plastic case types are potted with silicone compound to ensure high environmental resistance.

Refer to page 92 for the selection guide to D-type socket assemblies.

Figure 40: D-Type Socket Assembly



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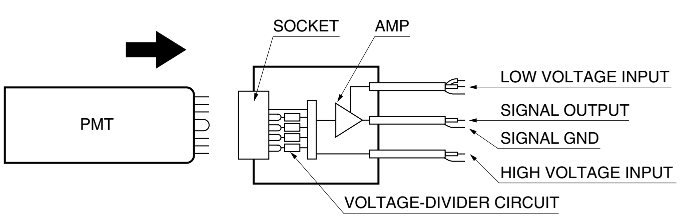
DA-Type Socket Assemblies (C7246, C7247 Series)

In addition to the circuit elements of the D-type socket assemblies, the DA-type socket assemblies include an amplifier that converts the low-level, high-impedance current output of a photomultiplier tube into a low-impedance voltage output. Possible problems from noise induction are eliminated since the high-impedance output of the photomultiplier tube is connected to the amplifier at the minimum distance.

Figure 41: DA-Type Socket Assembly

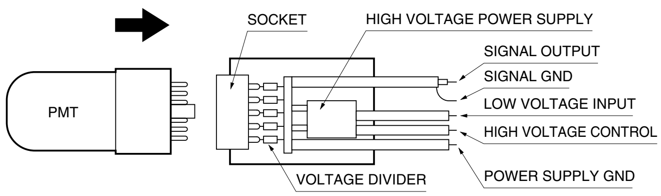


TACCC0002ED

DP-Type Socket Assemblies (C6270, C8991, etc.)

DP-type socket assemblies comprise a built-in high-voltage power supply circuit added to a D-type socket assembly.

Figure 42: DP-Type Socket Assembly

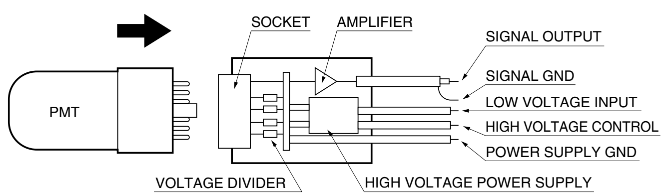


TACCC0003EB

DAP-Type Socket Assemblies (C6271, C7950, C7950-01)

This type of socket assembly has a current-to-voltage conversion amplifier and a high voltage power supply, efficiently added to the circuit components of the D-type socket assembly.

Figure 43: DAP-Type Socket Assembly



TACCC0054EA

Basics of Voltage Dividers

The following information describes voltage divider circuits which are basic to all types of socket assemblies. Refer to this section for information on proper use of the socket assemblies.

Voltage Divider Circuits

To operate a photomultiplier tube, a high voltage of 500 volts to 2000 volts is usually supplied between the photocathode (K) and the anode (P), with a proper voltage gradient set up along the photoelectron focusing electrode (F) or grid (G), secondary electron multiplier electrodes or dynodes (Dy) and, depending on photomultiplier tube type, an accelerating electrode (Acc). Figure 44 shows a schematic representation of photomultiplier tube operation using independent multiple power supplies, but this is not a practical method. Instead, a voltage divider circuit is commonly used to divide, by means of resistors, a high voltage supplied from a single power supply.

Figure 44: Schematic Representation of Photomultiplier Tube Operation

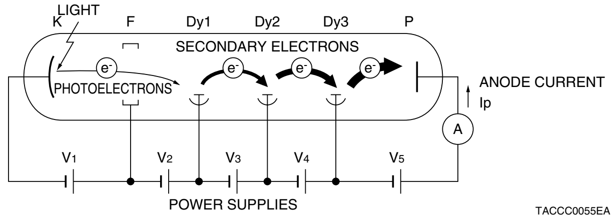
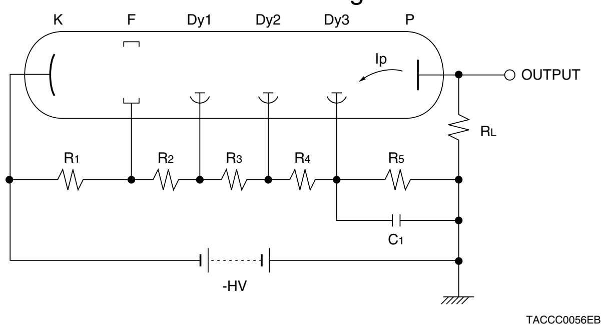


Figure 45 shows a typical voltage divider circuit using resistors, with the anode side grounded. The capacitor C_1 connected in parallel to the resistor R_5 in the circuit is called a storage capacitor and improves the output linearity when the photomultiplier tube is used in pulse operation, and not necessarily used in providing DC output. In some applications, transistors or Zener diodes may be used in place of these resistors.

Figure 45: Anode Grounded Voltage Divider Circuit

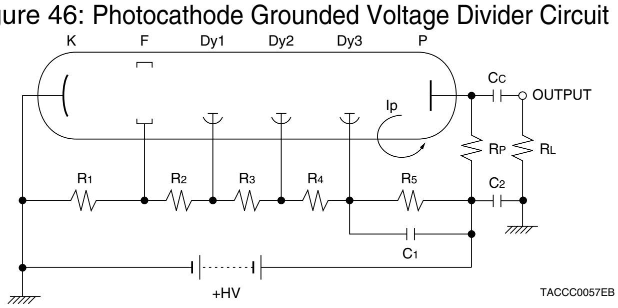


Anode Grounding and Photocathode Grounding

In order to eliminate the potential difference between the photomultiplier tube anode and external circuits such as an ammeter, and to facilitate the connection, the generally used technique for voltage divider circuits is to ground the anode and supply a high negative voltage (-HV) to the photocathode, as shown in Figure 45. This scheme provides the signal output in both DC and pulse operations, and is therefore used in a wide range of applications.

In photon counting and scintillation counting applications, however, the photomultiplier tube is often operated with the photocathode grounded and a high positive voltage (+HV) supplied to the anode mainly for purposes of noise reduction. This photocathode grounding scheme is shown in Figure 46, along with the coupling capacitor C_C for isolating the high voltage from the output circuit. Accordingly, this setup cannot provide a DC signal output and is only used in pulse output applications. The resistor R_P is used to give a proper potential to the anode. The resistor R_L is placed as a load resistor, but the actual load resistance will be the combination of R_P and R_L.

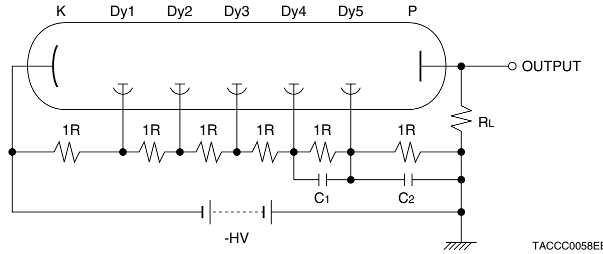
Figure 46: Photocathode Grounded Voltage Divider Circuit



Standard Voltage Divider Circuits

Basically, the voltage divider circuits of socket assemblies listed in this catalog are designed for standard voltage distribution ratios which are suited for constant light measurement. Socket assemblies for side-on photomultiplier tubes in particular mostly use a voltage divider circuit with equal interstage voltages allowing high gain.

Figure 47: Equally Divided Voltage Divider Circuit



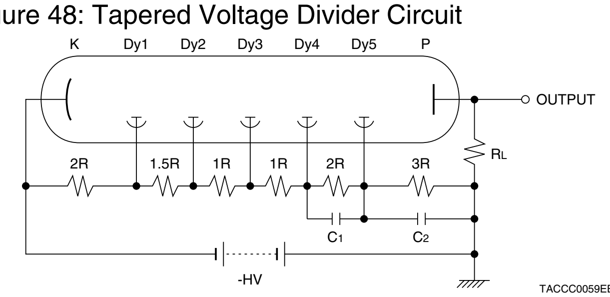
Tapered Voltage Divider Circuits

In most pulsed light measurement applications, it is often necessary to enhance the voltage gradient at the first and/or last few stages of the voltage divider circuit, by using larger resistances as shown in Figure 48. This is called a tapered voltage divider circuit and is effective in improving various characteristics. However it should be noted that the overall gain decreases as the voltage gradient becomes greater. In addition, care is required regarding the interstage voltage tolerance of the photomultiplier tube as higher voltage is supplied. The tapered voltage circuit types and their suitable applications are listed below.

Tapered circuit at the first few stages (resistance: large → small)
- Photon counting (improvement in pulse height distribution)
- Low-light-level detection (S/N ratio enhancement)
- High-speed pulsed light detection (improvement in timing properties)
- Other applications requiring better magnetic characteristics and uniformity

Tapered circuit at the last few stages (resistance: small → large)
- High pulsed light detection (improvement in output linearity)
- High-speed pulsed light detection (improvement in timing properties)
- Other applications requiring high output across the load resistor

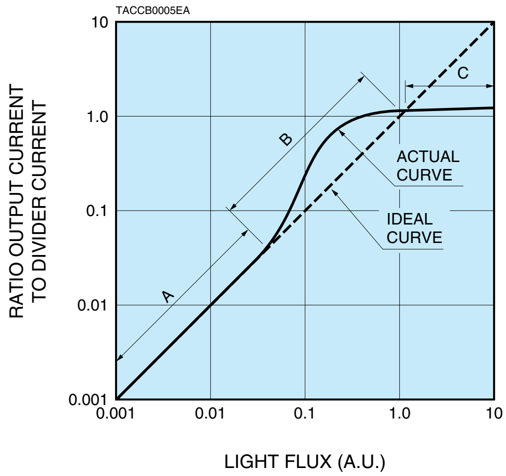
Figure 48: Tapered Voltage Divider Circuit



Voltage Divider Circuit and Photomultiplier Tube Output Linearity

In both DC and pulse operations, when the light incident on the photocathode increases to a certain level, the relationship between the incident light level and the output current begins to deviate from the ideal linearity. As can be seen from Figure 49, region A maintains good linearity, and region B is the so-called overlinearity range in which the output increase is larger than the ideal level. In region C, the output goes into saturation and becomes smaller than the ideal level. When accurate measurement with good linearity is essential, the maximum output current must be within region A. In contrast, the lower limit of the output current is determined by the dark current and noise of the photomultiplier tube as well as the leakage current and noise of the external circuit.

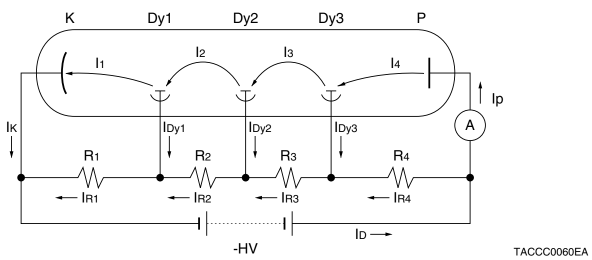
Figure 49: Output Linearity of Photomultiplier Tube



Output Linearity in DC Mode

Figure 50 is a simplified representation showing photomultiplier tube operation in the DC output mode, with three stages of dynodes and four dividing resistors R_1 through R_4 having the same resistance value.

Figure 50: Basic Operation of Photomultiplier Tube and Voltage Divider Circuit



[When light is not incident on the tube]

In dark state operation where a high voltage is supplied to a photomultiplier tube without incident light, the current components flowing through the voltage divider circuit will be similar to those shown in Figure 51 (if we ignore the photomultiplier tube dark current). The relation of current and voltage through each component is given below

Interelectrode current of photomultiplier tube

$I_1=I_2=I_3=I_4$ (= 0 A)

Electrode current of photomultiplier tube

$I_K=I_{Dy1}=I_{Dy2}=I_{Dy3}=I_P$ (= 0 A)

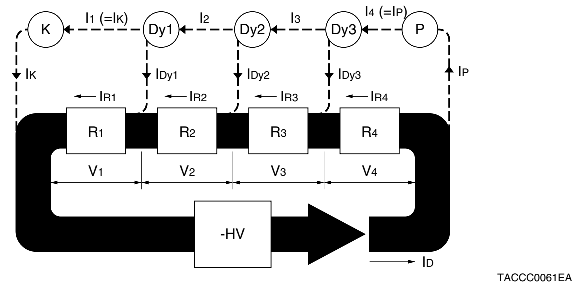
Voltage divider circuit current

$I_{R1}=I_{R2}=I_{R3}=I_{R4}=I_D=(HV/\sum_{n=1}^{4} R_n)$

Voltage divider circuit voltage

$V_1=V_2=V_3=V_4=I_D \bullet R_n$ (= HV/4)

Figure 51: Operation without Light Input



[When light is incident on the tube]

When light is allowed to strike the photomultiplier tube under the conditions in Figure 51, the resulting currents can be considered to flow through the photomultiplier tube and the voltage divider circuit as schematically illustrated in Figure 52. Here, all symbols used to represent the current and voltage are expressed with a prime ('), to distinguish them from those in dark state operation.

The voltage divider circuit current I_D' is the sum of the voltage divider circuit current I_D in dark state operation and the current flowing through the photomultiplier tube ΔI_D (equal to average interelectrode current). The current flowing through each dividing resistor Rn becomes as follows:

$I_{Rn}' = I_D' - I_n'$

Where In' is the interelectrode current which has the following relation:

$I_1' < I_2' < I_3' < I_4'$

Thus, the interstage voltage V_n' ($=I_{Rn}' \bullet R_n$) becomes smaller at the latter stages, as follows:

$V_1' > V_2' > V_3' > V_4'$

Figure 52: Operation with Light Input

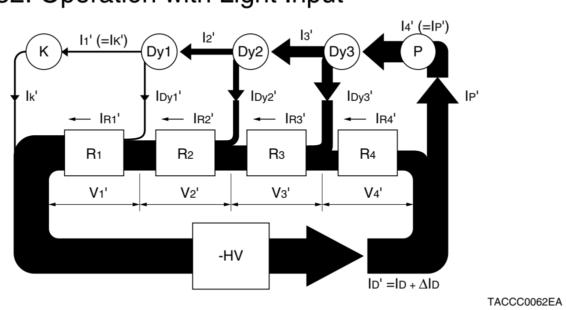
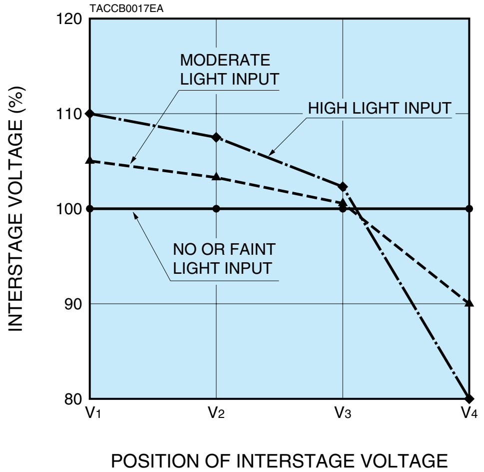


Figure 53 shows changes in the interstage voltages as the incident light level varies. The interstage voltage V_4' with light input drops significantly compared to V_4 in dark state operation. This voltage loss is redistributed to the other stages, resulting an increases in V_1', V_2' and V_3' which are higher than those in dark state operation. The interstage voltage V_4' is only required to collect the secondary electrons emitted from the last dynode to the anode, so it has little effect on the anode current even if dropped to 20 or 30 volts. In contrast, the increases in V_1', V_2' and V_3' directly raise the secondary emission ratios (δ_1, δ_2 and δ_3) at the dynodes Dy1, Dy2 and Dy3, and thus boost the overall gain m (= $\delta_1 \bullet \delta_2 \bullet \delta_3$). This is the cause of overlinearity in region B in Figure 49. As the incident light level further increases so that V4' approaches 0 volts, output saturation occurs in region C.

Figure 53: Changes in Interstage Voltages at Different Incident Light Levels



Linearity Improvement in DC Output Mode

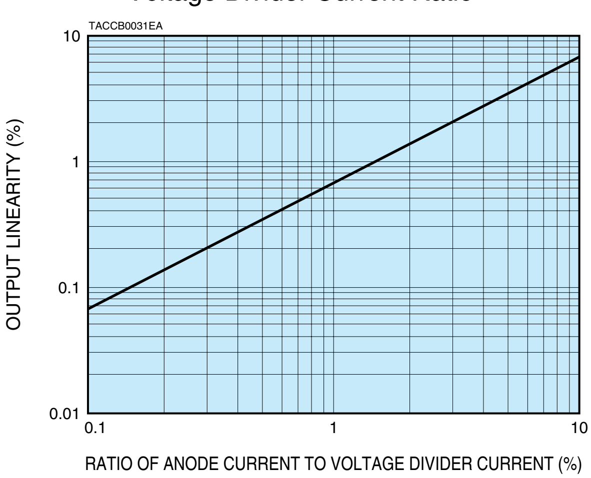
To improve the linearity in DC output mode, it is important to minimize the changes in the interstage voltage when photocurrent flows through the photomultiplier tube. There are several specific methods for improving the linearity, as discussed below.

①Increasing the voltage divider current

Figure 54 shows the relationship between the output linearity of a 28 mm (1-1/8") diameter side-on photomultiplier tube and the ratio of anode current to voltage divider current. For example, to obtain an output linearity of 1 %, it can be seen from the figure that the anode current should be set approximately 1.4 % of the divider circuit current. However, this is a calculated plot, so actual data may differ from tube to tube even for the same type of photomultiplier tube, depending on the supply voltage and individual dynode gains. To ensure high photometric accuracy, it is recommended that the voltage divider current be maintained at least twice the value obtained from this figure.

The maximum linear output in DC mode listed for the D-type socket assemblies in this catalog indicates the anode current equal to 1/20 of the voltage divider current. The output linearity at this point can be maintained within ±3 % to ±5 %.

Figure 54: Output Linearity vs. Anode Current to Voltage Divider Current Ratio

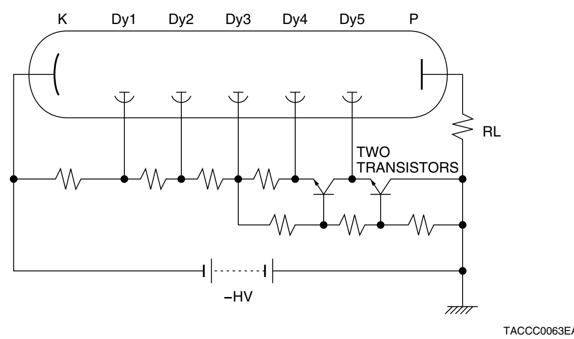


As stated above, good output linearity can be obtained simply by increasing the voltage divider current. However, this is accompanied by heat emanating from the voltage divider. If this heat is conducted to the photomultiplier tube, it may cause problems such as an increase in the dark current, and variation in the output.

②Using the active voltage divider circuit

Use of a voltage divider circuit having transistors in place of the dividing resistors in last few stages (for example, Hamamatsu C6270 series using FETs) is effective in improving the output linearity. This type of voltage divider circuit ensures good linearity up to an output current equal to 60 % to 70 % of the voltage divider current, since the interstage voltage is not affected by the interelectrode current inside the photomultiplier tube. A typical active voltage divider circuit is shown in Figure 55.

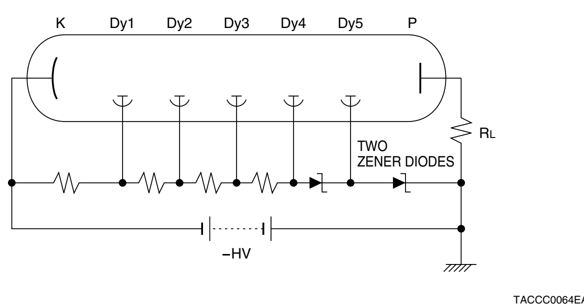
Figure 55: Active Voltage Divider Circuit



③Using Zener Diodes

The output linearity can be improved by using Zener diodes in place of the dividing resistors in the last few stages, because the Zener diodes serve to maintain the interstage voltages at a constant level. However, if the supply voltage is greatly varied, the voltage distribution may be imbalanced compared to other interstage voltages, thus limiting the adjustable range of the voltage with this technique. In addition, if the supply voltage is reduced or if the current flowing through the Zener diodes becomes insufficient due to an increase in the anode current, noise may be generated from the Zener diodes. Precautions should be taken when using this type of voltage divider circuit. Figure 56 shows a typical voltage divider circuit using Zener diodes.

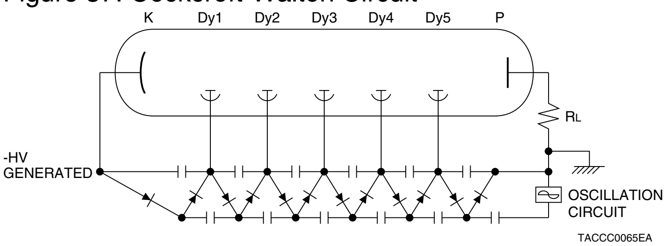
Figure 56: Voltage Divider Circuit Using Zener Diodes



④Using Cockcroft-Walton Circuit

When a Cockcroft-Walton circuit as shown in Figure 57 is used to operate a 28 mm (1-1/8") diameter side-on photomultiplier tube with a supply voltage of 1000 volts, good DC linearity can be obtained up to 200 µA and even higher. Since a high voltage is generated by supplying a low voltage to the oscillator circuit, there is no need for using a high voltage power supply.
This Cockcroft-Walton circuit achieves superior DC output linearity as well as low current consumption.

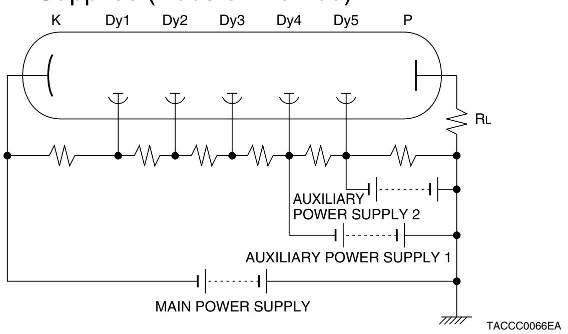
Figure 57: Cockcroft-Walton Circuit



⑤Using multiple high voltage power supplies

As shown in Figure 58, this technique uses multiple power supplies to directly supply voltages to the last few stages near the anode. This is sometimes called the booster method, and is used for high pulse and high count rate applications in high energy physics experiments.

Figure 58: Voltage Divider Circuit Using Multiple Power Supplies (Booster Method)



Output Linearity in Pulsed Mode

In applications such as scintillation counting where the incident light is in the form of pulses, individual pulses may range from a few to over 100 milliamperes even though the average anode current is small at low count rates. In this pulsed output mode, the peak current in extreme cases may reach a level hundreds of times higher than the voltage divider current. If this happens, it is not possible to supply interelectrode currents from the voltage divider circuit to the last few stages of the photomultiplier tube, thus leading to degradation in the output linearity.

Improving Linearity in Pulsed Output Mode

①Using storage capacitors

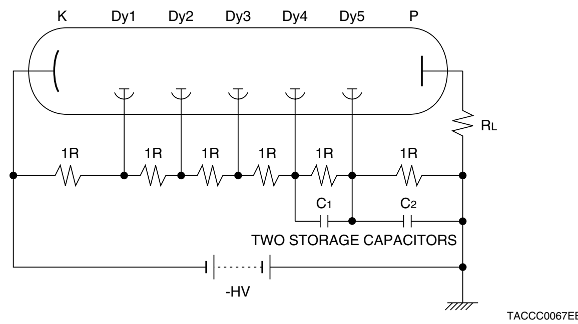
Using multiple power supplies mentioned above is not popular in view of the cost. The most commonly used technique is to supply the interelectrode current by using storage capacitors as shown in Figure 59. There are two methods for connecting these storage capacitors: the serial method and the parallel method. As Figures 59 and 60 show, the serial method is more widely used since it requires lower tolerance voltages of the capacitors. The capacitance value C (farads) of the storage capacitor between the last dynode and the anode should be at least 100 times the output charge as follows:

$$C > 100 \cdot Q/V$$

where Q is the charge of one output pulse (coulombs) and V is the voltage (volts) across the last dynode and the anode.

Since this method directly supplies the pulse current with electrical charges from the capacitors, if the count rate is increased and the resulting duty factor becomes larger, the electrical charge will be insufficient. Therefore, in order to maintain good linearity, the capacitance value obtained from the above equation must be increased according to the duty factor, so that the voltage divider current is kept at least 50 times larger than the average anode current just as with the DC output mode.
The active voltage divider circuit and the booster method using multiple power supplies discussed previously, provide superior pulse output linearity even at a higher duty factor.

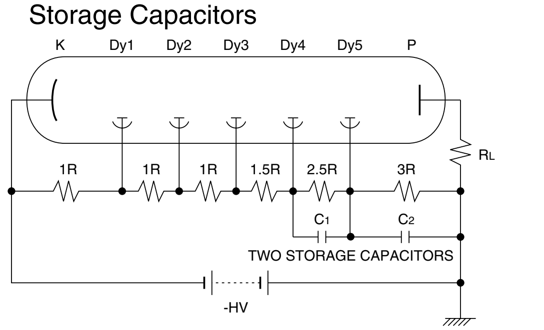
Figure 59: Equally Divided Voltage Divider Circuit and Storage Capacitors



②Using tapered voltage divider circuit with storage capacitors

Use of the above voltage divider circuit having storage capacitors is effective in improving pulse linearity. However, when the pulse current increases further, the electron density also increases, particularly in last stages. This may cause a space charge effect which prevents interelectrode current from flowing adequately and leading to output saturation. A commonly used technique for extracting a higher pulse current is the tapered voltage divider circuit in which the voltage distribution ratios in the latter stages are enhanced as shown in Figure 60. Care should be taken in this case regarding loss of the gain and the breakdown voltages between electrodes.
Since use of a tapered voltage divider circuit allows an increase in the voltage between the last dynode and the anode, it is possible to raise the voltage across the load resistor when it is connected to the anode. It should be noted however, that if the output voltage becomes excessively high, the voltage between the last dynode and the anode may drop, causing a degradation in output linearity.

Figure 60: Tapered Voltage Divider Circuit Using Storage Capacitors



D-Type Socket Assemblies

The D-type socket assemblies are grouped as follows:

(a) For DC output (-HV supply)
Available only upon request

(b) For DC or pulsed output (-HV supply)
ex. E717-63

(c) For pulsed output (+HV supply)
ex. E990-08

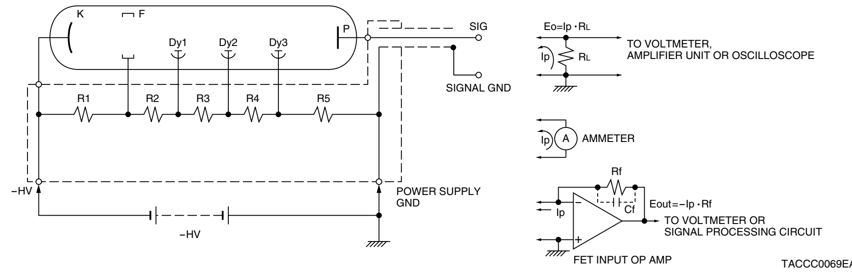
(d) For DC or pulsed output (-HV supply), or pulsed output (+HV supply)
ex. E717-74

Connection of D-Type Socket Assemblies to External Circuits

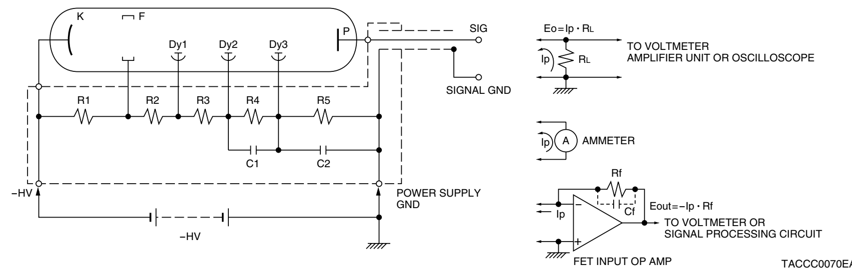
Figure 61 shows typical examples of connecting various D-type socket assemblies to external circuits.

Figure 61: Connection of D-Type Socket Assemblies to Extrernal Circuits

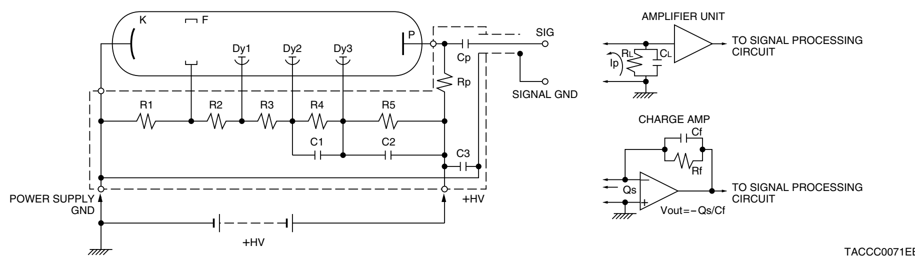
(a) For DC output (-HV supply)



(b) For DC or pulsed output (-HV supply)



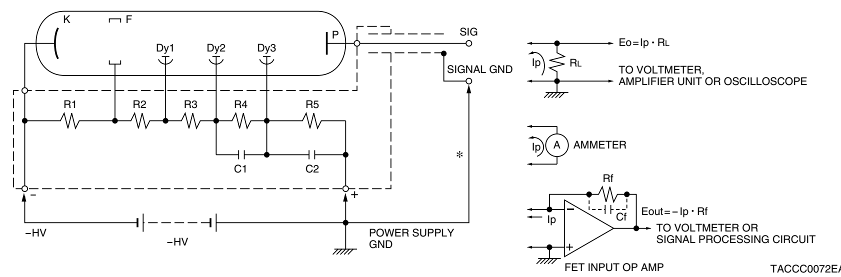
(c) For pulsed output (+HV supply)



(d) For DC or pulsed output (-HV supply), or pulsed output (+HV supply)

d-1. For DC or pulsed output (-HV supply)

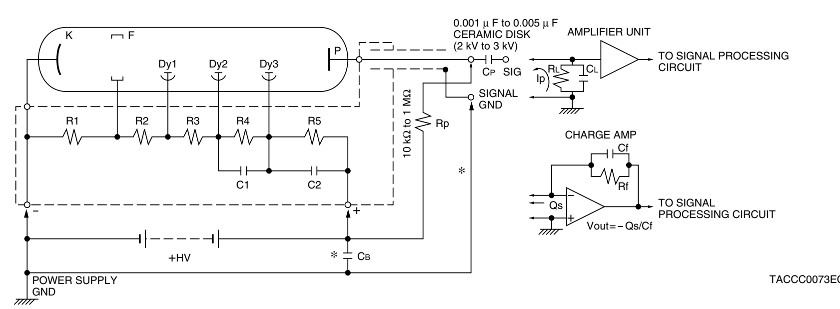
* GND should be connected externaly.



d-2. For pulsed output/+HV supply

For general scintillation counting and photon counting applications, recommended values for C_P and R_P are 0.001 μF to 0.005 μF and 10 kΩ to 1 MΩ. Since a high voltage is supplied to these parts, care must be taken when handling this circuit.

* GND and C_B should be connected externally.



D-Type Socket Assemblies

Socket Assembly Type No.	Applicable PMT Diameter	Outline and Diagram	Grounded Electrode / Supply Voltage Polarity	Maximum Ratings: Insulation Voltage between Case and Pins (V)	Maximum Ratings: Supply Voltage (V)	Maximum Ratings: (A) Voltage Divider Current (mA)	(B) Leakage Current in Signal Max. (A)	Total Voltage Divider Resistance (MΩ)	(C) Maximum Linear Output in DC Mode (μA)	Signal Output	Note
For Side-on Types											
E850-13	13 mm (1/2")	1	Anode / -	1500	1250	0.38	1×10^{-10}	3.30	18 (at 1250 V)	DC / Pulse	
E850-22	13 mm (1/2")	2	Anode / -	1500	1250	0.38	1×10^{-10}	3.30	18 (at 1250 V)	DC / Pulse	E850-13, with connector
E717-63	28 mm (1-1/8")	3	Anode / -	1500	1500	0.45	1×10^{-10}	3.30	22 (at 1500 V)	DC / Pulse	
E717-74	28 mm (1-1/8")	4	Anode•Cathode / +•-	1500	1500	0.45	1×10^{-10}	3.30	22 (at 1500 V)	DC / Pulse	Pin output
E717-500	28 mm (1-1/8")	5	Anode / -	1250	1250	0.38	1×10^{-10}	3.30	18 (at 1250 V)	DC / Pulse	E717-63, with connector
For Head-on Types											
E1761-04	10 mm (3/8")	6	Anode / -	1500	1500	0.41	1×10^{-10}	3.63	20 (at 1500 V)	DC / Pulse	
E1761-22	10 mm (3/8")	7	Anode / -	1500	1500	0.37	1×10^{-10}	4.02	19 (at 1500 V)	DC / Pulse	For R2496, with connector
E1761-05	10 mm (3/8")	8	Anode / -	1500	1500	0.37	1×10^{-10}	4.02	19 (at 1500 V)	DC / Pulse	For R2496
E849-35	13 mm (1/2")	9	Anode / -	1500	1250	0.34	1×10^{-10}	3.63	17 (at 1250 V)	DC / Pulse	
E849-90	13 mm (1/2")	10	Anode / -	1500	1250	0.34	1×10^{-10}	3.63	17 (at 1250 V)	DC / Pulse	E849-35, with connector
E849-68	13 mm (1/2")	11	Anode / -	1500	1250	0.27	1×10^{-10}	4.48	13 (at 1250 V)	DC / Pulse	For R4124
E849-52	13 mm (1/2")	12	Anode / -	1500	1250	0.31	1×10^{-10}	3.98	15 (at 1250 V)	DC / Pulse	For R2557, with connector
E974-13	19 mm (3/4")	13	Anode / -	1800	1800	0.47	1×10^{-10}	3.81	23 (at 1800 V)	DC / Pulse	
E974-14	19 mm (3/4")	14	Cathode / +	1800	1800	0.47	—	3.81	—	Pulse	For Scintillation Counting
E974-17	19 mm (3/4")	15	Anode / -	1800	1800	0.47	1×10^{-10}	3.81	23 (at 1800 V)	DC / Pulse	E974-13, with connector
E974-22	19 mm (3/4")	16	Anode / -	1800	1800	0.43	1×10^{-10}	4.16	21 (at 1800 V)	DC / Pulse	For R1450, with connector
E2253-05	19 mm (3/4")	17	Anode / -	1800	1800	0.35	1×10^{-10}	5.13	17 (at 1800 V)	DC / Pulse	For R3478, with connector
E2253-08	19 mm (3/4")	18	Cathode / +	1800	1800	0.35	—	5.13	—	Pulse	For R3478, for Scintillation Counting
E974-18	19 mm (3/4")	19	Anode / -	1500	1500	0.37	1×10^{-10}	3.98	18 (at 1500 V)	DC / Pulse	For R1878, with connector
E2924-11	25 mm (1")	20	Anode / -	1800	1800	0.41	1×10^{-10}	4.47	20 (at 1800 V)	DC / Pulse	For R7899
E2924	25 mm (1")	21	Anode / -	1500	1250	0.29	1×10^{-10}	4.29	14 (at 1250 V)	DC / Pulse	
E2924-500	25 mm (1")	22	Anode / -	1500	1250	0.29	1×10^{-10}	4.29	14	DC / Pulse	E2924, with connector
E2924-05	25 mm (1")	23	Cathode / +	1500	1250	0.29	—	4.30	—	Pulse	For Scintillation Counting
E990-07	28 mm (1-1/8")	24	Anode / -	1500	1500	0.38	1×10^{-10}	3.96	18 (at 1500 V)	DC / Pulse	
E990-08	28 mm (1-1/8")	25	Cathode / +	1500	1500	0.38	—	3.96	—	Pulse	For Scintillation Counting
E990-501	28 mm (1-1/8")	26	Anode / -	1500	1500	0.38	1×10^{-10}	3.96	18 (at 1500 V)	DC / Pulse	E990-07, with connector
E2624	28 mm (1-1/8")	27	Anode / -	2500	2500	0.52	1×10^{-10}	4.80	26 (at 2500 V)	DC / Pulse	For R6427,
E2624-05	28 mm (1-1/8")	28	Cathode /+	2500	2500	0.52	—	4.80	—	Pulse	For R6427, for Scintillation Counting
E2624-14	28 mm (1-1/8")	29	Anode / -	2500	2500	0.52	1×10^{-10}	4.80	26 (at 2500 V)	DC / Pulse	E2624, with connector

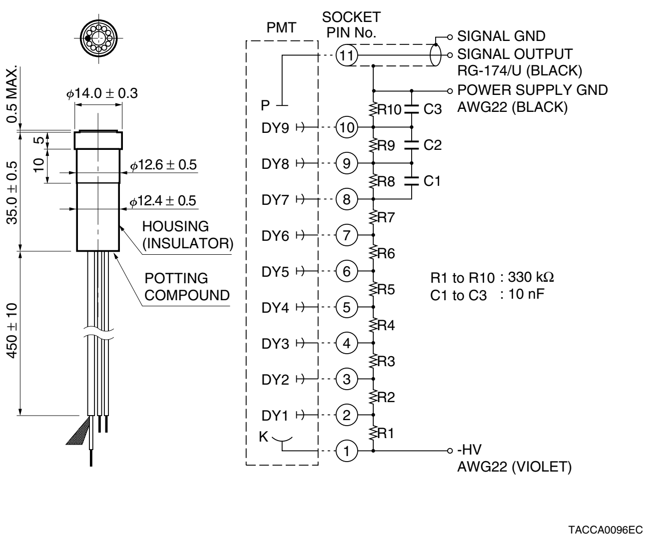
NOTE: (A) Measured with the maximum supply voltage
(B) Measured with a supply voltage of 1000 V except for E5996, E7083 and E6736 (900 V)
(C) The current at which the output linearity is kept within ±5 %

Socket Assembly Type No.	Applicable PMT Diameter	Outline and Diagram	Grounded Electrode / Supply Voltage Polarity	Maximum Ratings: Insulation Voltage between Case and Pins (V)	Maximum Ratings: Supply Voltage (V)	Maximum Ratings: Ⓐ Voltage Divider Current (mA)	Ⓑ Leakage Current in Signal Max. (A)	Total Voltage Divider Resistance (MΩ)	Ⓒ Maximum Linear Output in DC Mode (μA)	Signal Output	Note
For Head-on Types											
E990-500	28 mm (1-1/8")	30	Anode / -	1500	1500	0.35	1×10^{-10}	4.29	17 (at 1500 V)	DC / Pulse	With connector
E990-29		31	Anode / -	1500	1500	0.34	1×10^{-10}	4.48	16 (at 1500 V)	DC / Pulse	For R3998-02
E2183-500	38 mm (1-1/2")	32	Anode / -	2000	1750	0.45	1×10^{-10}	3.97	22 (at 1750 V)	DC / Pulse	With connector
E2183-502		33	Cathode / +	2000	1750	0.45	—	3.96	—	Pulse	With connector, for scintillation counting
E1198-26	51 mm (2") 76 mm (3")	34	Anode / -	1500	1500	0.38	1×10^{-10}	4.01	18 (at 1500 V)	DC / Pulse	
E1198-27		35	Cathode / +	1500	1500	0.38	—	4.01	—	Pulse	For scintillation counting
E1198-05		36	Anode / -	1500	1500	0.46	1×10^{-10}	3.3	22 (at 1500 V)	DC / Pulse	
E1198-20		37	Cathode / +	1500	1500	0.46	—	3.3	—	Pulse	For scintillation counting
E1198-07	51 mm (2")	38	Anode / -	1750	1750	0.44	1×10^{-10}	3.98	22 (at 1750 V)	DC / Pulse	For R2154-02
E2979-500		39	Anode / -	3000	3000	0.70	1×10^{-10}	4.31	34 (at 3000 V)	DC / Pulse	For R1828-01, with rear panel connector, with magnetic shield
E1198-23	51 mm (2") 76 mm (3") 127 mm (5")	40	Cathode / +	2200	2000	0.50	—	3.97	—	Pulse	For scintillation counting
E1198-22		41	Anode / -	2200	2000	0.50	1×10^{-10}	3.97	25 (at 2000 V)	DC / Pulse	
E6316		42	Cathode / +	2200	2000	0.50	—	3.97	—	Pulse	E1198-23, with rear panel connector, for scintillation counting
E6316-01		43	Anode / -	2200	2000	0.50	1×10^{-10}	3.97	25 (at 2000 V)	DC / Pulse	E1198-22, with rear panel connector
E5859-05	51 mm (2") 76 mm (3")	44	Anode / -	1500	1500	0.38	1×10^{-10}	3.98	18 (at 1500 V)	DC / Pulse	With rear panel connector
E5859-19		45	Anode / -	-2000	2000	0.57	1×10^{-10}	3.53	28 (at 2000 V)	DC / Pulse	For R7724 with rear panel connector
E5859		46	Anode / -	2700	2700	0.67	1×10^{-10}	4.06	33 (at 2700 V)	DC / Pulse	With rear panel connector
E5859-01		47	Anode / -	2700	2700	0.75	1×10^{-10}	3.62	37 (at 2700 V)	DC / Pulse	With rear panel connector
E5859-03		48	Cathode / +	2700	2700	0.75	—	3.63	—	Pulse	With rear panel connector, for scintillation counting
E1435-02	51 mm (2")	49	Anode / -	1500	1500	0.38	1×10^{-10}	3.96	18 (at 1500 V)	DC / Pulse	
E7693	127 mm (5")	50	Anode / -	3000	3000	1.02	1×10^{-10}	2.94	51 (at 3000 V)	DC / Pulse	For R1250, for R1584, with rear panel connector
E10679	Metal Package PMT R9880U Series	51	Anode / -	1250	1250	0.36	1×10^{-10}	3.46	18 (at 1250 V)	DC / Pulse	
E5996	Metal Package PMT R7600U Series	52	Anode / -	900	900	0.33	1×10^{-10}	2.75	16 (at 900 V)	DC / Pulse	
E7083	Metal Package PMT R7600U-M4 Series	53	Anode / -	900	900	0.33	1×10^{-10}	2.75	4 Ⓓ (at 900 V)	DC / Pulse	
E6736	Metal Package PMT R5900U-L16	54	Anode / -	900	900	0.38	1×10^{-10}	2.42	1.16 Ⓓ (at 900 V)	DC / Pulse	
E10411	Metal Package PMT R8900U	55	Anode / -	1000	1000	0.37	1×10^{-10}	2.74	18 (at 1000 V)	DC / Pulse	
E9349	Metal Package PMT R8900-00-M16	56	Anode / -	1000	1000	0.35	1×10^{-10}	2.86	1.0 Ⓓ (at 1000 V)	DC / Pulse	
E7514	Metal Package PMT R8900U-C12	57	Anode / -	1000	1000	0.34	1×10^{-10}	2.97	1.4 Ⓓ (at 1000 V)	DC / Pulse	
E6133-04	For High Magnetic Environments 25 mm (1")	58	Cathode / +	2500	2500	0.45	—	5.62	—	Pulse	For R5505, with connector

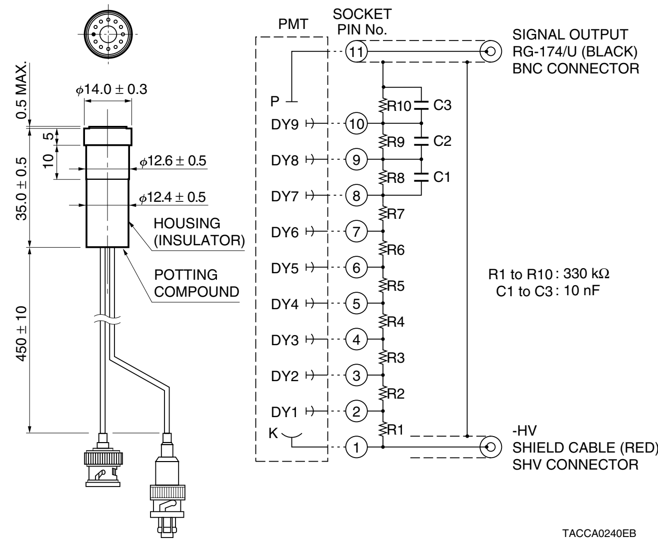
NOTE: Ⓓ Current of one anode

CAUTION: Socket assemblies are not designed to operate in a vacuum.
Temperature ranges of D-type socket assemblies are as follows (except for some products):
Operating: 0 °C to +50 °C
Storage: -15 °C to +60 °C
Do not use the socket assemblies if condensation occurs, since a high voltage is output from the socket.
Insert the photomultiplier tube all the way into the socket.
Insert the photomultiplier tube straight into the socket, or pull the photomultiplier tube straight out of the socket when removing it.

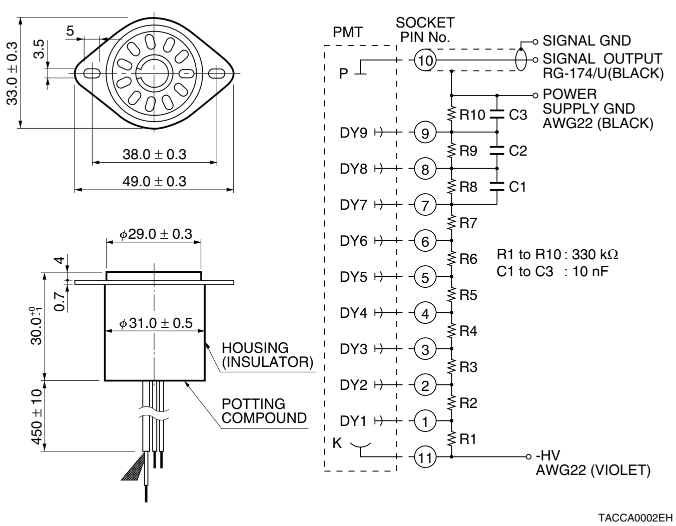
1 E850-13



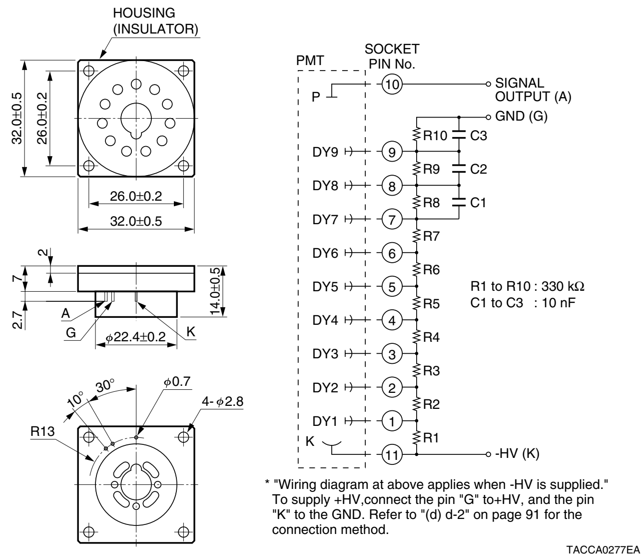
2 E850-22



3 E717-63

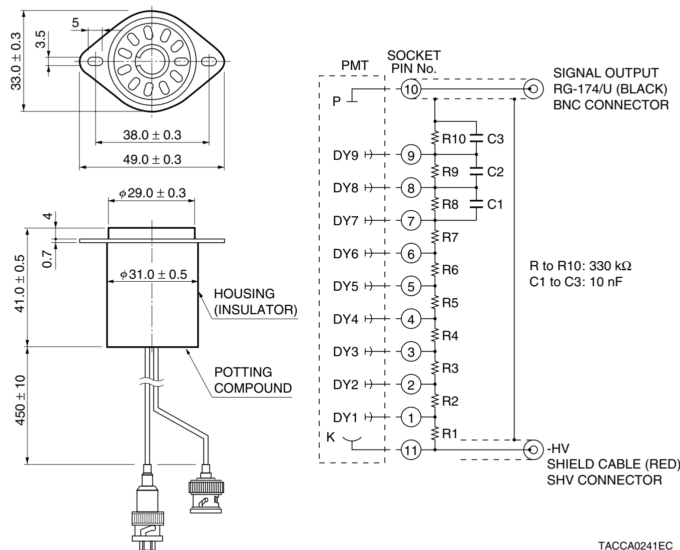


4 E717-74

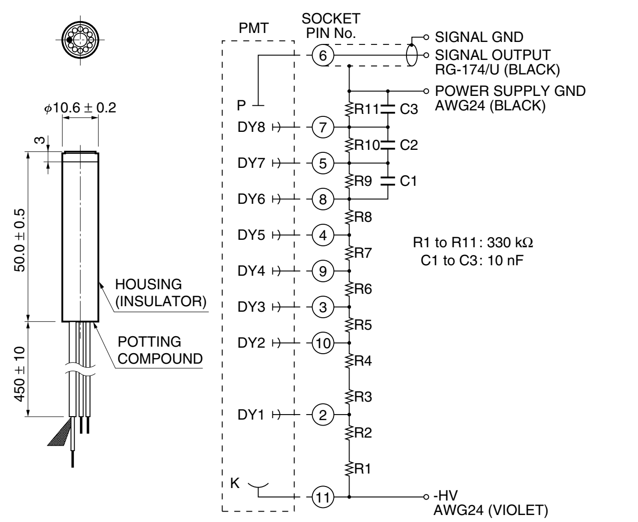


* "Wiring diagram at above applies when -HV is supplied." To supply +HV,connect the pin "G" to+HV, and the pin "K" to the GND. Refer to "(d) d-2" on page 91 for the connection method.

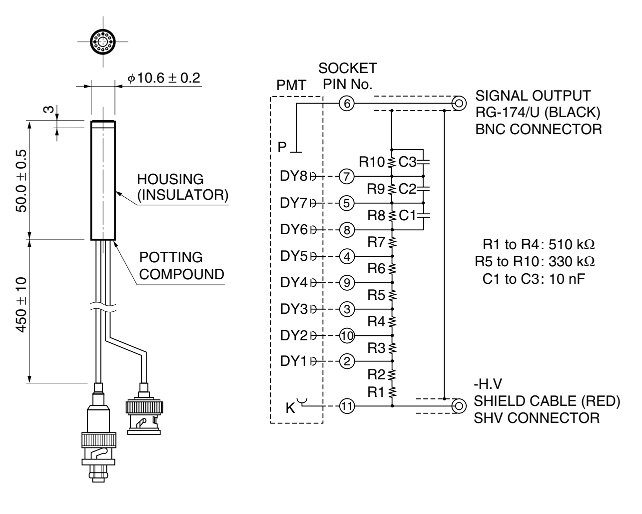
5 E717-500



6 E1761-04



⑦ E1761-22



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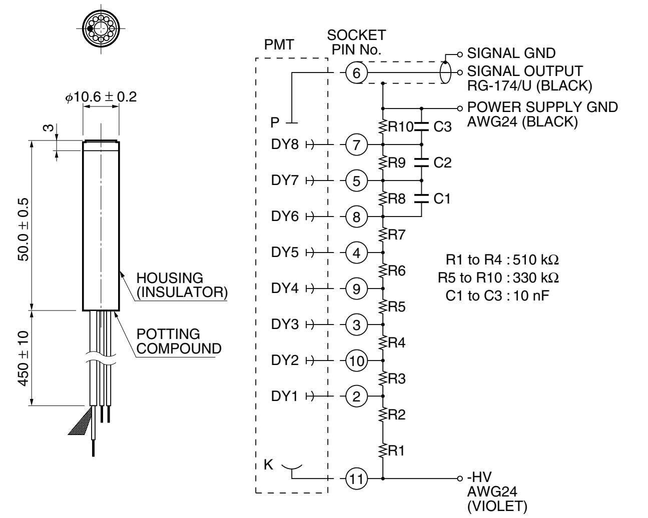
⑧ E1761-05



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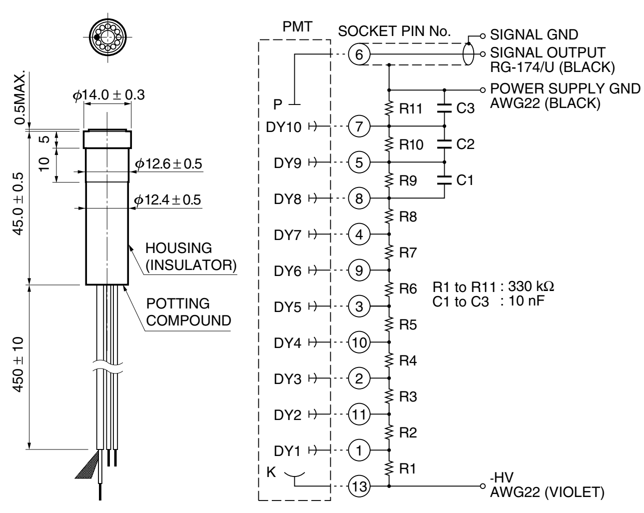
⑨ E849-35



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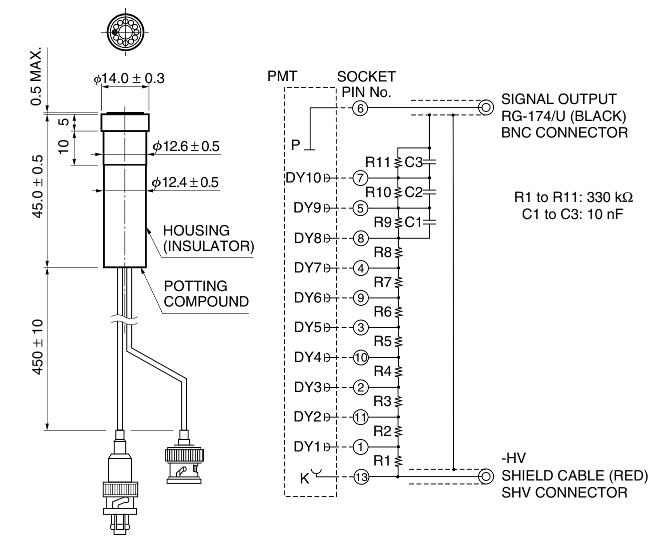
⑩ E849-90



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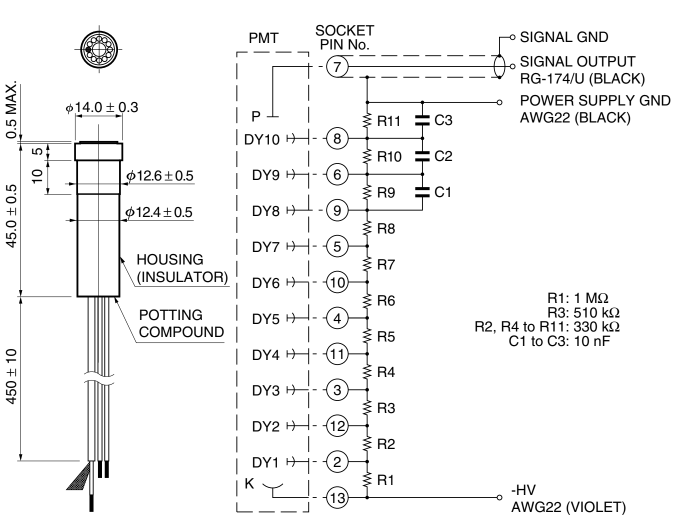
⑪ E849-68



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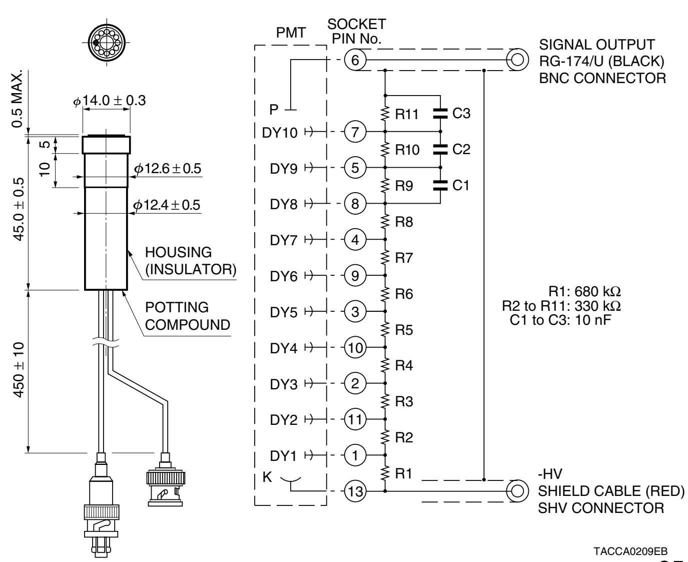
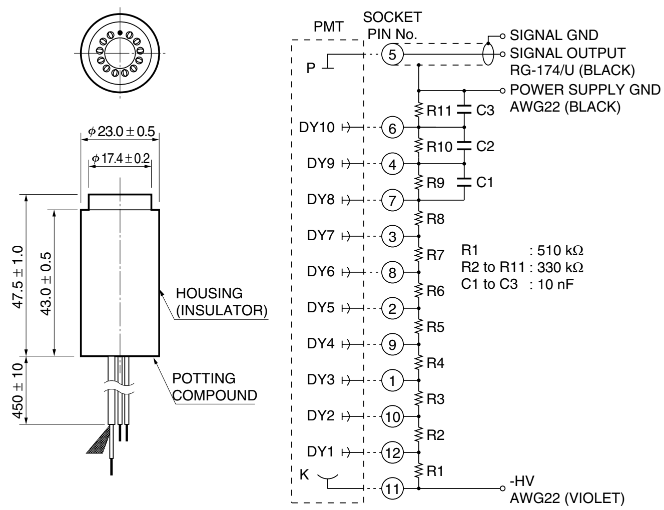
⑫ E849-52



TACCA0209EB

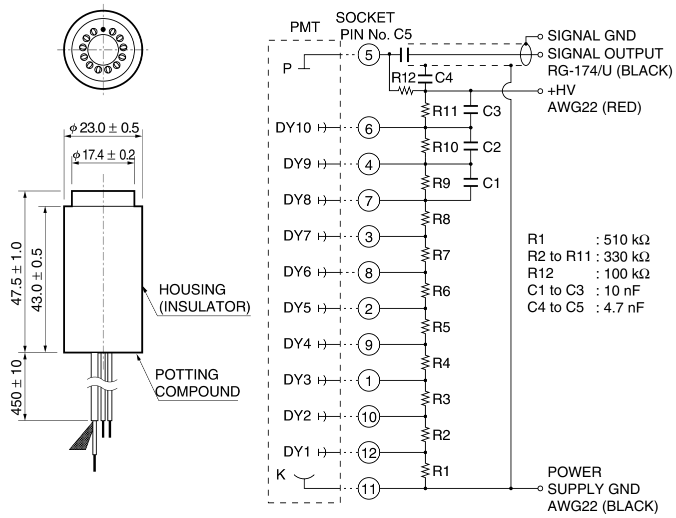
D-Type Socket Assemblies Dimensional Outlines and Diagrams (Unit: mm)

⑬ E974-13



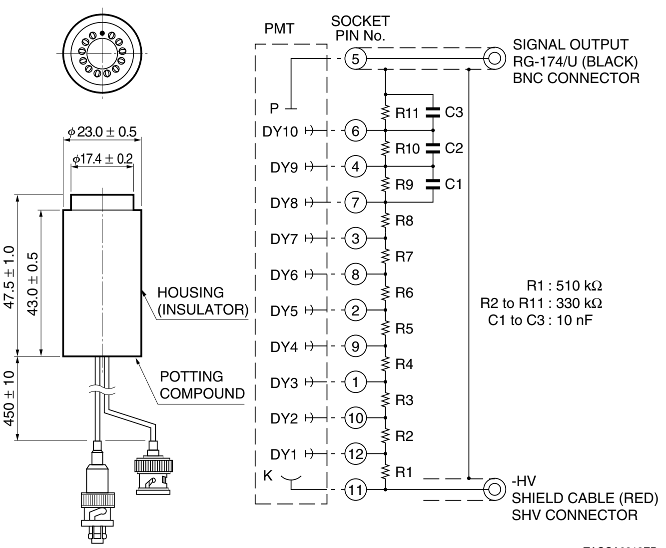
TACCA0099EB

⑭ E974-14



TACCA0100EB

⑮ E974-17



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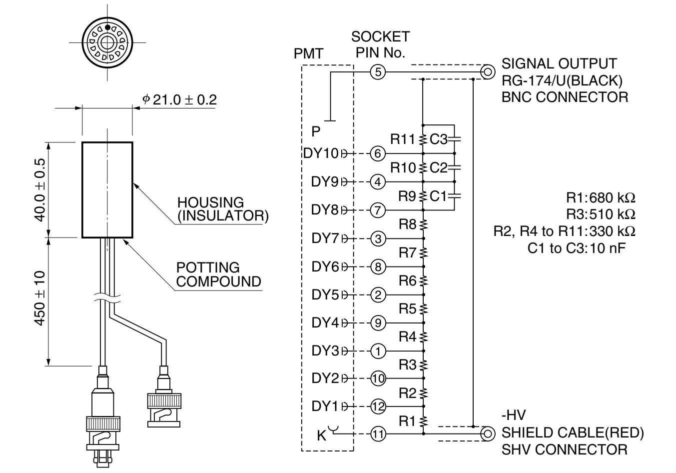
⑯ E974-22



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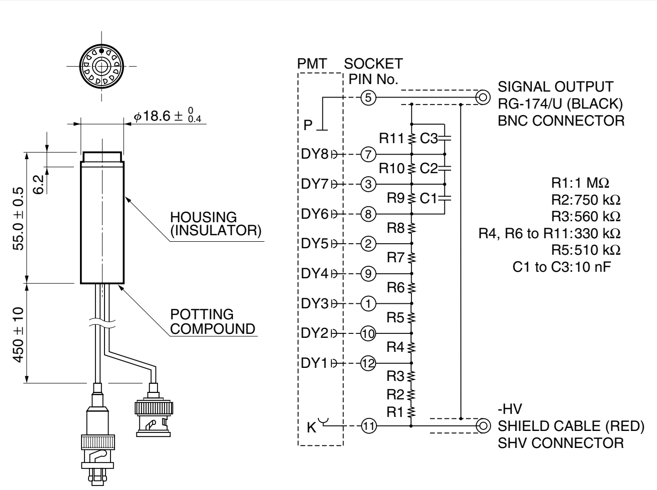
⑰ E2253-05



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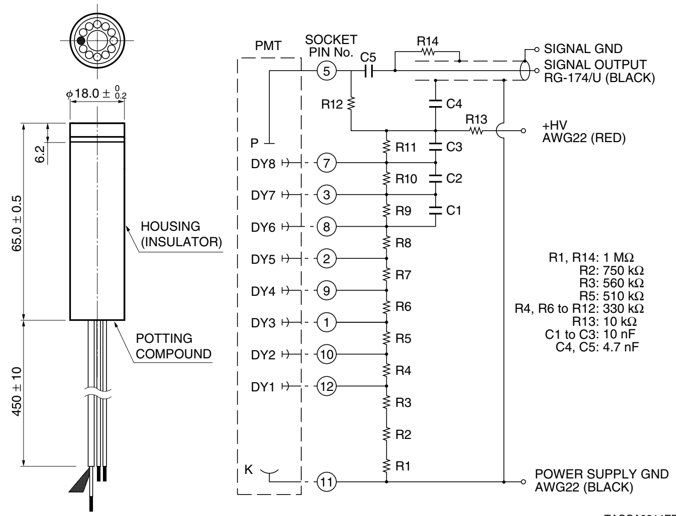
⑱ E2253-08



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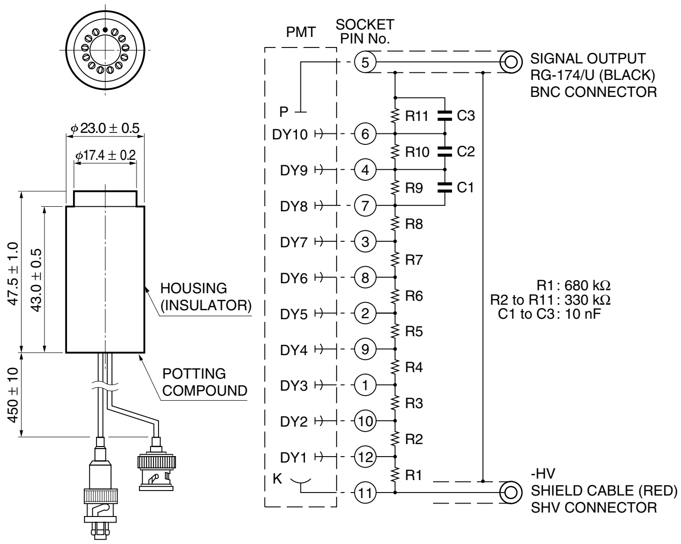
⑲ E974-18



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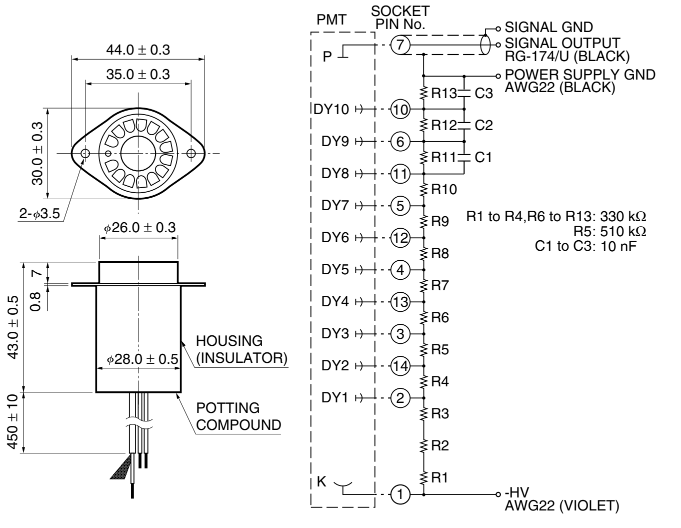
⑳ E2924-11



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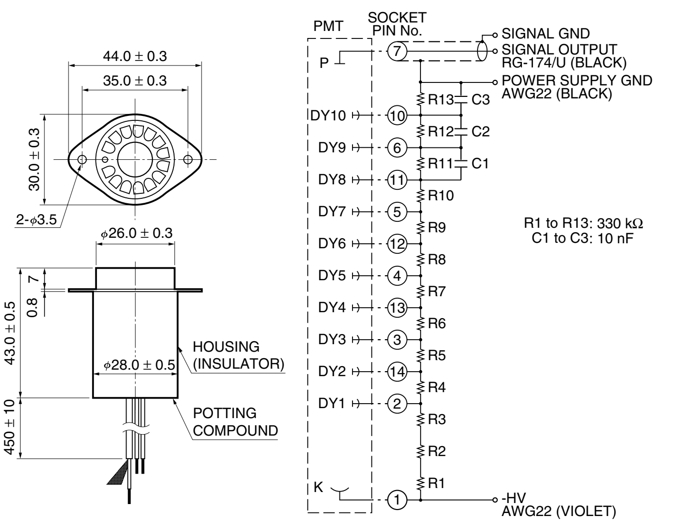
㉑ E2924



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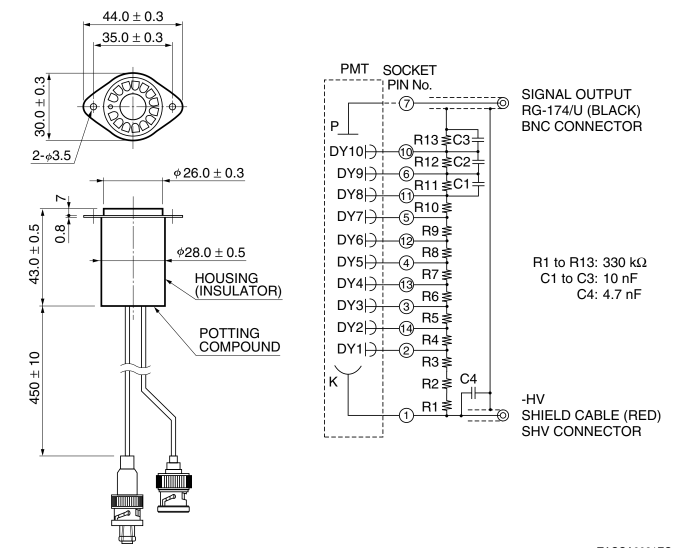
㉒ E2924-500



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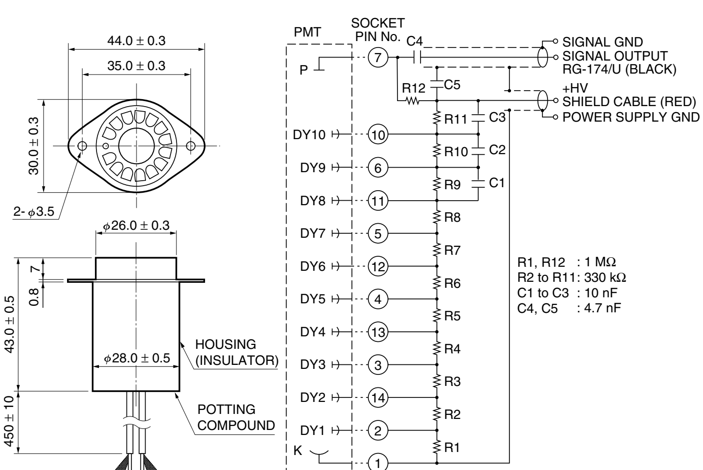
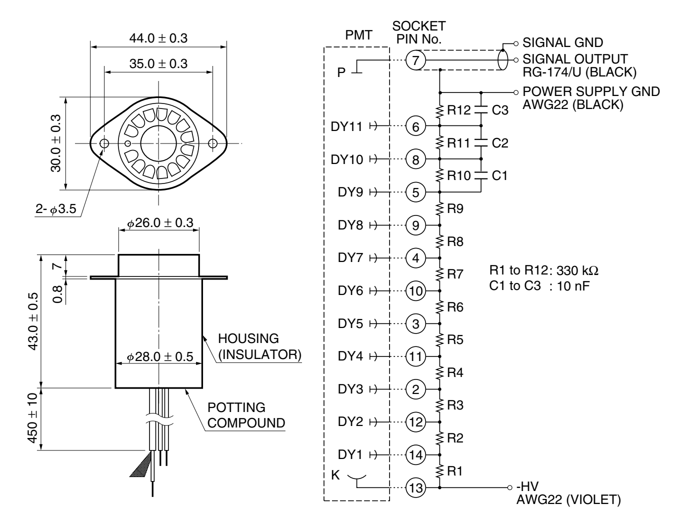
㉓ E2924-05



* High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0102EA

㉔ E990-07



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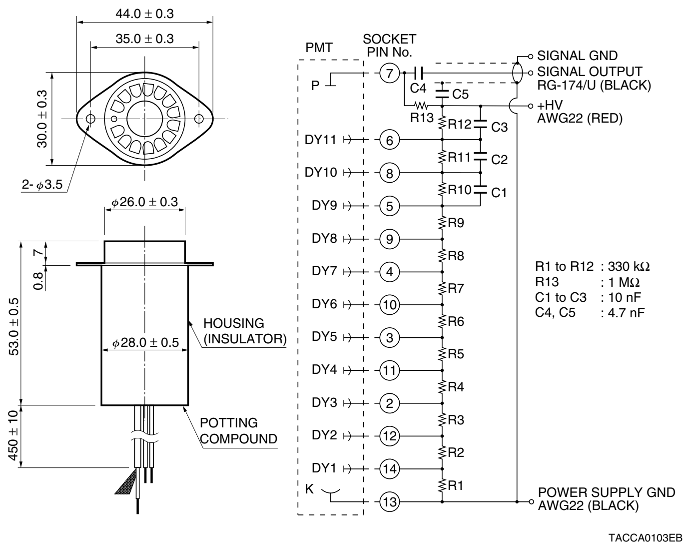
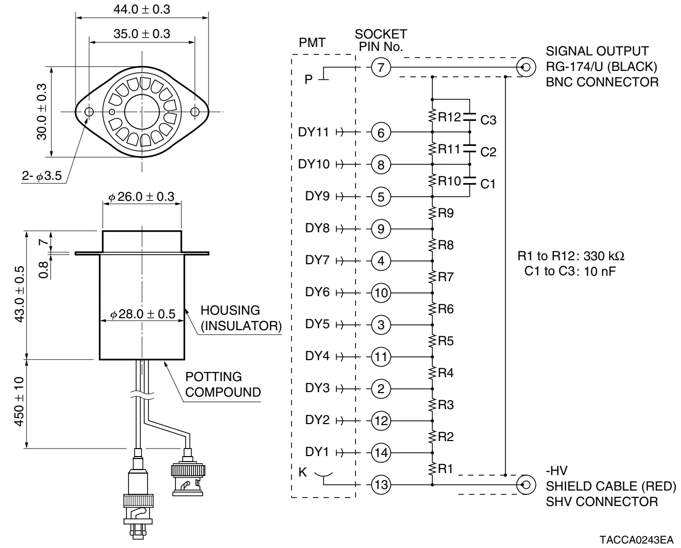
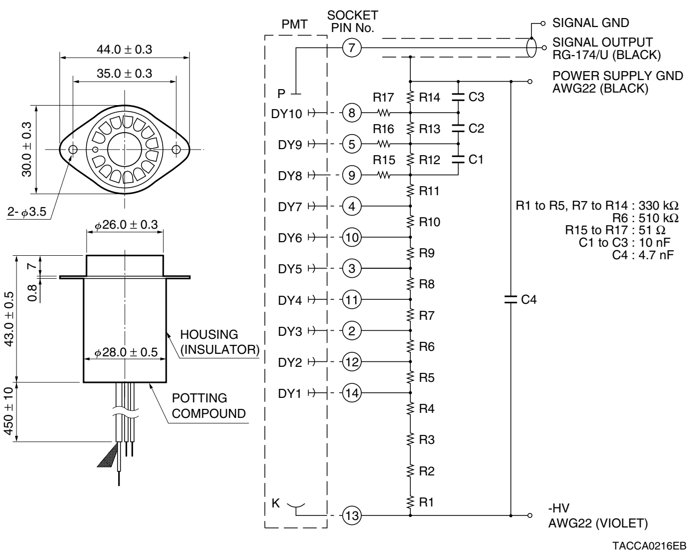
㉕ E990-08



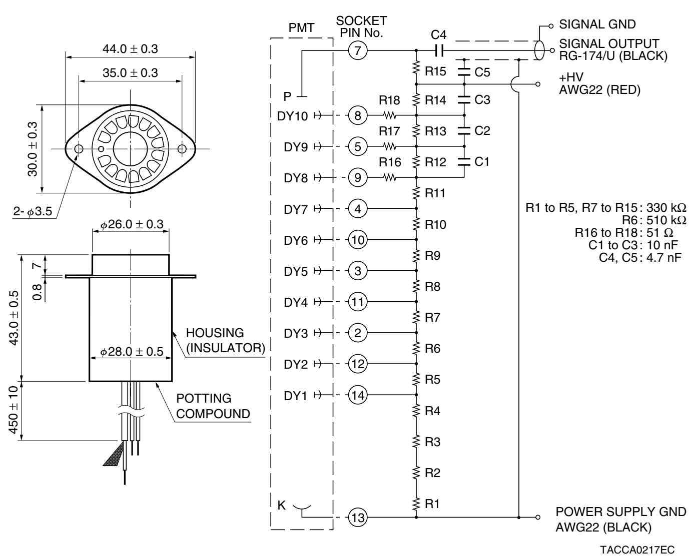
㉖ E990-501



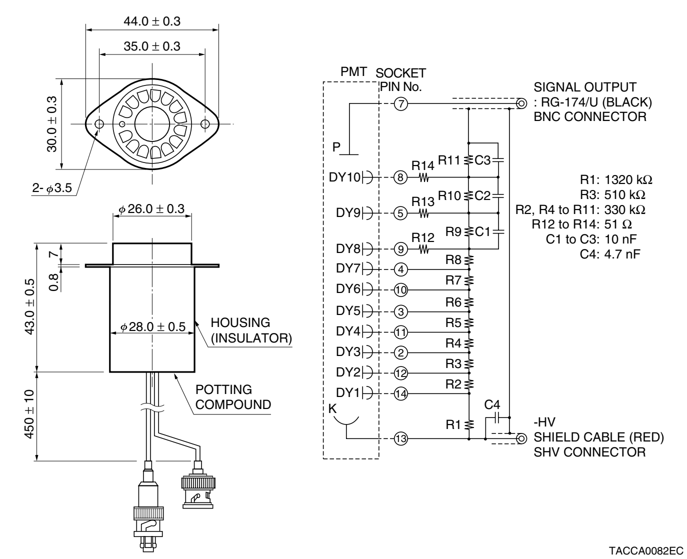
㉗ E2624



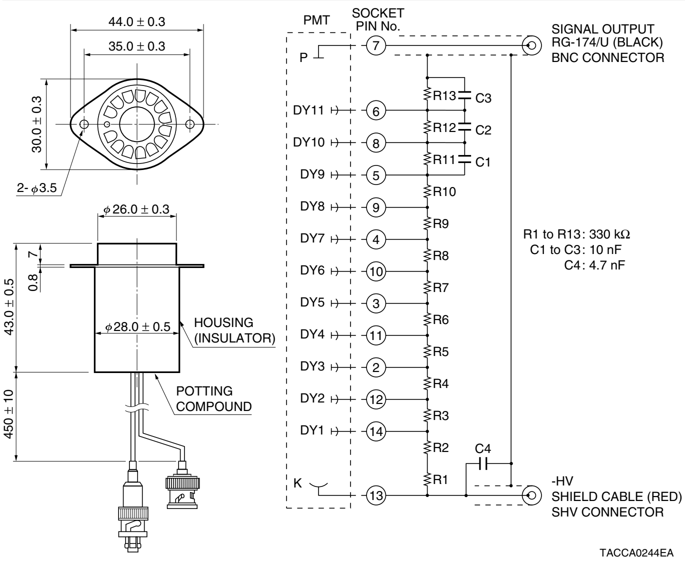
㉘ E2624-05



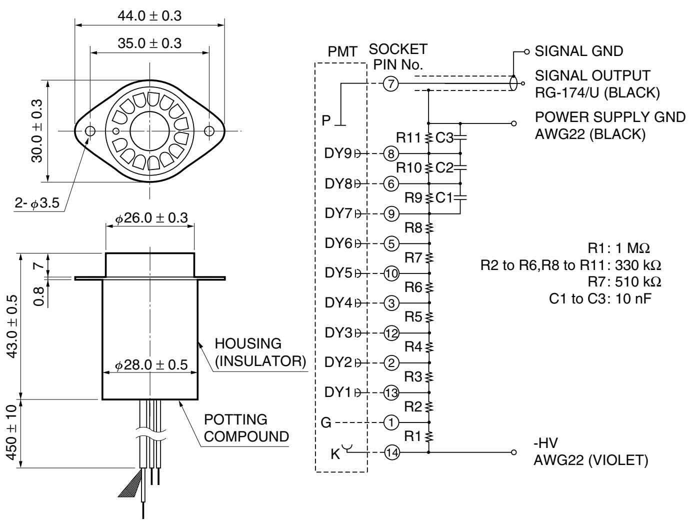
㉙ E2624-14



㉚ E990-500



㉛ E990-29



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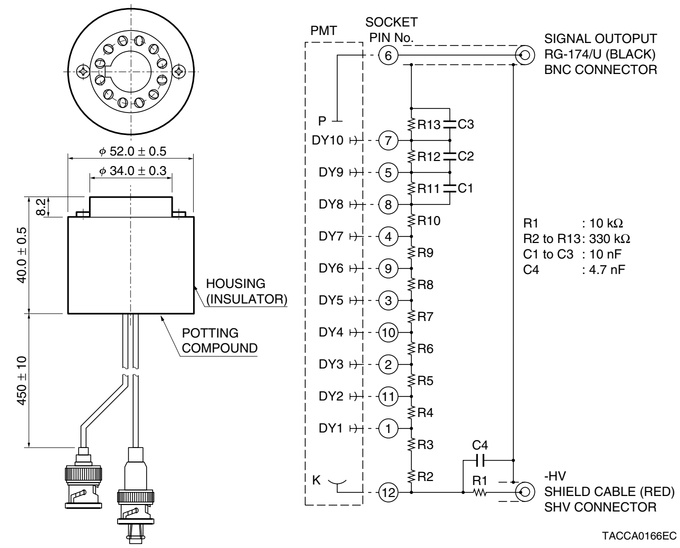
㉜ E2183-500



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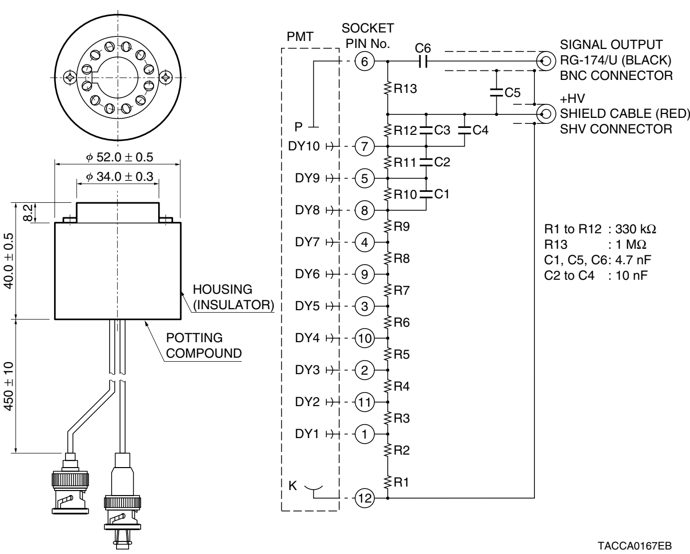
㉝ E2183-502



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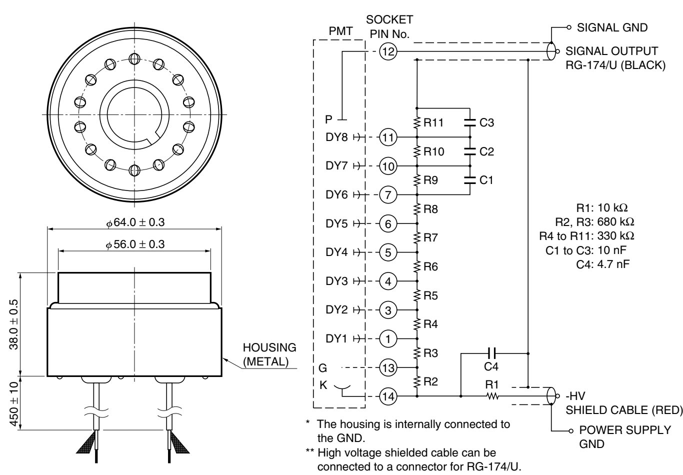
㉞ E1198-26

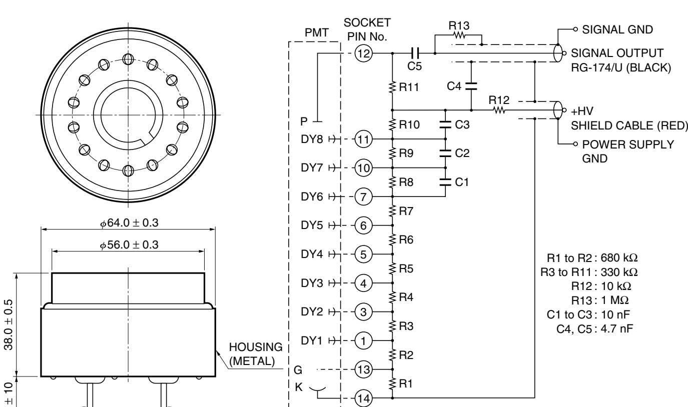


* The housing is internally connected to the GND.

** High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0224EC

㉟ E1198-27

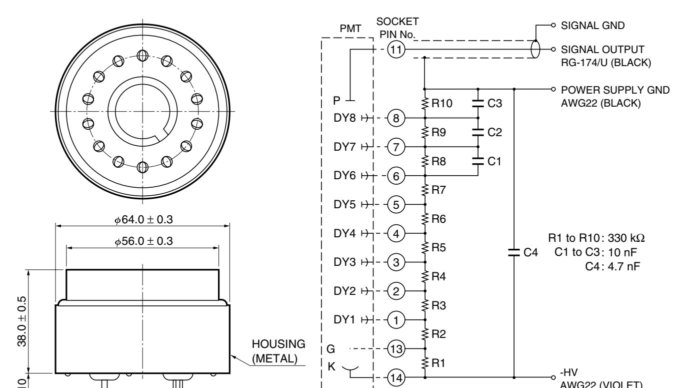


* The housing is internally connected to the GND.

** High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0225EB

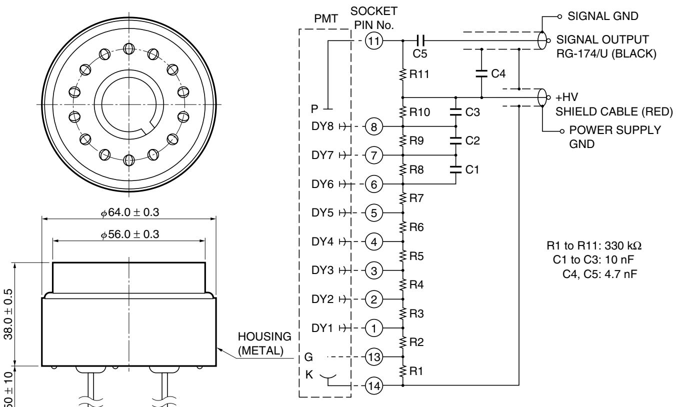
㊱ E1198-05



* The housing is internally connected to the GND.

TACCA0221EB

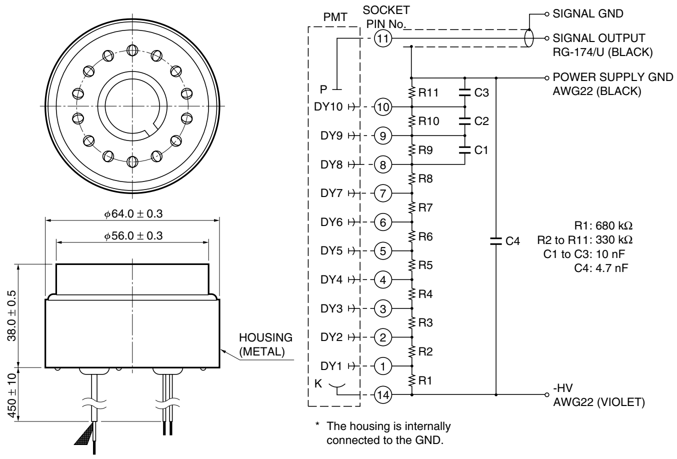
37 E1198-20



* The housing is internally connected to the GND.
** High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0223EB

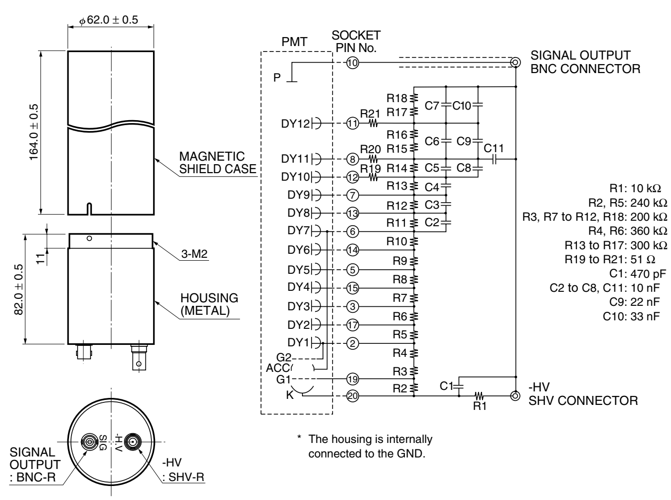
38 E1198-07



* The housing is internally connected to the GND.

TACCA0220EC

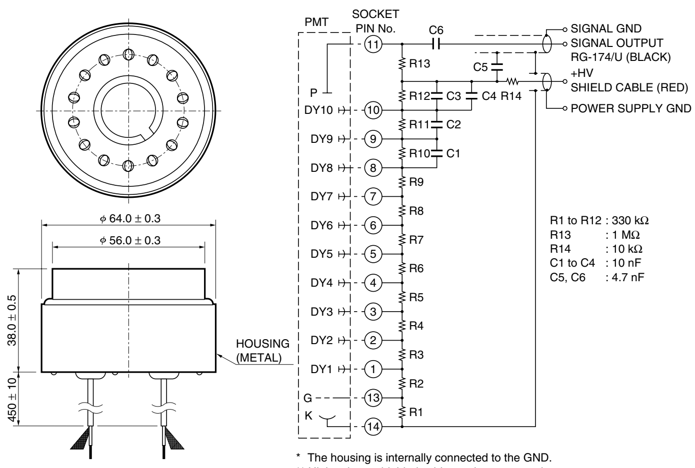
39 E2979-500



* The housing is internally connected to the GND.

TACCA0093EB

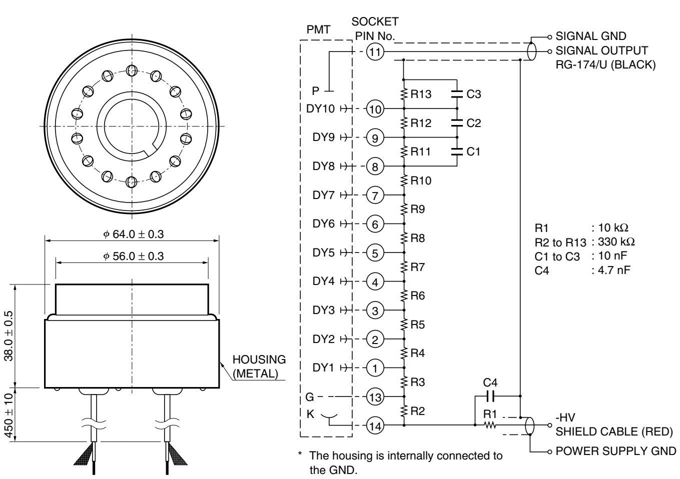
40 E1198-23



* The housing is internally connected to the GND.
** High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0169EC

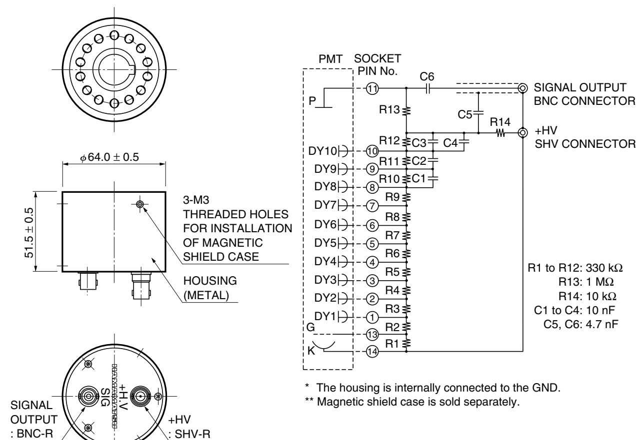
41 E1198-22



* The housing is internally connected to the GND.
** High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0168EB

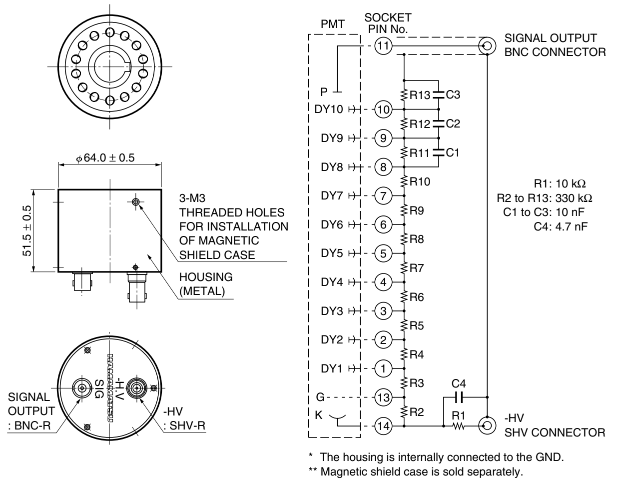
42 E6316



* The housing is internally connected to the GND.
** Magnetic shield case is sold separately.

TACCA0226EC

㊸ E6316-01

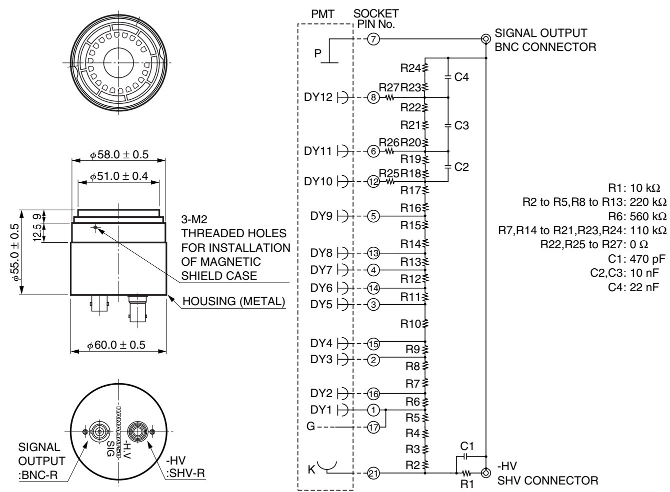


R1: 10 kΩ
R2 to R13: 330 kΩ
C1 to C3: 10 nF
C4: 4.7 nF

* The housing is internally connected to the GND.
** Magnetic shield case is sold separately.

TACCA0245EB

㊹ E5859-05

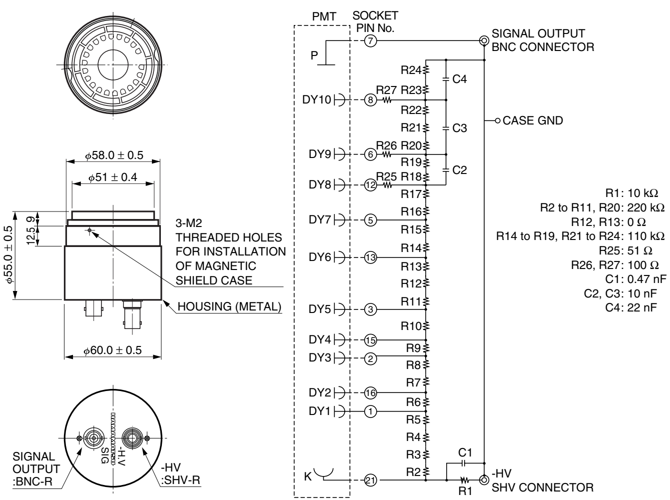


R1: 10 kΩ
R2 to R5,R8 to R13: 220 kΩ
R6: 560 kΩ
R7,R14 to R21,R23,R24: 110 kΩ
R22,R25 to R27: 0 Ω
C1: 470 pF
C2,C3: 10 nF
C4: 22 nF

* The housing is internally connected to the GND.
** Magnetic shield case is sold separately.

TACCA0219EC

㊺ E5859-19

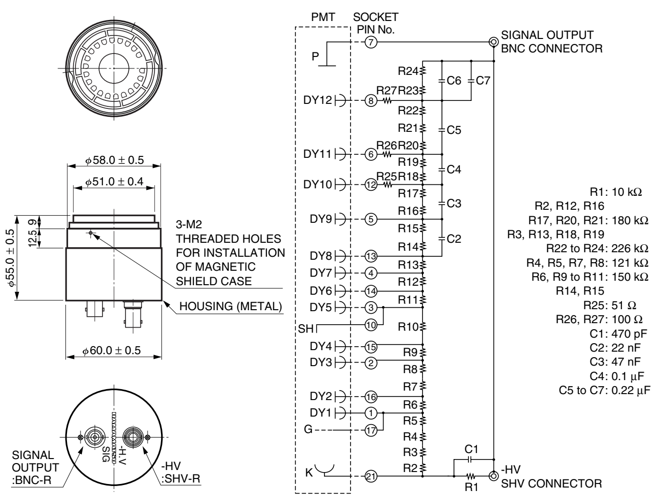


R1: 10 kΩ
R2 to R11, R20: 220 kΩ
R12, R13: 0 Ω
R14 to R19, R21 to R24: 110 kΩ
R25: 51 Ω
R26, R27: 100 Ω
C1: 0.47 nF
C2, C3: 10 nF
C4: 22 nF

* The housing is internally connected to the GND.
** Magnetic shield case is sold separately.

TACCA0305EA

㊻ E5859

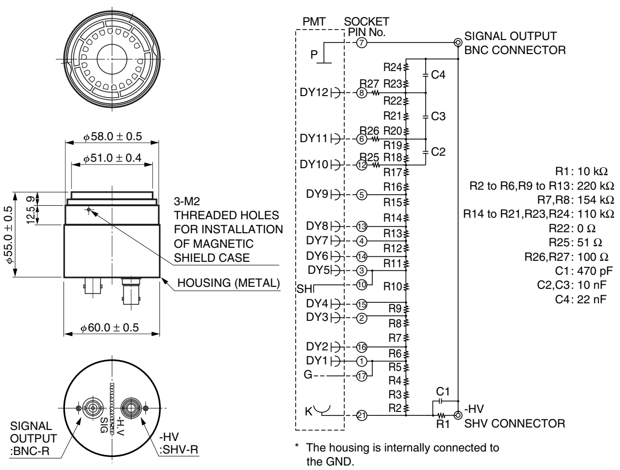


R1: 10 kΩ
R2, R12, R16
R17, R20, R21: 180 kΩ
R3, R13, R18, R19
R22 to R24: 226 kΩ
R4, R5, R7, R8: 121 kΩ
R6, R9 to R11: 150 kΩ
R14, R15
R25: 51 Ω
R26, R27: 100 Ω
C1: 470 pF
C2: 22 nF
C3: 47 nF
C4: 0.1 µF
C5 to C7: 0.22 µF

* The housing is internally connected to the GND.
** Magnetic shield case is sold separately.

TACCA0176ED

㊼ E5859-01

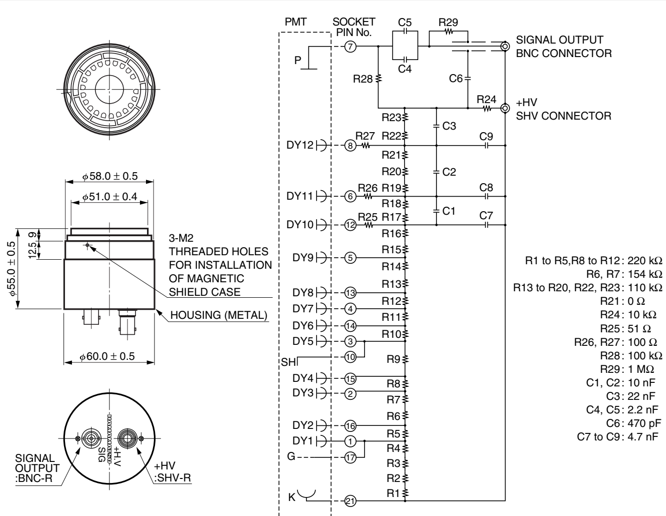


R1: 10 kΩ
R2 to R6,R9 to R13: 220 kΩ
R7,R8: 154 kΩ
R14 to R21,R23,R24: 110 kΩ
R22: 0 Ω
R25: 51 Ω
R26,R27: 100 Ω
C1: 470 pF
C2,C3: 10 nF
C4: 22 nF

* The housing is internally connected to the GND.
** Magnetic shield case is sold separately.

TACCA0178EC

㊽ E5859-03



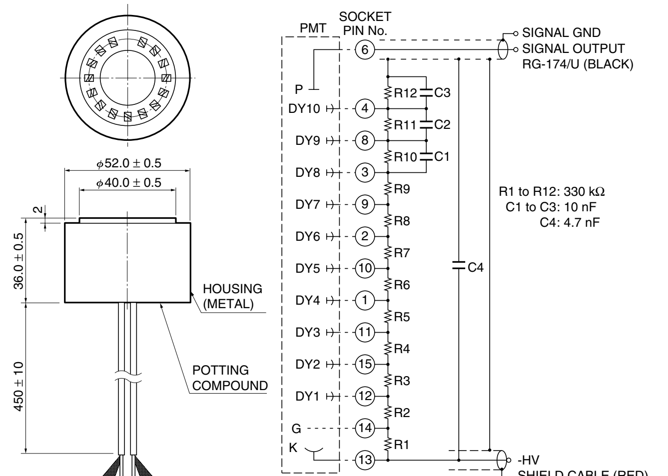
R1 to R5,R8 to R12: 220 kΩ
R6, R7: 154 kΩ
R13 to R20, R22, R23: 110 kΩ
R21: 0 Ω
R24: 10 kΩ
R25: 51 Ω
R26, R27: 100 Ω
R28: 100 kΩ
R29: 1 MΩ
C1, C2: 10 nF
C3: 22 nF
C4, C5: 2.2 nF
C6: 470 pF
C7 to C9: 4.7 nF

* The housing is internally connected to the GND.
** Magnetic shield case is sold separately.

TACCA0218EE

D-Type Socket Assemblies Dimensional Outlines and Diagrams (Unit: mm)

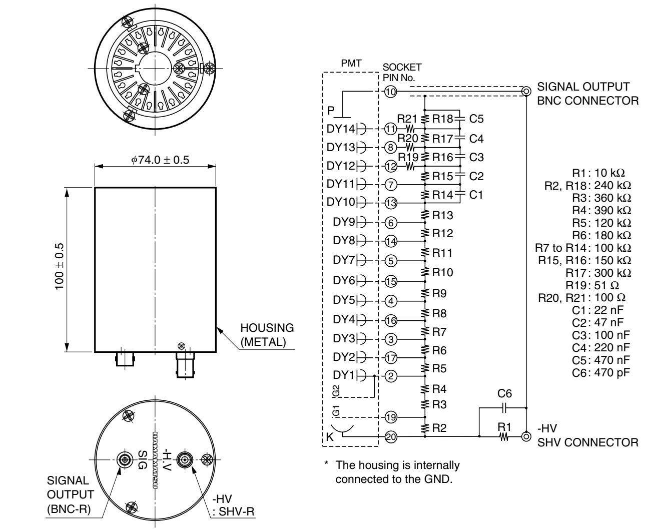
㊾ E1435-02



* The housing is internally connected to the GND.
** High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0246EB

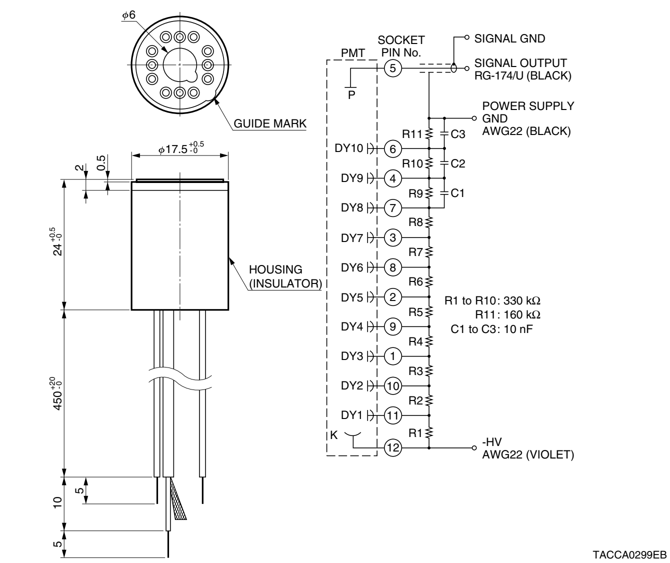
㊿ E7693



* The housing is internally connected to the GND.

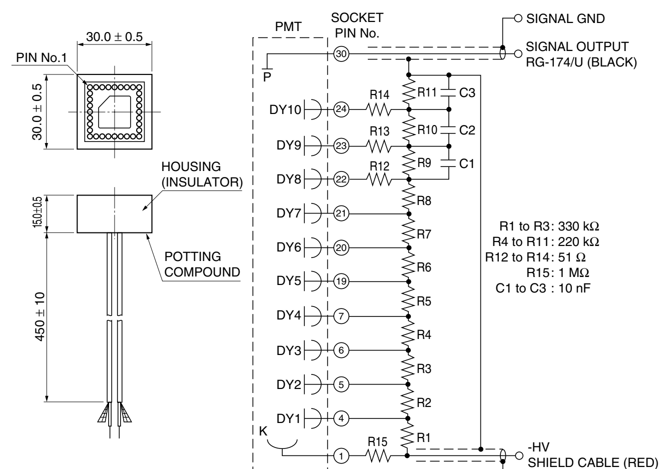
TACCA0227EC

51 E10679



TACCA0299EB

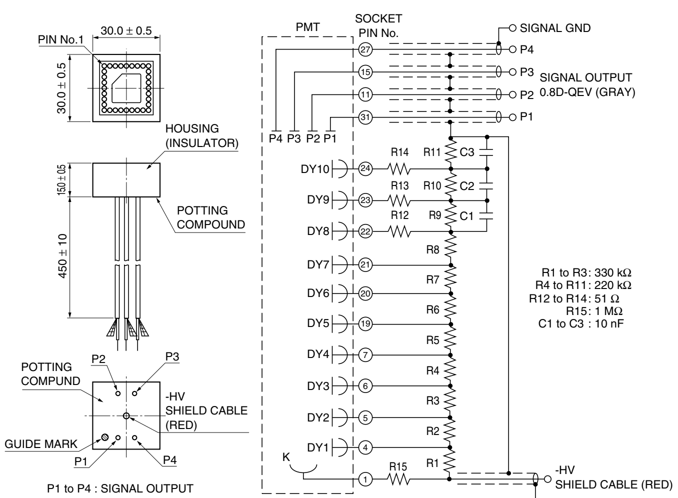
52 E5996



* High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0234EC

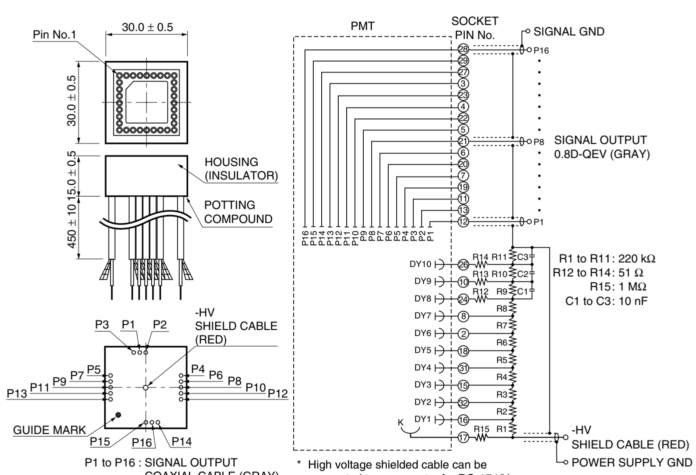
53 E7083



* High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0162ED

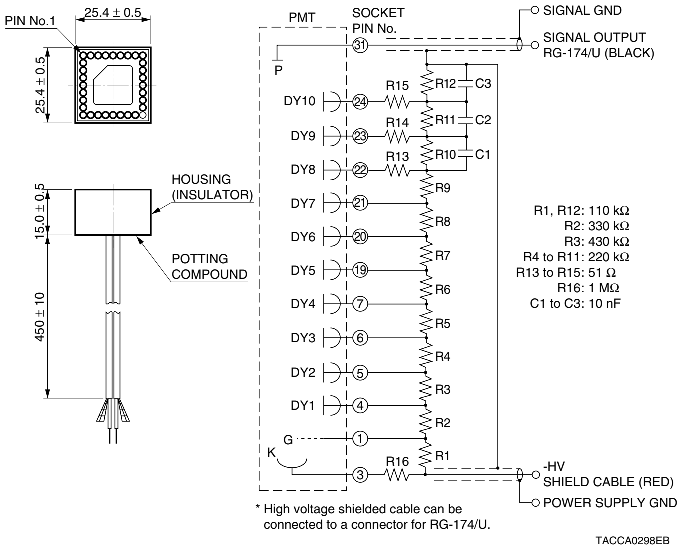
54 E6736



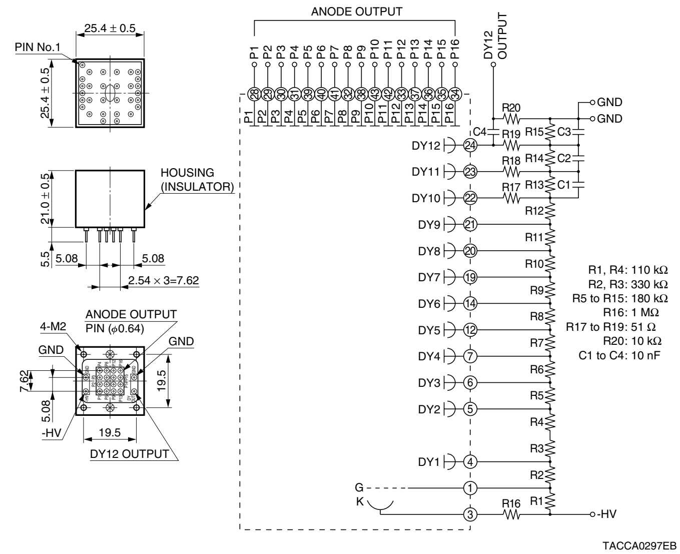
* High voltage shielded cable can be connected to a connector for RG-174/U.

TACCA0158ED

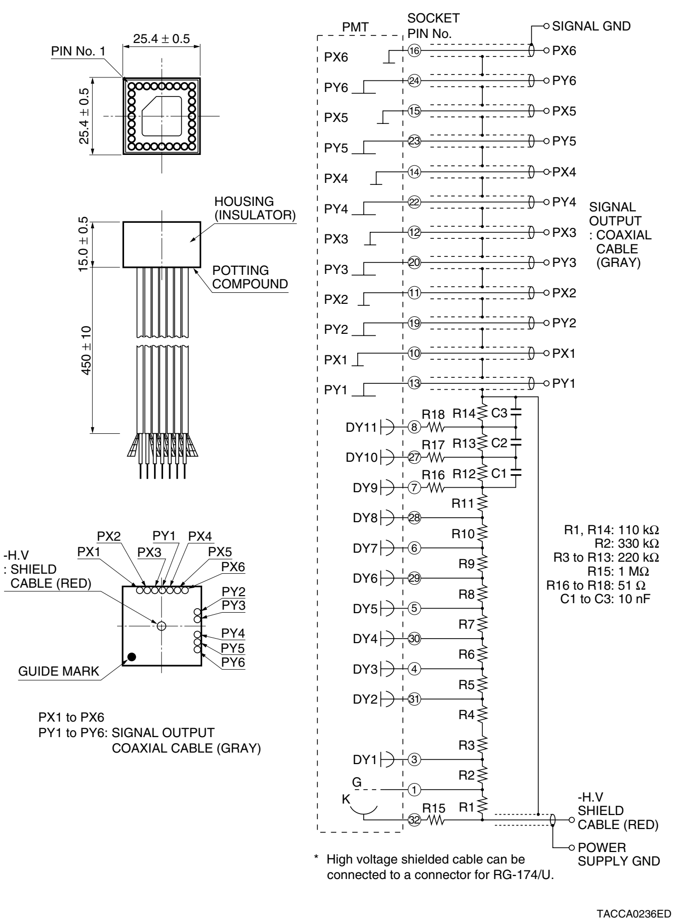
55 E10411



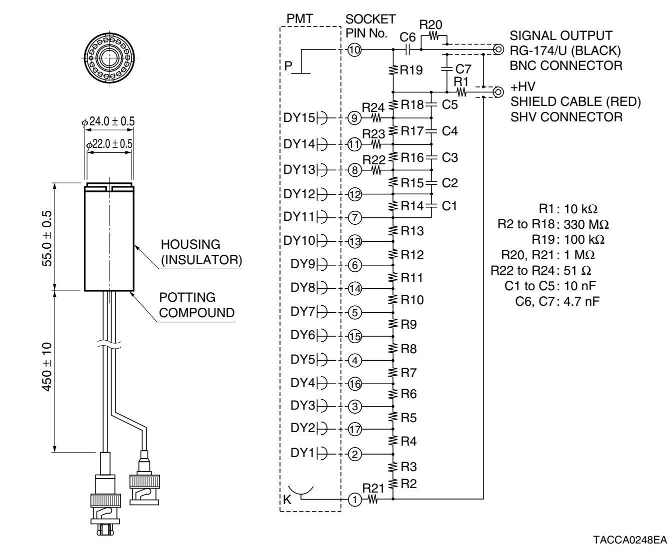
56 E9349



57 E7514



58 E6133-04



DA-TYPE SOCKET ASSEMBLIES C7246 SERIES, C7247 SERIES

The C7246 and C7247 series are DA type socket assemblies designed for 28 mm (1-1/8 inch) diameter side-on and head-on photomultiplier tubes. A voltage-divider circuit and an amplifier are incorporated in the same package.
The C7247 series uses an amplifier with a wide bandwidth of DC to 5 MHz, while the C7246 uses an amplifier with a practical bandwidth of DC to 20 kHz to improve the effective S/N ratio. The photomultiplier tube low-level, high-impedance current can be converted into a low-impedance voltage output.
Both the C7246 and C7247 series use an active voltage-divider circuit that ensures excellent DC linearity at low power consumption. The C7246 series also has a PMT gain adjustment function that does not affect amplifier frequency bandwidth.

Specifications

Parameter	C7246/C7246-22	C7246-01/C7246-23	C7247/C7247-22	C7247-01/C7247-23	Unit
Applicable PMTs	28 mm Dia. Head-on R374, R2228, R5929 R6094, R6095, etc.	28 mm Dia. Side-on	28 mm Dia. Head-on R374, R2228, R5929 R6094, R6095, etc.	28 mm Dia. Side-on	—

MAXIMUM RATINGS

Parameter	C7246/C7246-22	C7246-01/C7246-23	C7247/C7247-22	C7247-01/C7247-23	Unit
Supply Voltage for Amplifier	±18				V
Supply Voltage for Divider	-1500				V
Operating Ambient Temperature	0 to +40				°C
Storage Temperature	-15 to +60				°C

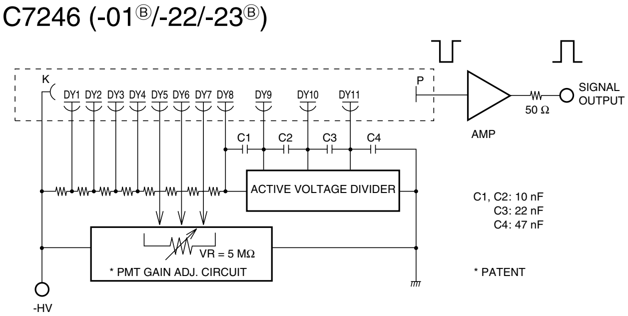
GENERAL

Parameter		C7246/C7246-22	C7246-01/C7246-23	C7247/C7247-22	C7247-01/C7247-23	Unit
Frequency Bandwidth (-3 dB)		DC to 20 kHz		DC to 5 MHz		—
Current to Voltage Conversion Factor		0.3 (at load resistance 10 kΩ)		0.15 (at load resistance 50 Ω)		V/μA
Maximum Output Signal Voltage		10 (at load resistance 10 kΩ)		3 (at load resistance 50 Ω)		V
Maximum Output Signal Current		18		60		mA
Output Impedance		50		50		Ω
Offset Voltage	Max.	±1		±3		mV
Output Noise Voltage (rms)	Typ.	0.09 (at load resistance 10 kΩ)		4.5 (at load resistance 50 Ω)		mV
PMT Gain Adjustable Range	Min.	10	30	—		dB
Supply Voltage for Amplifier		±12 to ±15		±12 to ±15		V
Supply Current for Amplifier (at ±15 V)	Max.	+20 / -0.53		+140 / -50		mA
Recommended Supply Voltage for Divider		-400 to -1000 Ⓐ	-300 to -1000 Ⓐ	-400 to -900	-300 to -600	V
Divider Current	Typ.	174 (at HV = -1000 V)	211 (at HV = -1000 V)	219 (at HV = -900 V)	166 (at HV = -600 V)	μA
Weight	Typ.	55 / 170	50 / 170	55 / 170	50 / 170	g

NOTE: Ⓐ If the output signal voltage is 3 V or higher (with 10 kΩ load), the divider circuit input voltage should be -600 V or higher. (C7246/-01/-22/-23)

Circuit Diagrams

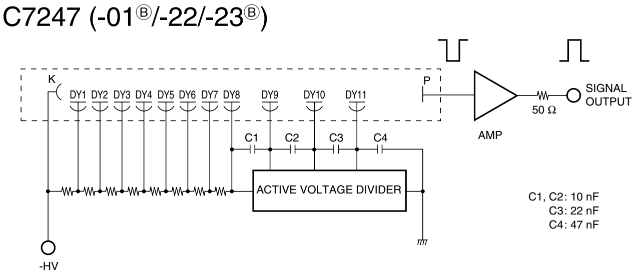
C7246 (-01Ⓑ/-22/-23Ⓑ)



NOTE: ⒷC7246-01/-23 are for 28 mm side-on PMT so that the last dynode number is "DY9"

TACCC0103EC

C7247 (-01Ⓑ/-22/-23Ⓑ)

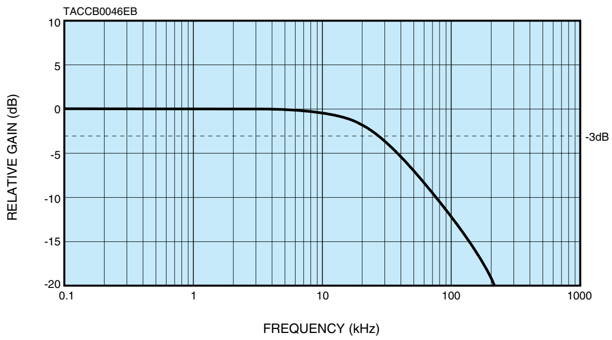


NOTE: ⒷC7247-01/-23 are for 28 mm side-on PMT so that the last dynode number is "DY9"

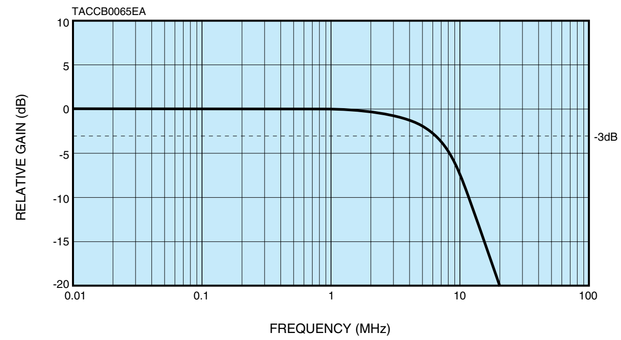
TACCC0115EB

Frequency Response of Built-in Amplifier

C7246/-01/-22/-23

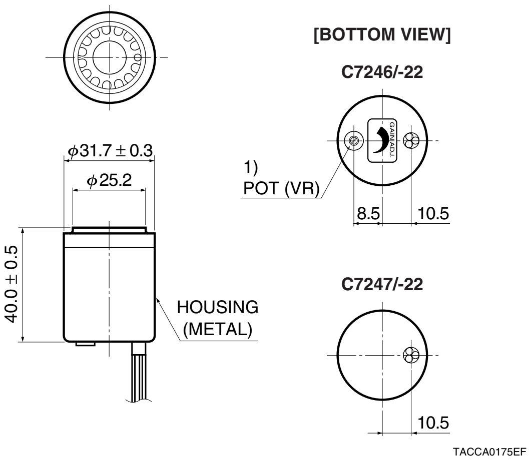


C7247/-01/-22/-23

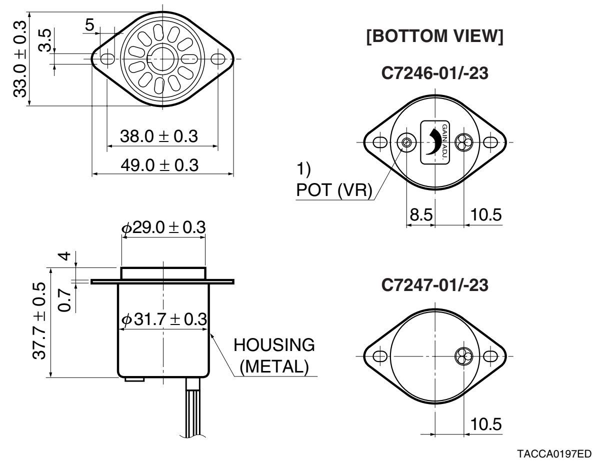


Dimensional Outlines (Unit : mm)

C7246/-22, C7247/-22



C7246-01/-23, C7247-01/-23



Type No.	Input/output	Cable Type	Cable Length	Connector
C7246/-01 C7247/-01	-HV	COAXIAL CABLE [2] (RED)	450 ± 10	—
	Signal Output	COAXIAL CABLE: RG-174/U (BLACK)		—
	±15 V	TWISTED PAIR CABLE WITH SHIELD [3] (GRAY)		—
C7246-22/-23 C7247-22/-23	-HV	COAXIAL CABLE (RED)	1500 ± 25	SHV-P
	Signal Output	COAXIAL CABLE: RG-174/U (BLACK)		BNC-P
	±15 V	TWISTED PAIR CABLE WITH SHIELD (GRAY)		DIN (6 PIN)-P

NOTES: 1) Turning this pot clockwise decreases the PMT gain. (25 turns max.)
2) At the end of HV cable, it's possible to attach SHV connector fitting RG-174/U.
3) Connect as follow.
WHITE········ -15 V
ORANGE···· +15 V
SHIELD······ GND

* See page 123 for details on flanges and housing.

HIGH VOLTAGE POWER SUPPLY SOCKET ASSEMBLY C6270, C9028-01, C9773, C8991, C10344-03 (DP Type)

C6270, C9028 and C9773 are high voltage power supply socket assemblies, incorporating a regulated high voltage power supply and an active voltage divider. It enables simple yet stable photomultiplier tube operations with extended DC output linearity by only supplying +15 V and connecting to a potentiometer or a 0 V to +5 V for high voltage adjustments.
The C8991 and C10344-03 use a Cockcroft-Walton type high voltage power supply that ensures high output linearity of photomultiplier tube while maintaining low power consumption.

Features (C6270, C9028-01, C9773)

- Active Voltage Divider
- Superior DC Output Linearity
- Fast High Voltage Programming Response
- Wide High Voltage Output Range
- Low Ripple / Noise

Features (C8991, C10344-03)

- Cockcroft-Walton Circuit
- Low Power Consumption
- Superior DC Output Linearity

Common Specifications

GENERAL

Parameter			C6270	C9028-01	C9773	C8991	C10344-03	Unit
Applicable PMTs			φ28 mm side-on type	φ28 mm head-on type R374, R2228 R5929, R6094 R6095, etc.	φ25 mm head-on type R1924A, R1925A R3550A, R5070A	φ28 mm side-on type	φ28 mm head-on type R374, R2228 R5929, R6094 R6095, etc.	—
Input Voltage			+15 ± 1			+11.5 to +15.5		V
Input Current		Typ.	45	60	50	8		mA
Linear DC Output Current of PMT Ⓐ	at -1000 V	Typ.	100 Ⓐ		90 Ⓐ	100 Ⓑ		μA
	at -500 V	Typ.	50 Ⓐ		45 Ⓐ	100 Ⓑ		μA
Operating Ambient Temperature / Humidity Ⓒ			0 to +40 / Below 80			0 to +50 / Below 85		°C/%
Storage Temperature / Humidity Ⓒ			-15 to +60 / Below 80			-15 to +60 / Below 85		°C/%
Weight		Typ.	50	60		57		g

NOTE: Ⓐ Within: ±2 % linearity Ⓑ Within: ±0.5 % linearity Ⓒ No condensation

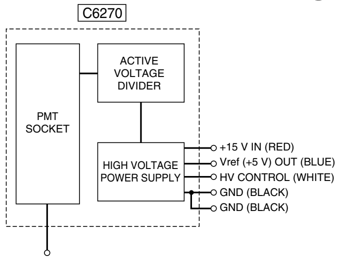
HIGH VOLTAGE POWER SUPPLY

Parameter		C6270	C9028-01	C9773	C8991	C10344-03	Unit
Output Voltage Range		0 to -1250			-200 to -1200 Ⓖ	-200 to -1500	V
Line Regulation Against ±1 V Input Change	Typ.	±0.01					%
Anode Ripple Noise Ⓓ (p-p)	Typ.	0.5			1		mV
Output Voltage Control		0 V to +5 V or external 50 kΩ potentiometer			0 V to +1.2 V or external 10 kΩ potentiometer	0 V to +1.5 V or external 10 kΩ potentiometer	—
Output Voltage Programming Response Ⓔ	Typ.	80			—		ms
Settling Time Ⓕ		—			10		s
Temperature Coefficient	Typ.	±0.01			±0.005		%/°C

NOTE: Ⓓ Load resistance = 1 MΩ, Load capacitance = 20 pF Ⓔ for 0 %→99 % HV change
Ⓕ 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.
Ⓖ C8991-01 with an output voltage range of -200 V to -1500 V is also provided.

Schematic Diagrams

C6270



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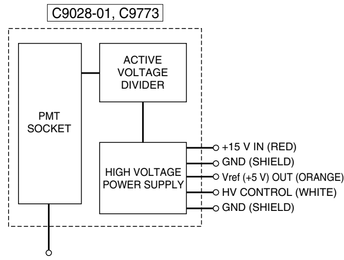
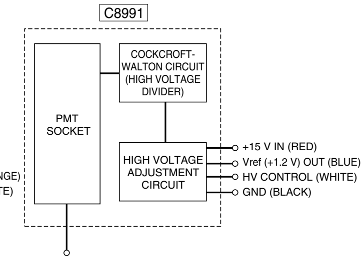
C9028-01, C9773



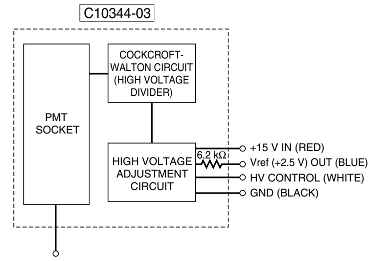
TACCC0122EA

C8991



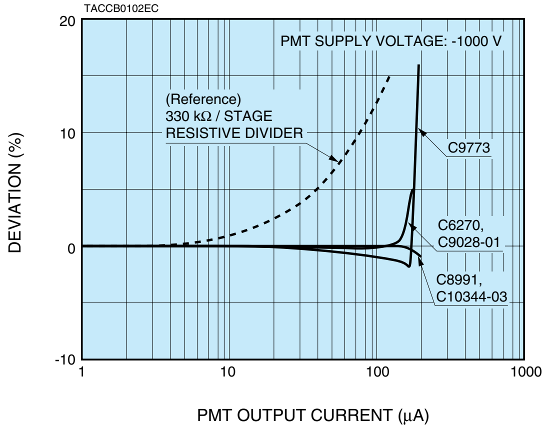
TACCC0124EA

C10344-03

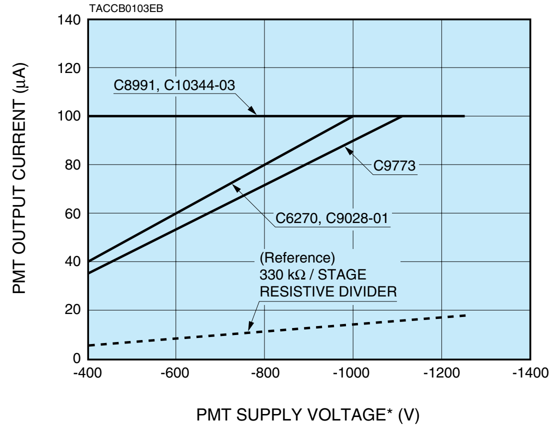


TACCC0141EA

DC Linearity Characteristics

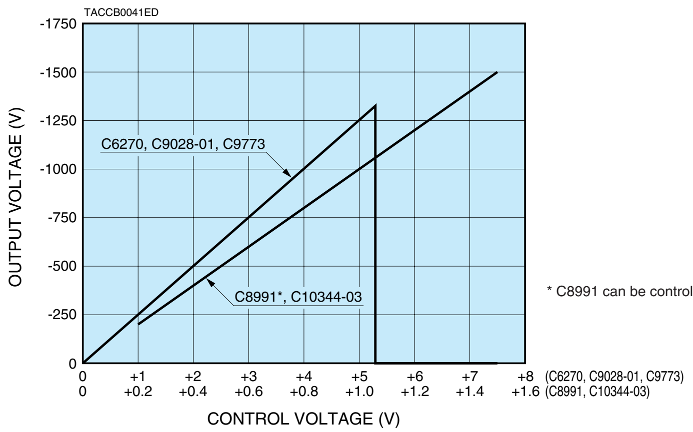


Practical PMT DC Output Limits



* Photomultiplier tube must be used with a supply voltage within the rated range.

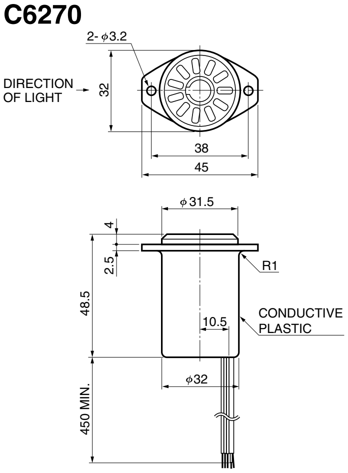
High Voltage Controlling Characteristics



* C8991 can be controlled up to +1.2 V (output voltage -1200 V).

Dimensional Outlines (Unit: mm)

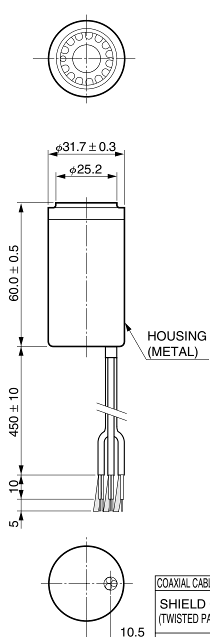
C6270



SIGNAL OUTPUT	COAXIAL CABLE RG-174/U
+15 V INPUT	AWG 24, RED
Vref OUTPUT	AWG 24, BLUE
HV CONTROL INPUT	AWG 24, WHITE
GND	AWG 24, BLACK
GND	AWG 24, BLACK

TACCA0156ED

C9028-01, C9773



COAXIAL CABLE RG-174/U	BLACK	SIGNAL OUTPUT	—
SHIELD CABLE (TWISTED PAIR CABLE)	GRAY	HV CONTROL INPUT	WHITE
		Vref OUTPUT	ORANGE
		GND	SHIELD
SHIELD CABLE (TWISTED PAIR CABLE)	LIGHT BLUE	+15 V INPUT	RED
		—	BLUE
		GND	SHIELD

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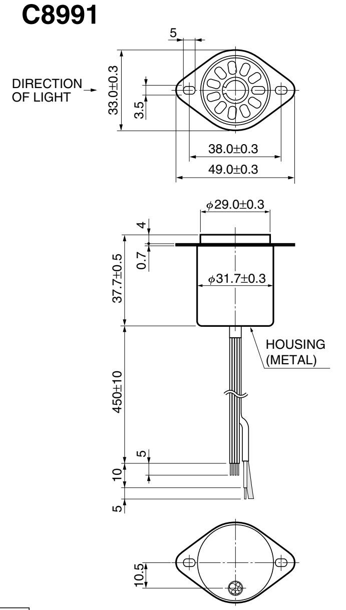
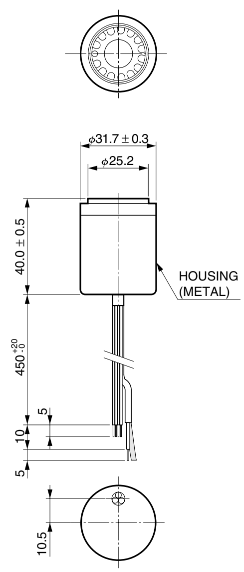
C8991



SIGNAL OUTPUT	COAXIAL CABLE RG-174/U
+15 V INPUT	AWG 24, RED
Vref OUTPUT	AWG 24, BLUE
HV CONTROL INPUT	AWG 24, WHITE
GND	AWG 24, BLACK

TACCA0053EE

C10344-03



SIGNAL OUTPUT	COAXIAL CABLE RG-174/U
+15 V INPUT	AWG 24, RED
Vref OUTPUT	AWG 24, BLUE
HV CONTROL INPUT	AWG 24, WHITE
GND	AWG 24, BLACK

TACCA0294EA

* See page 123 for details on flanges and housings.
(C9773 has no suitable flange and housing.)

HIGH VOLTAGE POWER SUPPLY SOCKET ASSEMBLY WITH TRANSIMPEDANCE AMPLIFIER C6271, C7950, C7950-01 (DAP Type)

These DAP type socket assemblies incorporate a regulated high voltage power supply and transimpedance amplifier that converts high-impedance current signals of a photomultiplier tube into low-impedance voltage signals.
The C7950 series are compatible with a wide band from DC to 5 MHz. The C6271 has lower noise than that of the C7950 series, although the frequency range is from DC to 10 kHz.

Features

- **Superior DC Output Linearity**
- **Fast High Voltage Programming Response**
- **Wide High Voltage Output Range**
- **Low Ripple / Noise**
- **Wide Frequency Bandwidth (C7950, C7950-01)**

Common Specifications

GENERAL

Parameter			C6271	C7950	C7950-01	Unit
Applicable PMTs			φ28 mm (1-1/8") side-on type		φ28 mm (1-1/8") head-on type R374, R2228, R5929 R6094, R6095, etc.	—
Input Voltage			+15 ± 1	±15 ± 1		V
Input Current	+15 V	Typ.	+55	+60	+65	mA
	-15 V	Typ.	—	-20		mA
Linear DC Output Current of PMT Ⓐ	at -1000 V	Typ.	43			μA
	at -500 V	Typ.	43			μA
Operating Ambient Temperature / Humidity Ⓑ			0 to +40 / Below 80			°C/%
Storage Temperature / Humidity Ⓑ			-15 to +60 / Below 80			°C/%
Weight		Typ.	55	65	70	g

NOTE: Ⓐ Within: ±2 % linearity Ⓑ No condensation

HIGH VOLTAGE POWER SUPPLY

Parameter		C6271	C7950	C7950-01	Unit
Output Voltage Range		0 to -1250	0 to -900		V
Line Regulation Against ±1 V Input Change	Typ.	±0.01	±0.03		%
Output Voltage Control		0 V to +5 V or external 50 kΩ potentiometer	0 V to +3.6 V		—
Output Voltage Programming Response Ⓒ	Typ.	80			ms
Temperature Coefficient	Typ.	±0.01	±0.03		%/°C

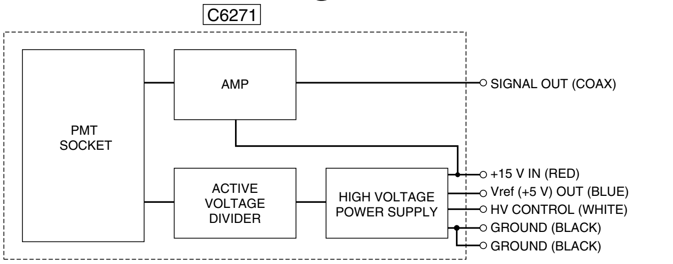
NOTE: Ⓒ for 0 %→99 % HV change

TRANSIMPEDANCE AMPLIFIER SECTION

Parameter		C6271	C7950	C7950-01	Unit
Frequency Bandwidth (-3 dB)		DC to 10 kHz	DC to 5 MHz		—
Current to Voltage Conversion Factor		0.3 (at load resistance 10 kΩ)	0.15 (at load resistance 50 Ω)		V/μA
Maximum Output Voltage		+13 (at load resistance 10 kΩ)	+1.6 (at load resistance 50 Ω)		V
Signal Output Offset Voltage	Typ.	±0.3	±10		mV
Induced Ripple on Signal Output	Typ.	2 mV p-p	10 mV rms		—

Schematic Diagrams

C6271



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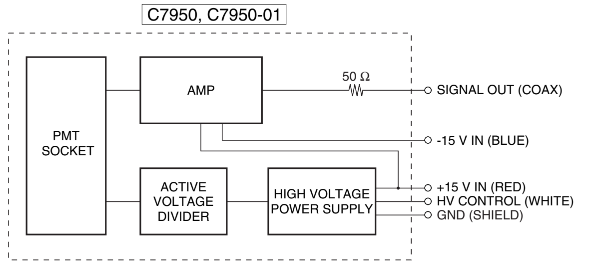
C7950, C7950-01



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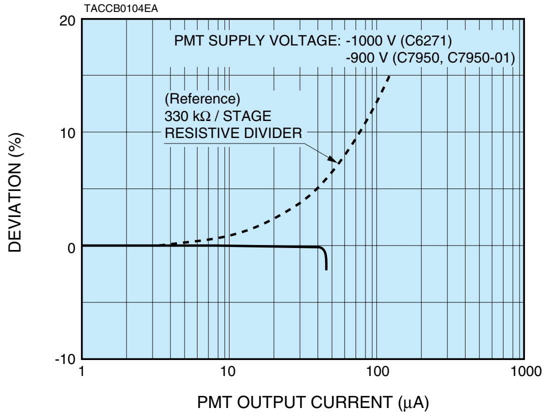
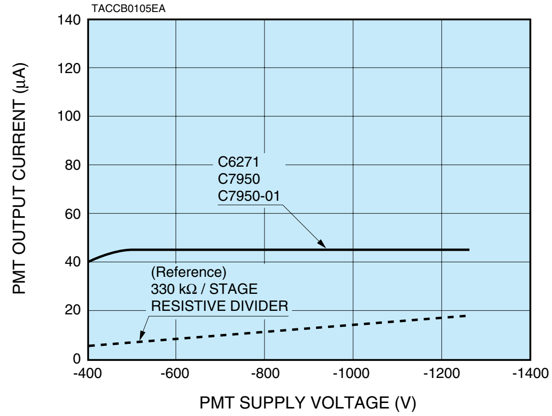
DC Linearity Characteristics

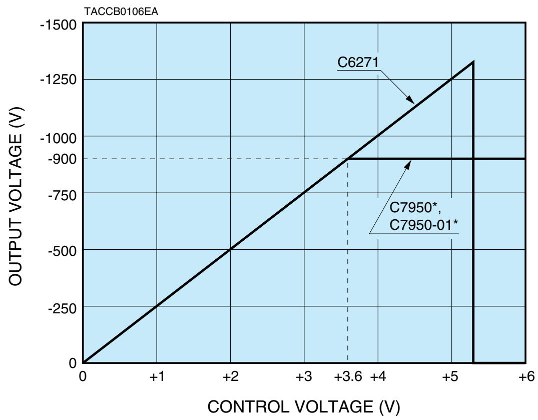


Practical PMT DC Output Limits



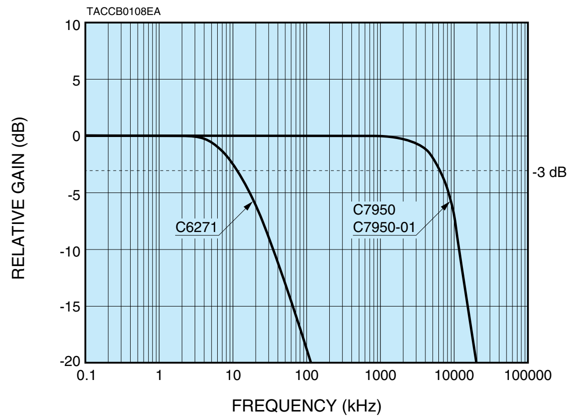
* Use the C7950 and C7950-01 in a range up to -900 V.

High Voltage Controlling Characteristics



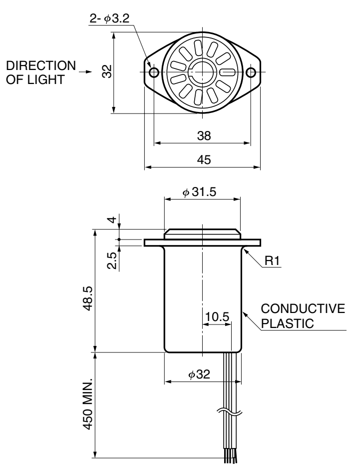
* The output is -900 V even if the control voltage is set higher than +3.6 V.

Frequency Bandwidth



Dimensional Outlines (Unit: mm)

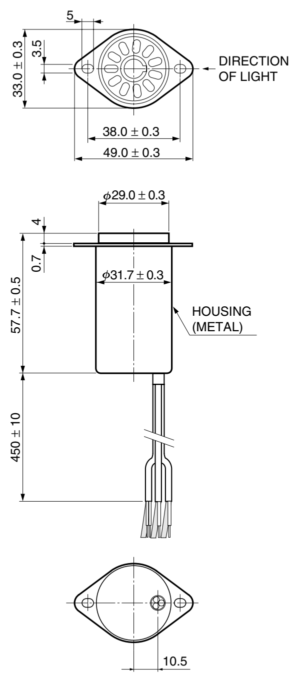
C6271



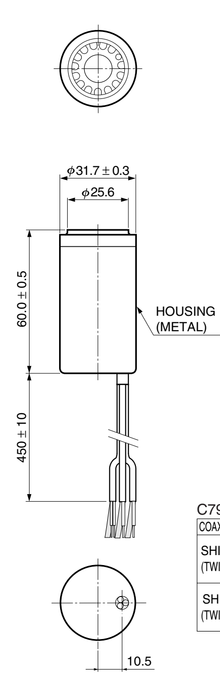
SIGNAL OUTPUT	COAXIAL CABLE RG-174/U
+15 V INPUT	AWG 24, RED
Vref OUTPUT	AWG 24, BLUE
HV CONTROL INPUT	AWG 24, WHITE
GND	AWG 24, BLACK
GND	AWG 24, BLACK

TACCA0156JD

C7950



C7950-01



C7950, C7950-01

COAXIAL CABLE RG-174/U	BLACK	SIGNAL OUTPUT	—
SHIELDED CABLE (TWISTED PAIR CABLE)	GRAY	HV CONTROL INPUT	WHITE
		—	ORANGE
		GND	SHIELD
SHIELDED CABLE (TWISTED PAIR CABLE)	LIGHT BLUE	+15 V INPUT	RED
		-15 V INPUT	BLUE
		GND	SHIELD

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* See page 123 for details on flanges and housings.

Amplifier Units C7319, C9999, C6438, C9663, C11184, C5594

CE From left: C9663 (C9999), C7319, C6438, C5594

Hamamatsu provides six series of amplifier units for photomultiplier tubes. Select the one that best matches your application.

Features

● **C7319**
- Switchable frequency bandwidth (2 ranges) and current-to-voltage conversion factor (3 ranges)
- Ideal for applications requiring low noise and high gain

● **C9999**
- Bandwidth from DC to 10 MHz and gain of 43 dB

● **C6438**
- Ideal for applications requiring high gain for photon counting

● **C6438-01**
- Wide bandwidth from DC to 50 MHz and gain of 54 dB

● **C9663**
- Wide bandwidth from DC to 150 MHz and gain of 38 dB

● **C11184**
- Wide bandwidth from DC to 300 MHz and gain of 28 dB

● **C5594 Series**
- Ideal for applications of high-speed timing measurement using MCP-PMT
- 1.5 GHz cutoff frequency for reliable amplification of high-speed output pulse from PMT
- Choice of SMA or BNC input and output connectors

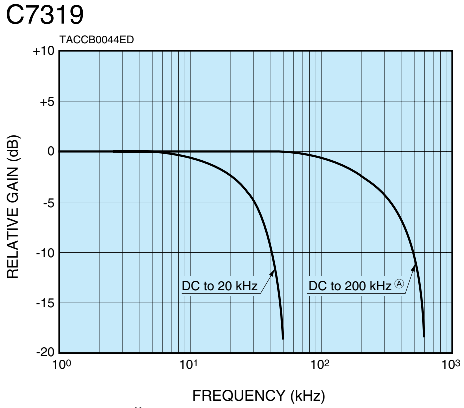
Characteristics

Parameter		C7319	C9999	C6438	C6438-01	C9663	C11184	C5594-44	Unit
Frequency Bandwidth (-3 dB)		DC to 20 kHz or DC to 200 kHz (switchable)Ⓐ	DC to 10 MHz	DC to 50 MHz	DC to 50 MHz	DC to 150 MHz	DC to 300 MHz	50 kHz to 1.5 GHz	—
Voltage Gain		— Ⓑ	43 ± 3 Ⓓ (Approx. 139 times)	20 ± 3 Ⓓ (Approx. 10 times)	54 ± 3 Ⓓ (Approx. 500 times)	38 Ⓓ (Approx. 80 times)	28 ± 2 Ⓓ (Approx. 25 times)	36 Ⓓ (Approx. 63 times)	dB
Current-to-Voltage Conversion Factor		0.1 V/µA, 1 V/µA or 10 V/µA (switchable)	50 mV/µA Ⓔ	0.5 mV/µA Ⓔ	25 mV/µA Ⓔ	4 mV/µA Ⓔ	1.25 mV/µA Ⓔ	3.15 mV/µA Ⓔ	—
Amplifier Input (output)		±Current (inverted)	±Voltage (non-inverted)	±Voltage (non-inverted)	±Voltage (non-inverted)	±Voltage (non-inverted)	±Voltage (non-inverted)	±Voltage (non-inverted)	—
Input Impedance		— Ⓑ	360	50	50	50	50	50	Ω
Recommended Load Resistance		—	50	50	50	50	50	50	Ω
Max. Output Signal Voltage		±13 Ⓒ	±1.3 Ⓓ	±1 Ⓓ	±1 Ⓓ	±1.4 Ⓓ	±1 Ⓓ	+0.8, -2.5 Ⓓ	V
Connector	Input	BNC-R	BNC-R	BNC-R	BNC-R	BNC-R	MCX-R Ⓕ	BNC-R	—
	Output	BNC-R	BNC-R	BNC-R	BNC-R	BNC-R	MCX-R Ⓕ	BNC-R	—
	Power	DIN (6-pin)	DIN (6-pin)	DIN (6-pin)	DIN (6-pin)	DIN (6-pin)	—	—	—
Supply Voltage		±5 to ±15	±5	±5	±5	±5	±5	+12 to +16	V
Supply Current	Max.	±50	±70	±55	±80	±80	±70	+95	mA
Dimensions (W × H × D)		60 × 43.2 × 65	60 × 43.2 × 65	60 × 43.2 × 65	60 × 43.2 × 65	60 × 43.2 × 65	52 × 14.5 × 28	54 × 17 × 33	mm
Weight		Approx.170	Approx.180	Approx.160	Approx.160	Approx.180	Approx.40	Approx.80	g

NOTE: ⒶFrequency bandwidth is limited to DC to 100 kHz at conversion coefficient of 10 V/µA. ⒷC7319 is current input type.
ⒸAt ±15 V Supply voltage and 10 kΩ load resistance. ⒹAt 50 Ω load resistance.
ⒺValue after current-to-voltage conversion by input impedance. ⒻMCX-BNC adapter supplied.

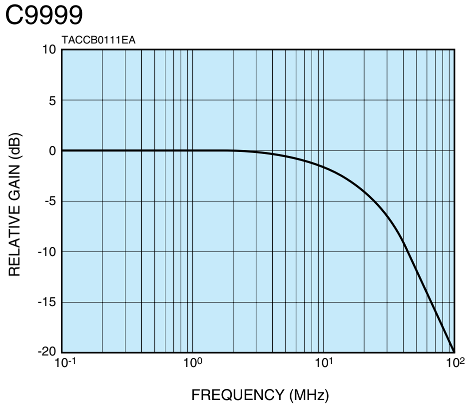
Frequency Response

C7319

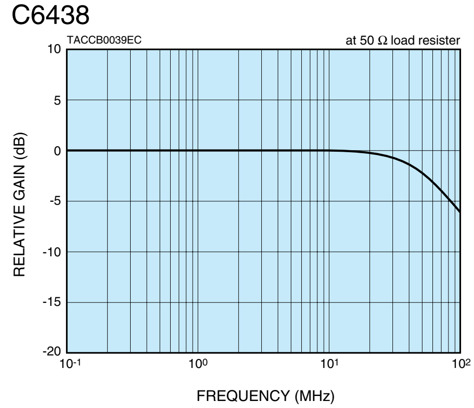


Ⓐ To be limited to DC to 100 kHz at 10 V/µA
(Current to voltage conversion factor)

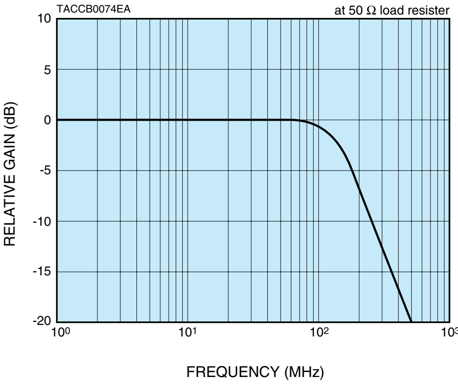
C9999



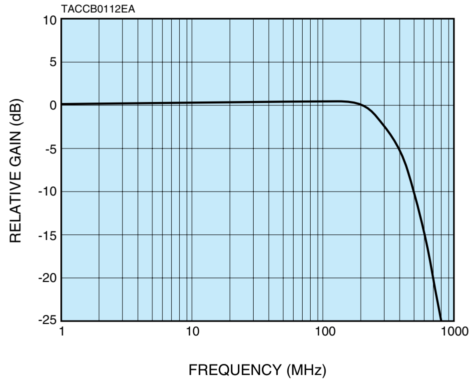
C6438



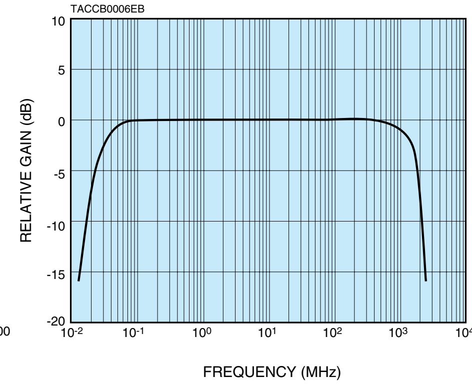
C9663



C11184

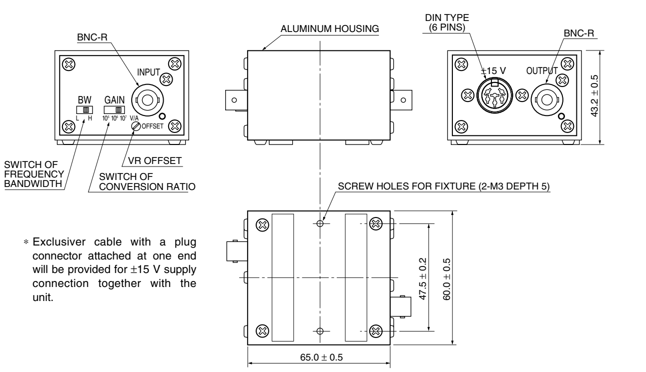


C5594 Series



Dimensional Outlines (Unit: mm)

C7319



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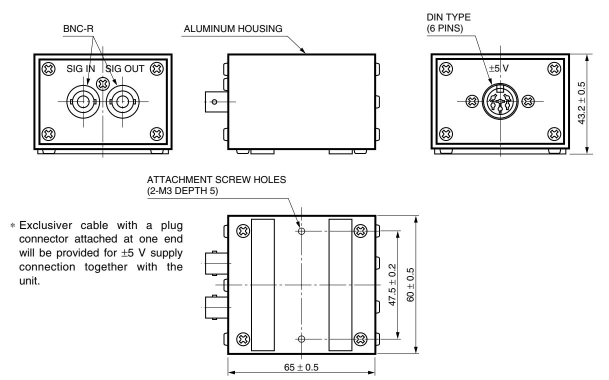
C6438



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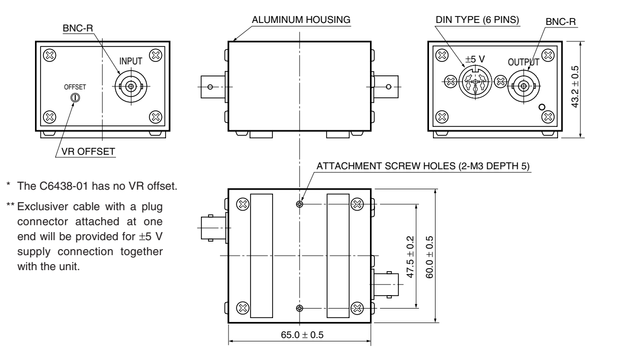
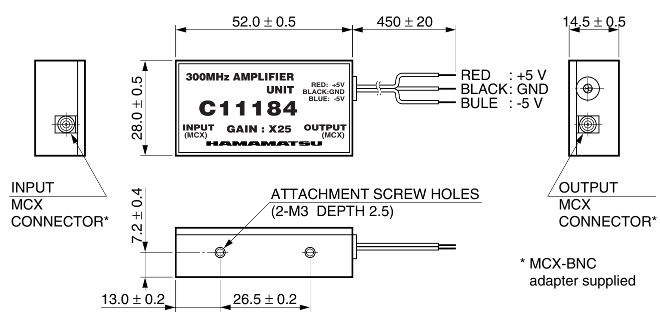
C9999/C6438-01/C9663



TACCA0262EB

C11184



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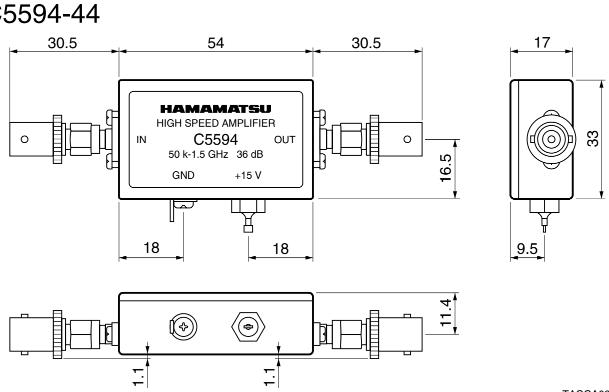
C5594-44



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C5594 Input / Output connectors and type No.

Input	Output	
	SMA receptacle (female)	BNC receptacle (female)
SMA plug (male)	**C5594-12**	**C5594-14**
SMA receptacle (female)	**C5594-22**	**C5594-24**
BNC plug (male)	**C5594-32**	**C5594-34**
BNC receptacle (female)	**C5594-42**	**C5594-44**

High Voltage Power Supplies

Voltage Dependence of Photomultiplier Tube Gain

The photoelectrons emitted from the photocathode of a photomultiplier tube are channeled by the electron lens to impinge on the first dynode where several times the number of secondary electrons are then emitted. This multiplicative increase of secondary electrons is repeated at the latter dynodes and as a result, the number of electrons reaching the anode is approximately 10^5 to 10^7 times the original number of photoelectrons emitted from the photocathode.
The relationship of the secondary electron emission δ for each dynode to the supplied voltage is expressed as follows:

$$\delta = A \bullet E^{\alpha}$$

where A is a constant, E is the interstage voltage, and α is another constant determined by the dynode material and geometric structure. The value of α is usually in the range 0.7 to 0.8. When a voltage V is supplied between the anode and the photocathode of a photomultiplier tube having n dynode stages, the overall gain μ is given by

$$\mu = (A \bullet E^{\alpha})^n = \{A \bullet [V/n+1]^{\alpha}\}^n = \{A^n/(n+1)^{\alpha n}\}V^{\alpha n}$$

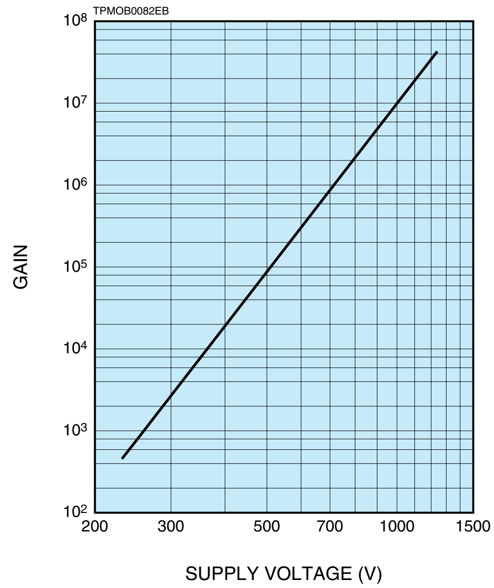
Here, if $\{A^n/(n+1)^{\alpha n}\}$ is substituted for K, μ becomes

$$\mu = K \bullet V^{\alpha n}$$

Typical photomultiplier tubes have 9 to 12 dynode stages and as shown in Figure 23, the gain is proportional to the 6th to 10th power of the voltage supplied between the photocathode and the anode. This essentially means that the output of a photomultiplier tube is extremely sensitive to variations in the supplied voltage. Thus the power supply stability such as drift, ripple, temperature regulation, input regulation and load regulation must be at least 10 times as stable as the output stability required of the photomultiplier tube.

Hamamatsu regulated high voltage power supplies are products developed based on our years of experience as a photomultiplier tube manufacturer and our leading edge technology. All models are designed to conform to stability requirements demanded of photomultiplier tube operations. Various models are provided, ranging from on-board unit types to general-purpose bench-top types, allowing you to choose the desired power supply that suits your application.

Gain vs. Supply Voltage

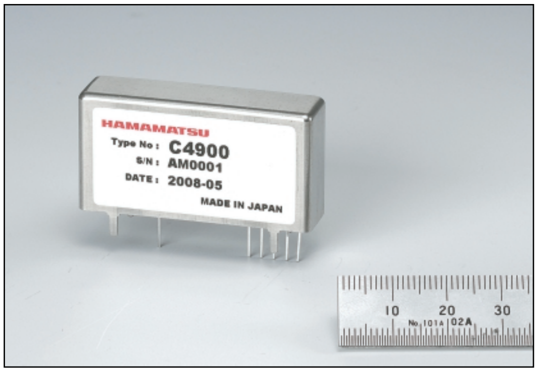


Selection Guide to High Voltage Power Supplies

Type	Type No.		Max. Output Voltage (V)	Output Current (mA)	Input Voltage	Dimensions (W × H × D) (mm)Ⓑ	Weight
Unit Type	C4900	—	-1250	0.6	+15 V	46 × 24 × 12	31 g
		-01		0.5	+12 V		
		-50	+1250	0.6	+15 V		
		-51		0.5	+12 V		
	C10673Ⓐ	—	-1250	0.6	+15 V	46 × 24 × 12	31 g
		-01		0.5	+12 V		
	C9619	—	-2000	2	+15 V	62 × 15 × 45	100 g
		-01			+12 V		
		-50	+2000		+15 V		
		-51			+12 V		
Bench-top Type	C9525	—	-2000	2	AC 100 V/120 V	246 × 70 × 312	3.0 kg
		-01			AC 230 V		
		-50	+2000		AC 100 V/120 V		
		-51			AC 230 V		
	C9727	—	-3500	2	AC 100 V/120 V	246 × 70 × 312	3.0 kg
		-01			AC 230 V		
		-50	+3500		AC 100 V/120 V		
		-51			AC 230 V		

ⒶThe C10673 and C10673-01 are UL-approved types of the C4900 and C4900-01.
ⒷExcluding projecting parts

Compact High Voltage Power Supply Units C4900 Series



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CE

The C4900 series is an on-board type high voltage power supply unit, with a design that aims at providing both "compactness and high performance". The newly developed circuit achieves high performance and low power consumption. The C4900 series in addition provides enhanced protective functions yet is offered at lower costs.
The C4900 and -01 are designed for negative output, while the C4900-50 and -51 have positive output.

Features

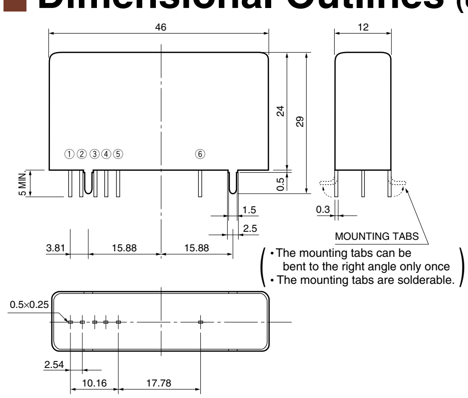
- Very compact and lightweight
- Low power consumption
- Variable output voltage range from 0 V
- High stability
- Quick response
- Ample protective functions

Specifications

Parameter	Condition	C4900	C4900-01	C4900-50	C4900-51	Unit
Input Voltage Range		+15 ± 1	+12 ± 0.5	+15 ± 1	+12 ± 0.5	V
Input Current Ⓐ	with no load Typ.	14	15	14	15	mA
	with full load Typ.	90	95	90	95	mA
Variable Output Range		0 to -1250		0 to +1250		V
Specification Guaranteed Output Voltage Range		-200 to -1250		+200 to +1250		V
Output Current	Max.	0.6	0.5	0.6	0.5	mA
Line Regulation Against ±1 V or ±0.5 V Input Change ⒶⒷ	Typ.	±0.01				%
Load Regulation Against 0 % to 100 % Load Change Ⓐ	Typ.	±0.01				%
Ripple / Noise (p-p) ⒶⒷ	Typ.	0.003				%
Output Voltage Control		By external controlling voltage (0 V to +5 V) or external potentiometer (50 kΩ ±2.5 kΩ)				—
Controlling Voltage Input Impedance	Typ.	80				kΩ
Output Voltage Setting (Absolute Value)	Typ.	((Controlling Voltage × 250) ± 0.5 %) ± 3				V
Output Voltage Rise Time (0 % → 99 %) ⒶⒷ	Typ.	50				ms
Temperature Coefficient ⒶⒷ	Typ.	±0.01				%/°C
Operating Ambient Temperature ⒶⒷ		0 to +50				°C
Operating Ambient Humidity Ⓒ		Below 80		Below 80 Ⓓ		%
Storage Temperature		-20 to +70				°C
Storage Humidity Ⓒ		Below 80				%
Weight		31				g
Protective Functions		Units protected against reversed power input, reversed / excessive controlling voltage input, continuous overloading / short circuit in output				—

NOTE: ⒶAt maximum output voltage. ⒷAt maximum output current. ⒸNo condensation.
ⒹAt 0 °C to +40 °C. Please contact our sales office if the operating ambient temperature is expected to be higher than +40 °C.
* The C10673 and C10673-01, which are UL-approved types of the C4900 and C4900-01, are also available.

Dimensional Outlines (Unit: mm)



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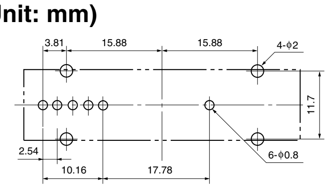
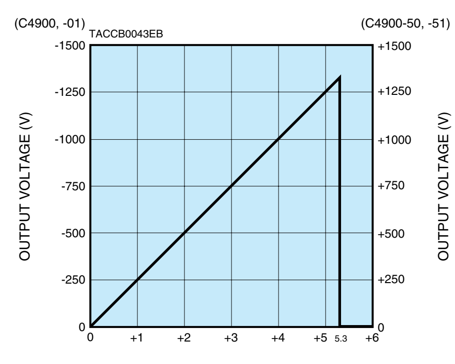


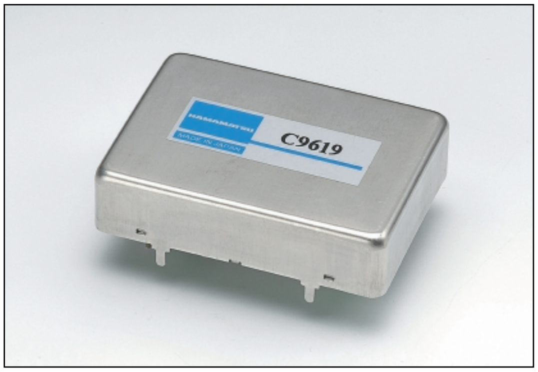
PIN ASSIGNMENT
①+15 V / +12 V IN
②GND 1 (INPUT / OUTPUT GND)
③GND 2 (CONTROLLING VOLTAGE GND)
④HV ADJ (CONTROLLING VOLTAGE INPUT)
⑤Vref OUT
⑥HV OUT
*The housing is internally connected to pin ②.
Pins ② and ③ are internally connected.

TACCA0159EB

Output Voltage Controlling Characteristic



High Voltage Power Supply Units C9619 Series



The C9619 series is compact PC-board mountable high voltage power supplies, especially designed for photomultiplier tubes.
The design offers better performance and complete fail-safe protection.
The C9619 and -01 output negative polarity and the C9619-50 and -51 output positive polarity high voltages.

Features

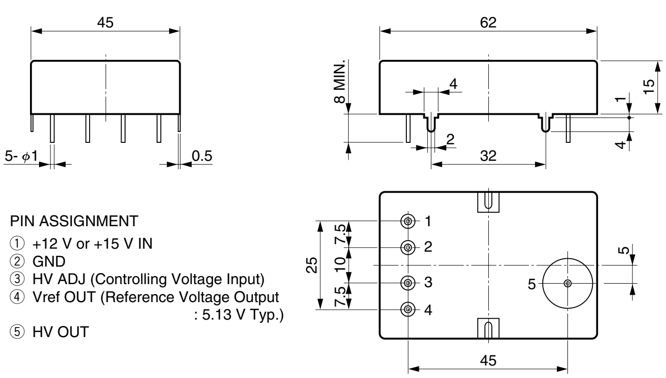
- Compact and Lightweight
- High Stability
- High Output Power (2 kV / 2 mA)
- Completed Fail-safe Functions

Specifications

Parameter		C9619	C9619-01	C9619-50	C9619-51	Unit
Input Voltage		+15 ± 1	+12 ± 1	+15 ± 1	+12 ± 1	V
Input Current Ⓐ	with no load Typ.	120	100	120	100	mA
	with full load Typ.	380	460	380	460	mA
Variable Output Voltage Range		0 to -2000		0 to +2000		V
Specification Guaranteed Output Voltage Range		-320 to -2000		+320 to +2000		V
Output Current	Max.	2				mA
Input Regulation against ± 1 V Input Change ⒶⒷ	Typ.	±0.01	±0.03	±0.01	±0.03	%
Load Regulation against 0 % to 100 % Load Change Ⓐ	Typ.	±0.03				%
Ripple / Noise (p-p) ⒶⒷ	Typ.	0.003				%
Output Voltage Controlling Modes		By external controlling voltage (0 V to +5 V) or external potentiometer (50 kΩ)				—
Controlling Voltage Input Impedance	Typ.	110		97		kΩ
Output Voltage Setting	Typ.	(Controlling voltage × (-400)) ± 1 %		(Controlling voltage × (+400)) ± 1 %		V
Output Voltage Rise Time (0 % → 99 %) ⒶⒷ	Typ.	100		500		ms
Temperature Coefficient ⒶⒷ	Typ.	±0.01				%/°C
Operating Ambient Temperature ⒶⒷ / Humidity ⒶⒷⒸ		0 °C to +40 °C / Below 85 %				—
Storage Temperature / Humidity Ⓒ		-20 °C to +60 °C / Below 90 %				—
Weight		100				g
Protective Functions		Units protected against reversed power input, reversed / excessive controlling voltage input, continuous overloading / short circuit in output				—

NOTE: ⒶAt maximum output voltage. ⒷAt maximum output current. ⒸNo condensation

Dimensional Outline (Unit: mm)



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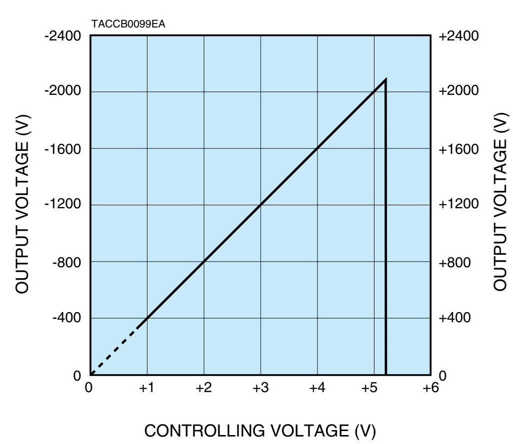
Output Voltage Controlling Characteristic



2 kV Output Compact Bench-Top Type Regulated DC Power Supply C9525 Series

The C9525 series is a compact, remote-controllable multi-output power supply incorporating a high voltage and low voltage power supply circuits.

Features

- **Compact bench-top type**
- **High stability**
- **USB control**
- **High output voltage (2 kV / 2 mA)**

Specifications

Parameter		High Voltage Power Supply Section	±5 V Power Supply Section	±15 V Power Supply Section
Output Voltage	C9525/C9525-01	0 V to -2000 V (variable)	±5 V ± 5 % (fixed)	±15 V ± 5 % (fixed)
	C9525-50/C9525-51	0 V to +2000 V (variable)		
Specification Guaranteed Output Voltage	C9525/C9525-01	-320 V to -2000 V (variable)		
	C9525-50/C9525-51	+320 V to +2000 V (variable)		
Maximum Output Current		2 mA	500 mA	200 mA
Input Regulation ⒶⒷⒸ	Max.	±0.005 %	±0.1 %	±0.1 %
Load regulation ⒶⒹ	Max.	±0.03 %	±1 %	±0.5 %
Ripple / noise (p-p) ⒶⒷ	Max.	0.003 %	0.06 %	0.02 %
Drift ⒶⒷⒺ	Max.	±0.05 %/h	±0.05 %/h	±0.05 %/h
Temperature Coefficient ⒶⒷ	Max.	±0.01 %/°C	±0.01 %/°C	±0.005 %/°C
High Voltage Output Monitoring Accuracy Ⓐ	Max.	±(0.1 % +2 V)	—	—
Output Connector Receptacle		SHV Type	DIN Type (6 pins)	
AC Input Voltage	C9525/C9525-50	100 V / 120 V (±10 %) (50 Hz / 60 Hz)		
	C9525-01/C9525-51	230 V (±10 %) (50 Hz / 60 Hz)		
Power Consumption ⒶⒷ		Approx. 40 V·A		
Operating Ambient Temperature ⒶⒷ / Humidity ⒶⒷⒻ		0 °C to +40 °C / Below 85 %		
Storage Temperature / Humidity Ⓕ		-20 °C to +50 °C / Below 90 %		
Weight		Approx. 3.0 kg		
CE Marking		Conforms to EMC directive (89/336/EEC) / EN61326: 1997 + A1: 1998 + A2: 2001 + A3: 2003 Class A Conforms to low voltage directive (73/223/EEC) / EN61010-1: 2001		

NOTE: ⒶAt maximum outut voltage ⒷAt maximum output current ⒸFor 10 % change in line voltage ⒹFor 0 % to 100 % change in load ⒺAfter 30 minute warm-up ⒻNo condensation

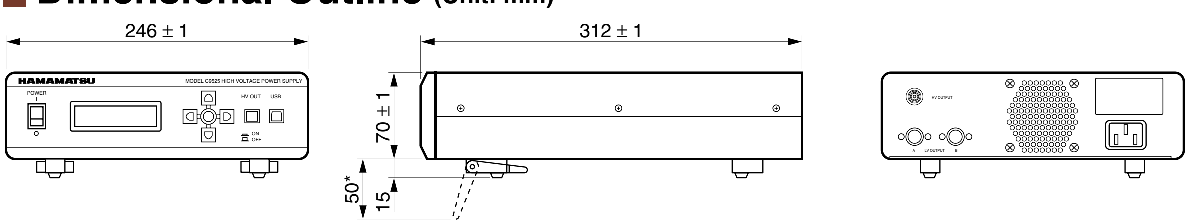
Accessories

①High voltage output cable (1.5 m long) terminated with SHV-P plugs E1168-17 1
②AC line cable 1
③3P/2P connector AC adapter (C9525/C9525-50 only) 1
④USB cable (1.5 m long) with filter 1
⑤Low voltage power supply section DIN connector plugs 2
⑥CD-R (Containing instruction manual, sample software) 1

Sold Separately

Connecting cable for low voltage power supply section E1168-26
(for C9744, C7319, C9999, C6438, C9663)

Dimensional Outline (Unit: mm)



* The height of the C9525 is 120 mm with front legs extended

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3.5 kV Output Compact Bench-Top Type Regulated DC Power Supply C9727 Series

The C9727 series is a compact, remote-controllable multi-output power supply incorporating a high voltage and low voltage power supply circuits.

Features

- Compact bench-top type
- High stability
- USB control
- High output voltage (3.5 kV / 2 mA)
- High voltage output current monitor

Specifications

Parameter			High Voltage Power Supply Section	±5 V Power Supply Section	±15 V Power Supply Section
Output Voltage	C9727/C9727-01		0 V to -3500 V (variable)	±5 V ± 5 % (fixed)	±15 V ± 5 % (fixed)
	C9727-50/C9727-51		0 V to +3500 V (variable)		
Specification Guaranteed Output Voltage	C9727/C9727-01		-320 V to -3500 V (variable)		
	C9727-50/C9727-51		+320 V to +3500 V (variable)		
Maximum Output Current			2 mA	500 mA	200 mA
Input Regulation ⒶⒷⒸ		Max.	±0.005 %	±0.1 %	±0.1 %
Load regulation ⒶⒹ		Max.	±0.03 %	±1 %	±0.5 %
Ripple / noise (p-p) ⒶⒷ		Max.	0.003 %	0.06 %	0.02 %
Drift ⒶⒷⒺ		Max.	±0.05 %/h	±0.05 %/h	±0.05 %/h
Temperature Coefficient ⒶⒷ		Max.	±0.01 %/°C	±0.01 %/°C	±0.005 %/°C
High Voltage Output Monitoring Accuracy Ⓐ		Max.	±(0.1 % +2 V)	—	—
Output Connector Receptacle			SHV Type	DIN Type (6 pins)	
AC Input Voltage	C9727/C727-50		100 V / 120 V (±10 %) (50 Hz / 60 Hz)		
	C9727-01/C9727-51		230 V (±10 %) (50 Hz / 60 Hz)		
Power Consumption ⒶⒷ			Approx. 40 V·A		
Operating Ambient Temperature ⒶⒷ / Humidity ⒶⒷⒻ			0 °C to +40 °C / Below 85 %		
Storage Temperature / Humidity Ⓕ			-20 °C to +50 °C / Below 90 %		
Weight			Approx. 3.0 kg		
CE Marking			Conforms to EMC directive (89/336/EEC) / EN61326: 1997 + A1: 1998 + A2: 2001 + A3: 2003 Class A Conforms to low voltage directive (73/223/EEC) / EN61010-1: 2001		

NOTE: ⒶAt maximum outut voltage ⒷAt maximum output current ⒸFor 10 % change in line voltage ⒹFor 0 % to 100 % change in load ⒺAfter 30 minute warm-up ⒻNo condensation

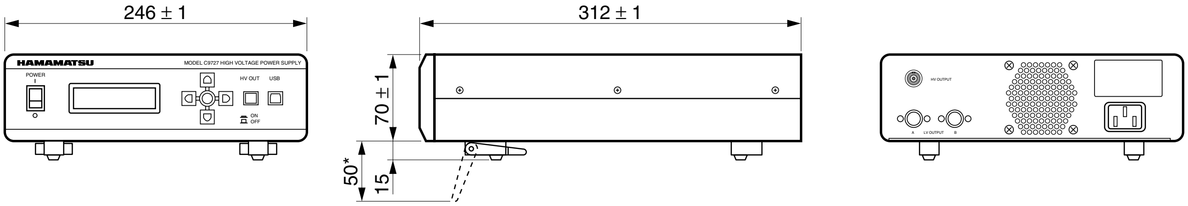
Accessories

①High voltage output cable (1.5 m long) terminated with SHV-P plugs E1168-19 1
②AC line cable 1
③3P/2P connector AC adapter (C9727/C9727-50 only) 1
④USB cable (1.5 m long) with filter 1
⑤Low voltage power supply section DIN connector plugs 2
⑥CD-R (Containing instruction manual, sample software) 1

Sold Separately

Connecting cable for low voltage power supply section E1168-26 (for C9744, C7319, C9999, C6438, C9663)

Dimensional Outline (Unit: mm)



* The height of the C9727 is 120 mm with front legs extended

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Photomultiplier Tube Dark Current and Cooling Effect

Causes of Dark Current

A small amount of current flows in a photomultiplier tube operated at a high voltage even when no light enters it. This output current is called the dark current. Since the dark current degrades the S/N ratio, it is the factor that determines the lower limit of detection when the output current is extremely low such as in low-level-light measurement. Major causes of the dark current can be classified into the seven described below. The extent to which each of these causes affects the dark current depends on the type of photomultiplier tube and varies from tube to tube or according to operating conditions.

Specific Causes

① Thermionic emission of electrons from the photocathode and dynode surfaces

② Leakage current between electrodes and lead pins
(Mainly due to impurities on the electrode supporting materials, glass stem, plastic base surfaces and on the socket surface)

③ Ion current flowing as a result of ionization of residual gases inside the bulb

④ Photoelectron emission caused by internal electrons and ions colliding with the electrode support materials and glass

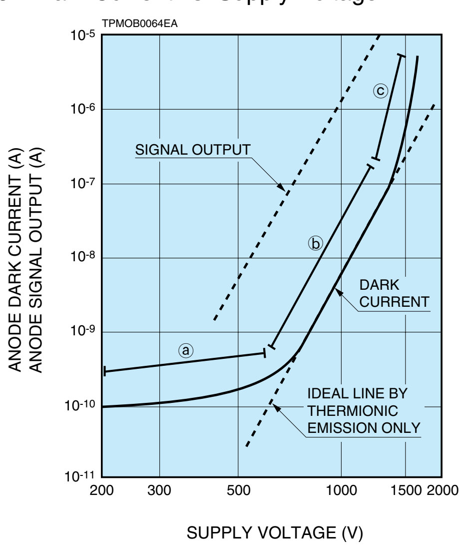
⑤ Photoelectron emission by the glass scintillation as a result of gamma rays emitted from radioactive elements (chiefly ^{40}K) inside the bulb

⑥ Photoelectron emission caused by Cherenkov radiation due to cosmic ray passing through the glass

⑦ Field emission of electrons from the photocathode and dynode surfaces

Figure 62 shows the relationship between the voltage supplied across the photomultiplier tube cathode and anode, and the anode dark current. This characteristic curve can be divided into three regions. In the low-voltage region ⓐ, the major cause of dark current is the leakage current ② and in the high-voltage region ⓒ, ③, ④, and ⑦ become the governing factors that determine the dark current. In contrast, in region ⓑ which approximates actual operating conditions, thermal electron emission is predominant. From this behavior, it can be seen that cooling the photocathode and dynodes would be very effective in reducing the dark current when the photomultiplier tube is operated at the normal voltage range.

Figure 62: Dark Current vs. Supply Voltage

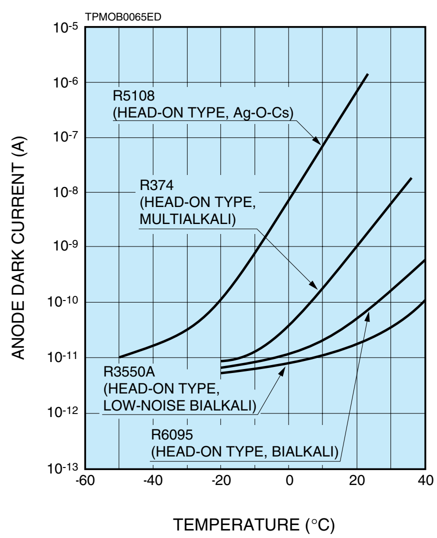


Thermal electron Emission and Cooling Effect

Figure 63 shows a comparison of the temperature characteristics of dark current for various photocathode materials used in photomultiplier tubes of the same configuration and dynode structure. From this figure, it is clear that photocathodes with higher sensitivity at longer wavelengths (multialkali and Ag-O-Cs) exhibit larger dark currents as the temperature increases. In other words, the cooling effect on the dark current and S/N ratio is more remarkable in such photocathodes. In this figure, the cooling effect is limited in the region below -20 °C to -30 °C, due to the fact that contribution of factors other than thermionic emission becomes relatively large in this region. In photon counting applications, since the leakage current can be ignored, greater cooling effect can be achieved.

Thermal electrons are emitted not only from the photocathode but also from the dynodes. However, thermal electrons emitted from the latter dynodes multiply less, and therefore the real problems are electrons from the photocathode and the first or second dynode. Cooling these portions can considerably reduce the dark current.

Figure 63: Dark Current vs. Temperature for Various photocathodes



Selection Guide

Type No.	Applicable PMTs
C10372 Series	ϕ28 mm (1-1/8"), ϕ38 mm (1-1/2") and ϕ51 mm (2") Head-on
C10373 Series	MCP-PMT (R3809U-50 series, R3809U-61/-63/-64)
C9143 Series	ϕ28 mm (1-1/8") Side-on
C9144 Series	ϕ28 mm (1-1/8") Side-on

High Performance Thermoelectric Coolers C10372, C10373 For 28 mm, 38 mm, 51 mm Diameter Head-on PMT and MCP-PMT

Left: Power Supply
Right: Cooled PMT Housing

The C10372 series and C10373 series are water-cooled thermoelectric coolers designed to reduce thermal electrons emitted from the photocathode of photomultiplier tubes (PMTs) in order to improve signal-to-noise ratio (S/N ratio). The C10372 series further contains an electrostatic and magnetic shield that minimizes the influence of the ambient environment.
The C10372 series are for 28 mm, 38 mm and 51 mm diameter head-on PMTs, while the C10373 series are for MCP-PMTs.

Features

- **Thermoelectric cooling using Peltier module**
- **About -30 °C cooling temperature (with +20 °C cooling water)**
- **Evacuated, double-pane window with heater for frost prevention**
- **Built-in electrostatic and magnetic shielding (C10372 series)**
- **Internal protective circuits safeguards Peltier module in case of low water**
- **Internal protective circuits prevent output short-circuit, output overvoltage, and excessive temperature rise in power supply**
- **Stable operation due to a regulated power supply**

Specifications

[Cooled PMT Housing]

Parameter	C10372/-01/-02 Ⓐ	C10373/-01/-02 Ⓐ	Unit
Cooling Method	Thermoelectric cooling using Peltier module		—
Heat Exchange Medium	Water (1 L/min to 3 L/min, water pressure: below 0.3 MPa)		—
Cooling Temperature (with cooling water at +20 °C)	Approx. -30		°C
Time to Stable Cooling Temperature	Approx. 120		min
Optical Window Material	Evacuated double-pane synthetic silica window with heater (185 nm to 2200 nm)		—
Applicable PMTs (sold separately)	28 mm (1-1/8") Dia., 38 mm (1-1/2") Dia and 51 mm (2") Dia. Head-on	MCP-PMT (R3809U-50 Series, R3809U-61/-63/-64)	—
Applicable Socket Assembly / Holder (sold separately)	E2762 Series Ⓑ	E3059-500 (R3809U-50 Seriess, R3809U-61/-63/-64)	—
Operating Ambient Temperature / Humidity Ⓒ	+5 °C to +40 °C / Below 75 %		—
Storage Temperature / Humidity Ⓒ	-15 °C to +50 °C / Below 80 %		—
Weight	Approx. 5.8	Approx. 5.5	kg

NOTE: ⒶC10372 / C10373: For AC 100 V operation. C10372-01 / C10373-01: For AC 120 V operation. C10372-02 / C10373-02: For AC 230 V operation.
ⒷSee P.119 ⒸNo condensation

[Power Supply]

Parameter	Value / Description	Unit
AC Input Voltage	100 to 240 (± 10 %) (50 Hz/60 Hz)	V
Maximum Power Consumption	200	V·A
Temperature Controllable Range (with cooling water at +20 °C)	-30 to 0 (continuously adjustable)	°C
Output Voltage	24 to 27	V
Output Current	4.2	A
Protection Circuit	Protective circuits to safeguard Peltier module in case of low water and to prevent output short-circuit, output overvoltage, and excessive temperature rise in power supply.	—
Operating Ambient Temperature / Humiditiy Ⓒ	+5 °C to +40 °C / Below 75 %	—
Storage Temperature / Humiditiy Ⓒ	-15 °C to +50 °C / Below 80 %	—
Weight	Approx. 2.1	kg

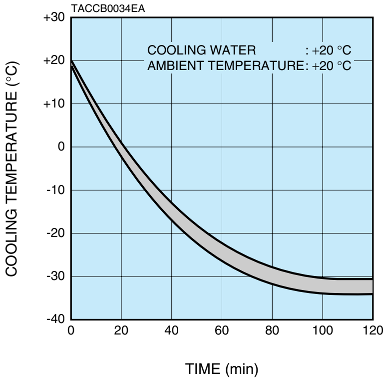
NOTE: ⒸNo condensation

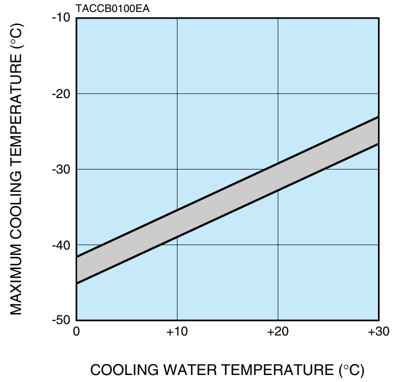
[Components and Accessories]

●Cooled PMT housing ●Power supply ●Light shield cap ●Water hose clamps (2 pcs) ●Connection cable (1.5 m)
●AC line cable (2.5 m: -02 type, 2.0 m: other types) ●Socket assembly / PMT holder mounting screws (4 pcs)

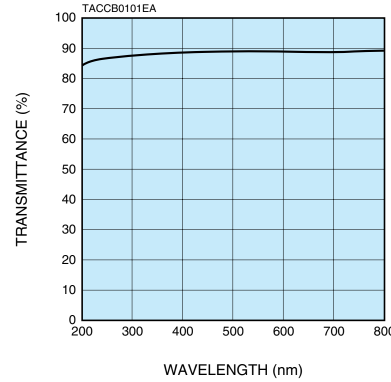
* To use these coolers, water hoses with an inner diameter of 15 mm and a water supply line with the matching round faucet are required. Prepare those hoses of the desired length. Hoses can also be connected by using PT 1/8 pipe taper screws.
** CE C10372 series and C10373 series conform to the EMC directive and the LVD of the European Union.

Cooling Characteristics

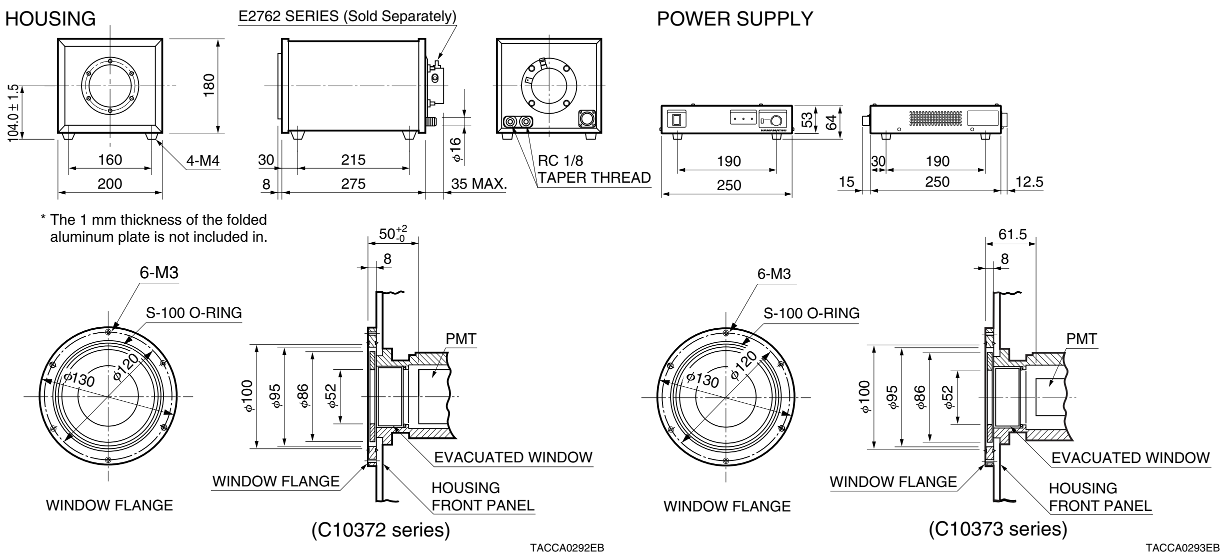




Spectral Transmission Characteristics of Optical Window

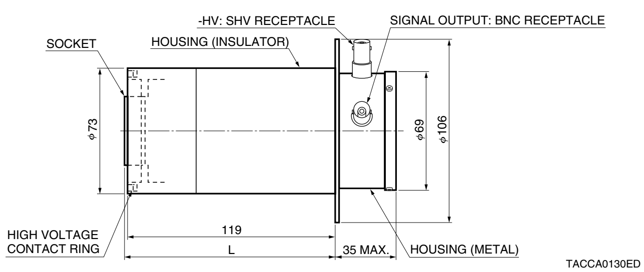


Dimensional Outlines (Unit: mm)



Sold Separately (Unit: mm)

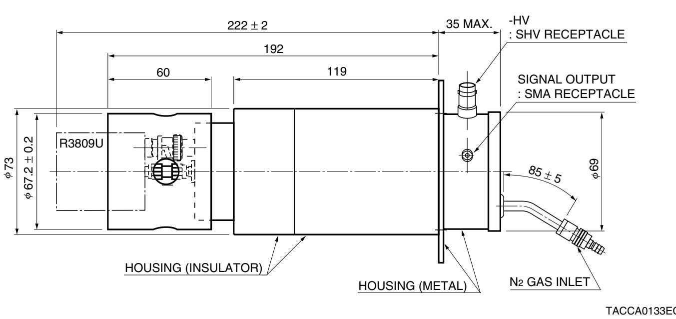
Socket Assemblies for C10372 Series E2762 Series



L: E2762-502...133.5
E2762-506...144.5
E2762-509...106.5
E2762-510...106.5
E2762-511...120.5
E2762-513...120.5

* The high voltage contact ring is used for internal electrical connection to the magnetic shield case in the cooler.

MCP-PMT Holder for C10373 Series E3059-500 (For R3809U Series)



NOTE: Ⓐ

E2762 Series	PMT
E2762-502	R11102, R2066, etc.
E2762-506	R943-02
E2762-509	R464, R649, etc.
E2762-510	R329-02, R331-05, R2257, etc.
E2762-511	R374, R2228, R5929, etc.
E2762-513	R375, R669

High Performance Thermoelectric Coolers for 28 mm Dia. Side-on PMTs C9143, C9144 Series

▲Left: Controller for C9144 and C9143
Center: C9144 and socket assembly C9145
Right: C9143 and socket assembly E9146

The C9143 and the C9144 are thermoelectric coolers designed for 28mm diameter side-on photomultiplier tubes (PMT). The C9143 and the C9144 improve S/N (signal to noise ratio) of PMT measurement because of reduction of thermal electrons, which are emitted from PMT photocathode, and minimization of external noise by a built-in electrostatic and magnetic shield. The C9143 and the C9144 can communicate with a PC via an RS-232C serial interface. It enables the PC to control the cooling temperature, high voltage output of C9145 (optionally available socket assembly with a built in Cockcloft-Wolton high voltage power supply) and ±5 V power supply for external equipment. The C9143 and the C9144 use water and forced air respectively to exchange heat of the thermoelectric cooler (Peltier module).

Features

- **Thermoelectric cooling using Peltier module**
- **Built-in electrostatic and magnetic shield**
- **Internal protective circuits safeguards Peltier module in case of low water flow or suspension of fan operation**
- **Low voltage output for driving C9145 (sold separately)**
- **Control and monitor function of high voltage output of C9145**
- **±5 V output for external equipment**
- **Built-in interface for controlling external equipment (D-Sub)**
- **PMT temperature control by PC**

Specifications

[Cooled PMT Housing]

Parameter	C9143/-01/-02 Ⓐ	C9144/-01/-02 Ⓐ	Unit
Cooling Method	Thermoelectric cooling using Peltier module		—
Heat Exchange Medium	Water	Forced air	—
Cooling Temperature	Approx. -30 Ⓑ (with cooling water of +20 °C)	Approx. -25 Ⓒ (with ambient temperature of +25 °C)	°C
Maximum Cooling Temperature	-30		°C
Time to Stable Cooling Temperature	Approx. 70	Approx. 90	min
Optical Window Material	Evacuated double-pane synthetic silica (185 nm to 2200 nm)		—
Light Input Aperture Dimension	8 × 24		mm
Applicable PMTs (sold separately)	28 mm Dia. Side-on Type		—
Applicable Socket Assembly (sold separately)	C9145 (DP-type), E9146 (D-type)		—
Operating Ambient Temperature / Humidity Ⓓ	+5 °C to +40 °C / Below 75 %	+5 °C to +35 °C / Below75 %	—
Storage Temperature / Humidity Ⓓ	-20 °C to +50 °C / Below 85 %		—
Weight	Approx. 1	Approx. 1.7	kg
Feature	Law infuluence by ambient temperature	Easy operation	—

NOTE: ⒶC9143/C9144: For AC 100 V operation. C9143-01/C9144-01: For AC 120 V operation. C9143-02/C9144-02: For AC 230 V operation. ⒷC9143 achieves cooling temperature of approx. -30 °C with water temperature of +20 °C. If the water temperature is higher, the possible lowest cooling temperature becomes higher (Note: Maximum cooling temperature is -30 °C). ⒸC9144 achieves cooling temperature of approx. -25 °C with ambient temperature of +25 °C. If the ambient temperature is higher, the possible lowest cooling temperature becomes higher. If the ambient temperature is lower, the possible lowest cooling temperature becomes lower (Note: Maximum cooling temperature is -30 °C). ⒹNo condensation

[Controller]

Parameter		Value/Description	Unit
AC Input Voltage		100 to 240 (±10 %) (50 Hz / 60Hz)	V
Maximum Power Consumption		150	V·A
Temperature Controllable Range		-30 to -5 (0.5 °C step) Ⓔ	°C
Protection Circuit		Protective circuits to safeguard Peltier module in case of low water or suspension of fan operation and to prevent output short-circuit, output overvoltage, and excessive temperature rise in controller.	—
Power Supply Unit for External Equipment	Output Voltage	±5 (±0.25)	V
	Output Current	0.5	A
	Connector	DIN (6 PIN)	—
Control Interface	DI (Input)	4 bits (TTL input)	—
	DO (Output)	4 bits (TTL open collector output)	
Serial Interface		RS-232C, 9600 bps	—
Operating Temperature / Humidity Ⓓ		+5 °C to +40°C / Below 75 %	—
Storage Temperature / Humidity Ⓓ		-20 °C to +50°C / Below 85 %	—
Weight		Approx. 4	kg

NOTE: ⒹNo condensation ⒺPMT temperature may not achieve set up cooling temperature controlled by the operator if ambient temperature and/or water temperature is high. The cooling temperature is controlled on personal computer.

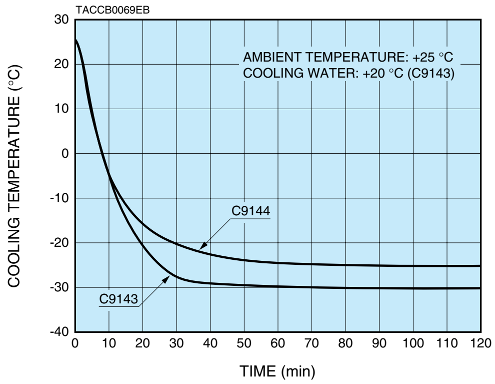
[Components and Accessories]

●Cooled PMT housing ●Controller ●Light shield cap ●AC line cable (2.5 m: -02 type, 2 m: other types) ●Connection cable (1.5 m) between cooled PMT housing and controller ●Serial communication cable (RS-232C crossing cable 1.8 m) ●D-Sub 15 pin connecter plug ●Cable terminated with a ±5 V plug (1.5 m, one end unterminated) ●CD-R (Instruction manual, sample software for control of cooling temperature and C9145 voltage) ●Spare fuses (2 pcs)

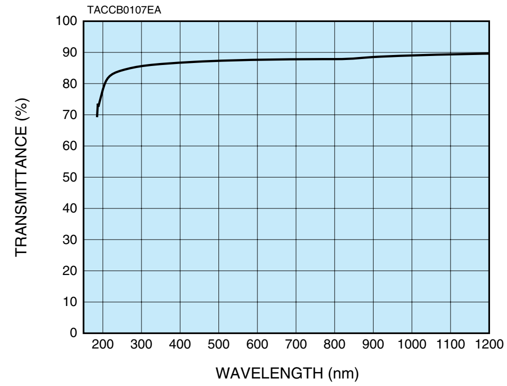
* To use C9143 series, water hoses with an outer diameter of 6 mm and an inner diameter of 4 mm and a water supply line with the matching round faucet are required. Prepare those hoses of the desired length. In addition, prepare a filter for removing impurities such as chlorine ions.

** CE C9143 series and C9144 series conform to the EMC directive and the LVD of the European Union.

Cooling Characteristics

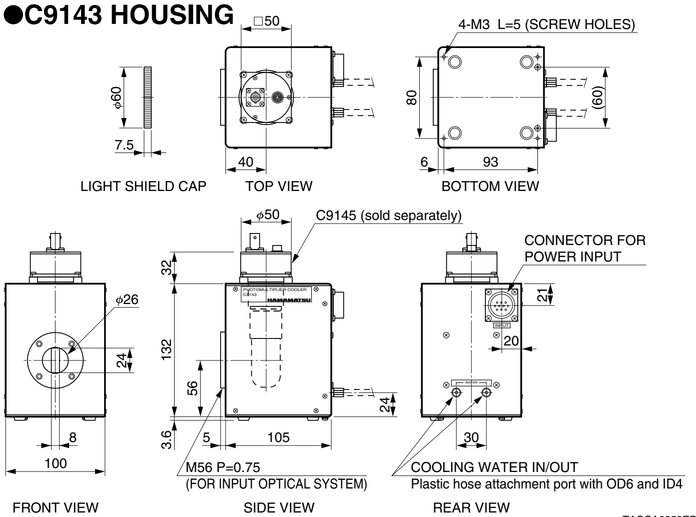


Spectral Transmission Characteristics of Optical Window

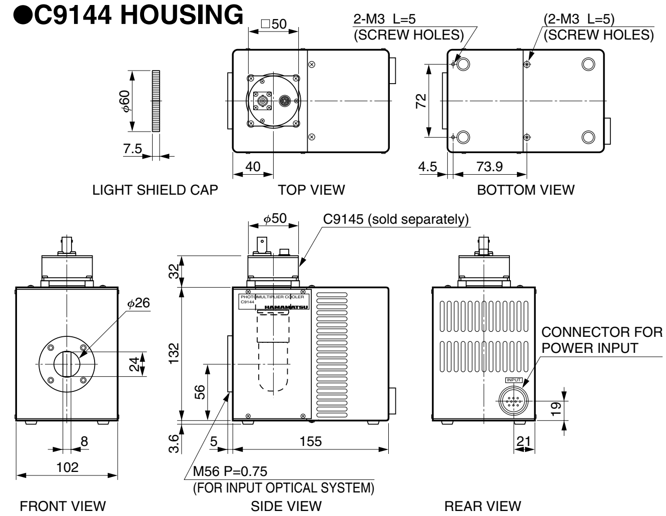


Dimensional Outlines (Unit: mm)

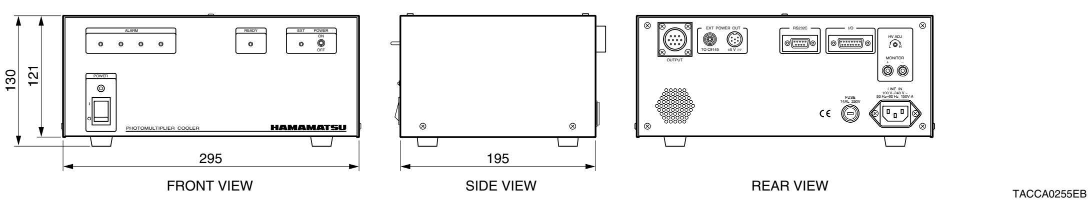
●C9143 HOUSING



●C9144 HOUSING

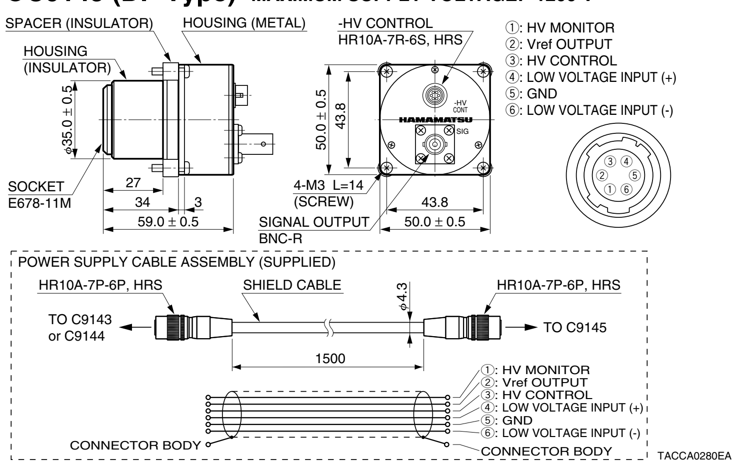


●CONTROLLER

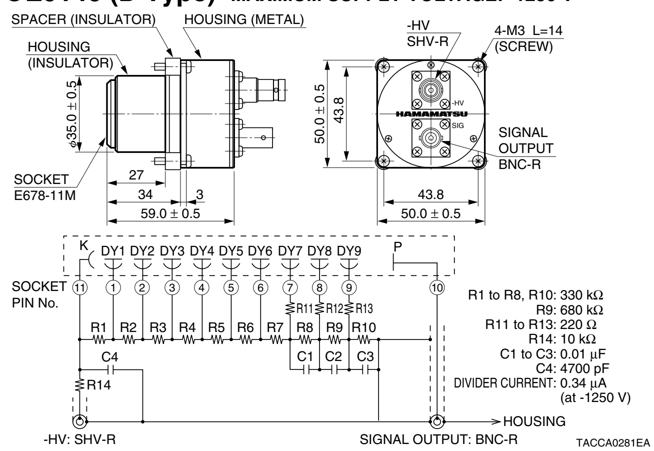


Sold Separately (Unit: mm)

●C9145 (DP Type) *MAXIMUM SUPPLY VOLTAGE: -1200 V

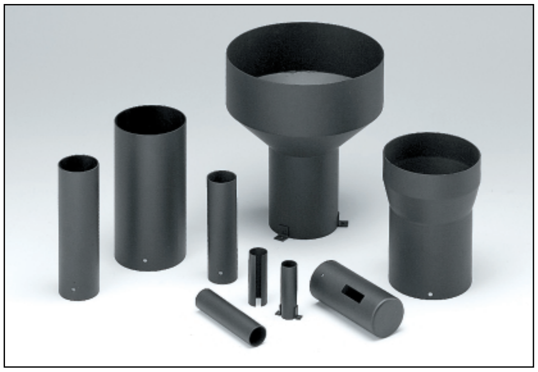


●E9146 (D Type) *MAXIMUM SUPPLY VOLTAGE: -1250 V



* The E9146-01 is also available, which is rated at maximum supply voltage of -1500 V.

Magnetic Shield Cases E989 Series



TACCF0093

Photomultiplier tubes are extremely sensitive to magnetic fields and exhibit output variations even from sources such as terrestrial magnetism.
Hamamatsu E989 series magnetic shield cases are designed specifically to protect photomultiplier tubes from the influence of such magnetic fields. The E989 series uses permalloy, a material that has an extremely high permeability (approximately 10^5). The magnetic field intensity within the shield case can be attenuated from 1/1000 to 1/10000 of that outside the shield case (this ratio is called the shielding factor). The E989 series ensures a stable output for photomultiplier tubes operating in proximity to magnetic fields.

Features

- **Made of high-permeability permalloy (Ni: 78 %, Fe and others: 22 %)**
- **Various sizes available with inner diameters from 12 mm to 138 mm**
- **Lusterless black paint finish**

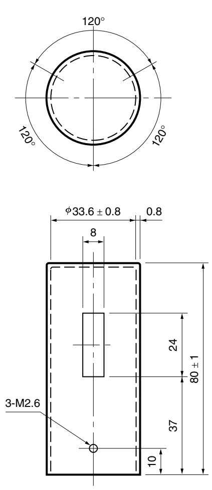
Specifications

Photomultiplier Tube Diameter		Type No.	Internal Dia. D (ϕmm)	Thickness t (mm)	Length L (mm)	Weight (g)
Side-on	ϕ13 mm (1/2")	E989-10	14.5	0.5	47 ± 0.5	10
	ϕ28 mm (1-1/8") *	E989	33.6 ± 0.8	0.8	80 ± 1	66
Head-on	ϕ10 mm (3/8")	E989-28	12 ± 0.5	0.5	48 ± 0.5	9
	ϕ13 mm (1/2")	E989-09	16 ± 0.5	0.8	75 ± 0.5	28
	ϕ19 mm (3/4")	E989-02	23 ± 0.5	0.8	95 ± 1	50
	ϕ25 mm (1")	E989-39	29 ± 0.5	0.8	48 ± 0.5	32
	ϕ28 mm (1-1/8")	E989-03	32 ± 0.5	0.8	120 ± 1	90
	ϕ38 mm (1-1/2")	E989-04	44^{+1}_{-0}	0.8	100 ± 1	102
	ϕ51 mm (2")	E989-05	60^{+1}_{-0}	0.8	130 ± 1	180
	ϕ76 mm (3")	E989-15	$80^{+1.5}_{-0}$	0.8	120 ± 1	200
	ϕ127 mm (5")	E989-26	138 ± 1.5	0.8	170 ± 1	400

* Photomultiplier tubes with HA treatment extending to the base portion cannot be used. Please consult our sales offices for details.

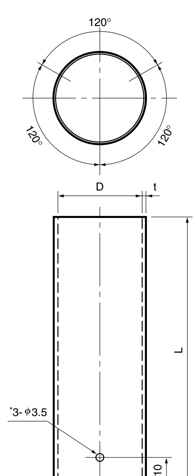
Dimensional Outlines (Unit: mm)

E989



TACCA0117EB

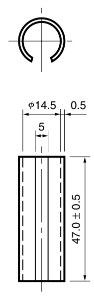
E989-02 to -05, -09*, -39*



*No mounting hole is provided for E989-09 and E989-39.

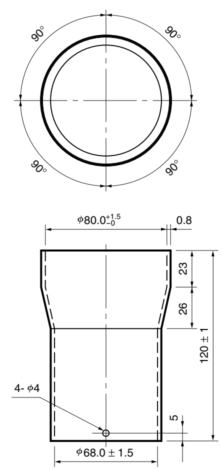
TACCA0118EA

E989-10



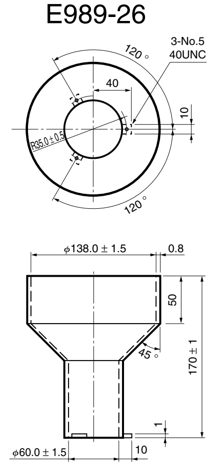
TACCA0119EC

E989-15



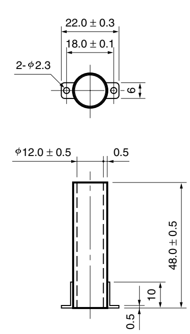
TACCA0120EC

E989-26



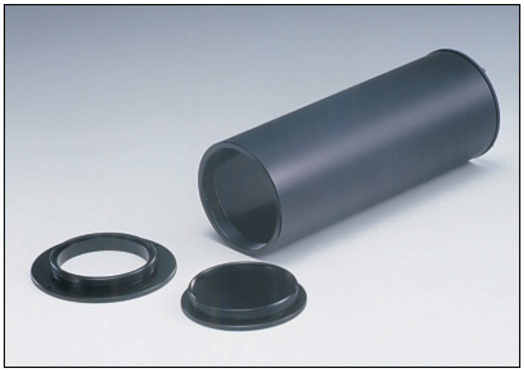
TACCA0121EC

E989-28



TACCA0122EC

Housing E1341-01/-02

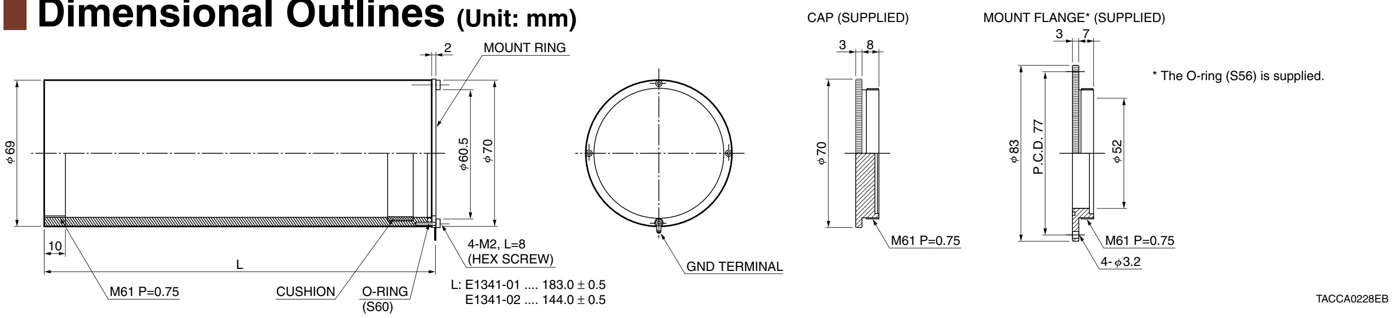


TACCF0177

The E1341-01/-02 are metal housings designed for the D-type socket assembly E5859 series (for 51 mm diameter head-on photomultiplier tubes; see page 101) operated at room temperature. To install the E5859 series socket assembly into the E1341-01/-02 and to ensure complete light-shielding, a magnetic shield case E989-62/-68 (sold separately) is required.
The E1341-01/-02 housings can be easily attached to a monochromator by preparing a simple adapter.

Type No.	Suitable Photomultiplier Tube	Magnetic Shield Case
E1341-01	R464, R649, R329-02, etc.	E989-62
E1341-02	R943-02	E989-68

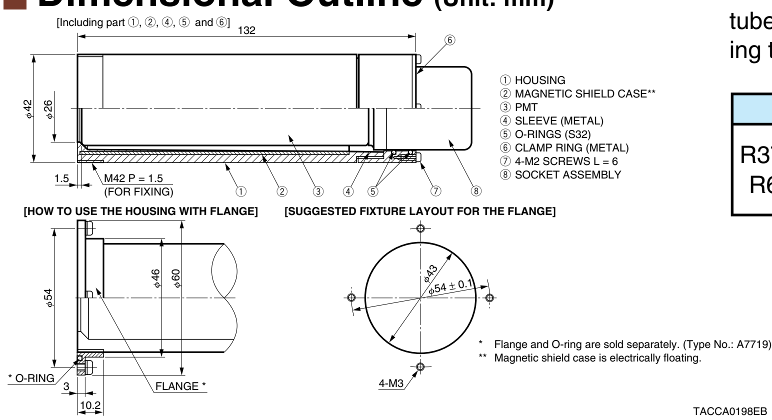
Dimensional Outlines (Unit: mm)



TACCA0228EB

Housing E7718

Dimensional Outline (Unit: mm)



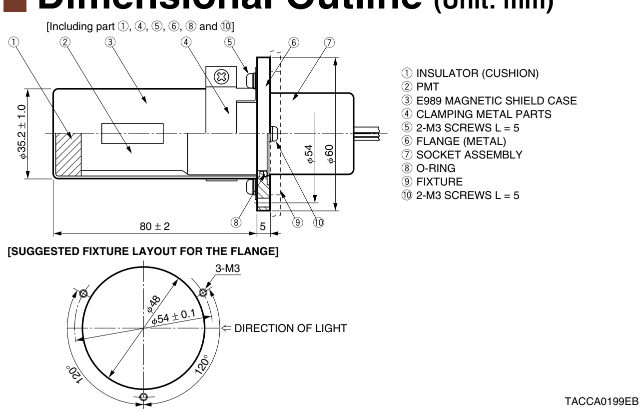
TACCA0198EB

The E7718 housing contains a magnetic shield case and is designed for use with 28 mm diameter head-on photomultiplier tubes. It can be easily attached to another device by connecting the A7719 flange (sold separately).

Suitable PMT	Suitable Socket Assembly	
R374, R2228, R5929 R6094, R6095, etc.	DA type	C7246/-22, C7247/-22
	DP type	C9028-01, C10344-03
	DAP type	C7950-01

Flange A7709

Dimensional Outline (Unit: mm)



TACCA0199EB

The A7709 is a flange for 28 mm diameter side-on photomultiplier tubes and is designed for use in combination with the E989 magnetic shield case (sold separately). It allows a photomultiplier tube to be integrated with a socket assembly.

Suitable PMT	Suitable Socket Assembly	
φ28 mm Side-on type	D type	E717-63/-500
	DA type	C7246-01/-23, C7247-01/-23
	DP type	C8991
	DAP type	C7950

* A7708 dedicated flange is provided for C6270 and C6271.

Power and Signal Cables, Connector Adapters

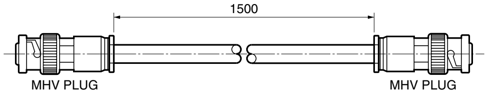
Power and Signal Cables E1168 Series, Connector Adapters A4184 Series

TACCF0153

Hamamatsu offers the E1168 series cables for connection of photomultiplier tube assemblies and their accessories. A variety of cables are available, for handling high voltage, low voltage and signals.
In addition, Hamamatsu also provides the A4184 series connector adapters designed for SHV/MHV connector conversion.

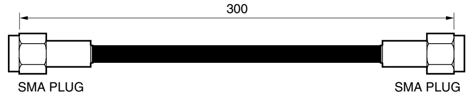
Dimensional Outlines (Unit: mm)

E1168 Series



TACCA0141EA

A5026 Series



TACCA0052EA

Selection Guide

● **For High Voltage**

Type No.	Cable Type	Cable Diameter	Maximum Voltage	Connector Types
E1168	RG-59B/U (Red)	ϕ6.2 mm	2.3 kV Max.	MHV Plug—MHV Plug
E1168-10				MHV Plug—SHV Plug
E1168-17				SHV Plug—SHV Plug
E1168-18	Custom High Voltage Cable (Red)	ϕ6.15 mm ± 0.3 mm	5 kV Max.	MHV Plug—MHV Plug
E1168-19				SHV Plug—SHV Plug
E1168-20				MHV Plug—SHV Plug

● **For Low Voltage**

Type No.	Cable Type	Connector Types
E1168-24	Multiconductor Cable with Shield	SR30-10PQ-4P—DIN6P Plug
E1168-26		DIN6P Plug—DIN6P Plug

● **For Signal**

Type No.	Cable Type	Impedance	Connector Types
E1168-01	3D-2V	50 Ω	N Plug—N Plug
E1168-02			N Plug—BNC Plug
E1168-03	3C-2V	75 Ω	BNC Plug—BNC Plug
E1168-05	3D-2V	50 Ω	BNC Plug—BNC Plug
A5026	SPECIAL COAXIAL CABLE	50 Ω	SMA Plug—SMA Plug
A5026-01			SMA Plug—SMA Jack

● **Connector Adapters**

Type No.	Connector Types
A4184-02	MHV Plug—SHV Jack
A4184-03	SHV Plug—MHV Jack

● **Relay Adapters**

Type No.	Connector Types
A5074	SHV Jack—SHV Jack
A7992	BNC Jack—BNC Jack

Photon Counting Unit C9744

TACCF0195

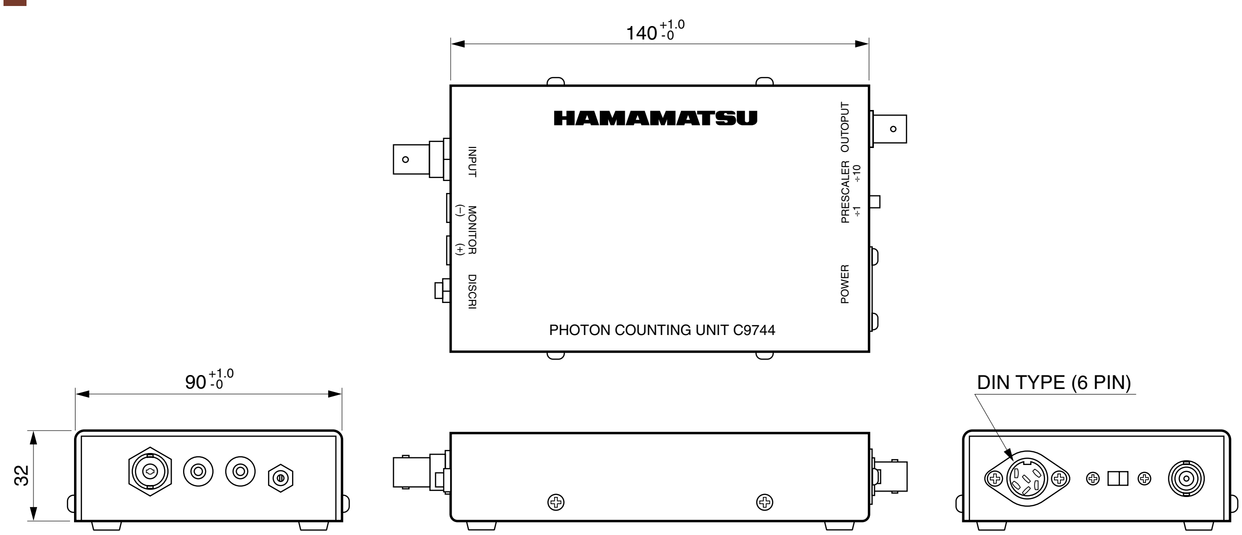
This photon counting unit contains an amplifier and a discriminator to convert the single photoelectric pulses from a photomultiplier tube into a 5 V digital signal.
The C9744 has an output linearity up to $1 \times 10^7\ s^{-1}$, and a high-speed counter is not required when set to division by 10.

Specifications

Parameter		Description / Value
Input Impedance		50 Ω
Discrimination Level (input conversion)		-0.4 mV to -16 mV
PMT Gain		3×10^6
Prescaler		÷1 / ÷10
Count Linearity	÷1	$4 \times 10^6\ s^{-1}$
	÷10	$1 \times 10^7\ s^{-1}$
Pulse-pair Resolution	÷1	25 ns
	÷10	10 ns
Output Pulse		CMOS 5 V, POSITIVE LOGIC
Output Pulse Width	÷1	10 ns
	÷10	Depends on count rate
Supply Voltage		+5.0 V ± 0.2 V, 130 mA / -5.0 V ± 0.2 V, 50 mA
Connector	Input	BNC-R
	Output	BNC-R
	Power	DIN (6 PIN) Ⓑ
Dimensions (W × H × D)		90 mm × 32 mm × 140 mm (excluding rubber feet and projecting parts)
Weight		Approx. 250 g
Operating Ambient Temperature / Humidity Ⓐ		0 °C to +50 °C / Below 80 %
Storage Temperature / Humidity Ⓐ		-15 °C to +60 °C / Below 85 %

NOTE: ⒶNo condensation ⒷSupplied with a cable (1.5 m) attached to the mating plug.

Dimensional Outline (Unit: mm)



TPHOA0031EA

Counting Unit C8855-01

The C8855-01 is a counting unit with a USB interface and can be used as a photon counter when combined with a photon counting head, etc.
The counter of the C8855-01 includes two counter circuits (double counter method) capable of counting input signals with no dead time. The USB interface easily connects to a notebook PC allowing measurement in an even wider application field. When used with a photon counting head, the C8855-01 supplies power (+5 V / 200 mA) necessary to operate the photon counting head.
Since the C8855-01 is hot-swap compatible (plug and play compatible), it helps you set up measurement environment quickly. You can start measurement on the day the C8855-01 is delivered by using the sample software that supplied with the C8855-01.

- **Time-resolved measurement (minimum resolution: 50 µs) for monitoring chemiluminescence and biological clocks**
- **Quick measurement setups (hot-swap compatible)**
  When software such as a device driver is installed into your PC beforehand, you can start measurement by just connecting the USB cable, without restarting the PC.
- **Applicable to various measurement methods**
  The C8855-01 is fully controlled by DLL (dynamic link library) functions that come with the C8855-01.
  All information on these DLL functions is available to support software programming that handles various types of user measurement applications.
- **Since the C8855-01 has an ID switch, a maximum of 16 units can be connected to one PC and controlled individually.**

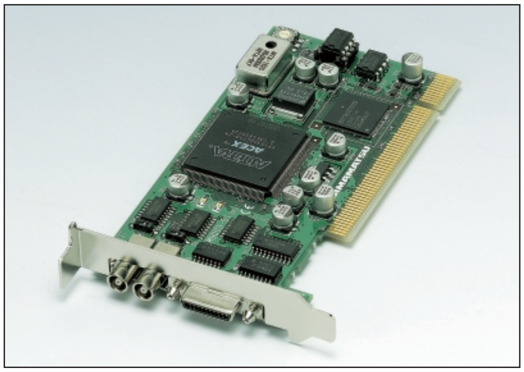
Specifications

Parameter		Description / Value
Input	Number of Input Signals	1 ch
	Signal Input Level	CMOS positive logic (high level: 2 V min.)
	Signal Pulse Width	8 ns or longer
	Input Impedance	50 Ω
Counter	Counter Method	Double counter method
	Maximum Count Rate	50 MHz
	Maximum Counter Capacity	2^{32} counts/counter gate
Counter Gate	Counter Gate Mode	Internal counter gate only
	Internal Counter Gate Time Ⓐ	50 µs to 10 s (1, 2, 5 step)
Trigger	Trigger Method	External trigger / Software trigger
	External Trigger Signal	TTL negative logic
ID Switch Ⓑ		0 to F(hexadecimal number) Select
General Output Section		Open collector / 2 bits
Voltage Output		+5 V / 200 mA Max.
Compatible OS		Windows® 2000 / XP Pro / Vista Business (32-bit)
Interface		USB
Supply Voltage		+7 V / 500 mA Max. (supplied from AC adapter)
Dimensions (W × H × D)		120 mm × 30 mm × 96 mm (excluding rubber feet and projecting parts)
Weight		250 g
Operating Ambient Temperature / Humidity Ⓒ		+5 °C to +45 °C / Below 80 %
Storage Temperature / Humidity Ⓒ		0 °C to +50 °C / Below 85 %
CE Marking		Conforms to the IEC 61236-1 GROUP 1, CLASS B
AC Adapter	AC Input	90 V to 264 V
	Output	7 V / 1.6 A

NOTE: ⒶThe C8855-01 is not suitable for applications requiring time resolution higher than 50 µs. In such applications, use a counting board M9003-01.
ⒷThe ID switch is used to set ID numbers when two or more C8855-01 units are connected to single PC. ⒸNo condensation

Supplied: CD-ROM (containing instruction manual, device driver, DLL, sample software*, etc.) USB cable, AC adapter, AC cable, power output connector
* Sample software is configured from Lab VIEW™ of National Instruments, Inc.

Counting Board M9003-01



The M9003-01 counting board is a PCI bus add-in board counter that functions as a photon counter when used along with a Hamamatsu photon counting head.

The counter section of the M9003-01 has two counter circuits (double counter method) capable of counting the input signal pulses without any dead time. The counter operates in either gate counter mode or in reciprocal counter mode. Gate counter mode counts the input signal pulses only during each gate time produced by the internal oscillator. (Minimum gate time during gate counter mode is 50 ns.) Reciprocal counter mode counts the number of internal clock pulses generated between input signal pulses.

The M9003-01 does not have its own memory so it sends measurement data directly to the PC's main memory by DMA (direct memory access) transfer. This enables measurement of up to 64 Mbytes. External trigger signals can also be inserted into the count data as timing information.

Counting can also be performed for a predetermined number of gates starting from the input of an external trigger signal (only during gate counter mode). This allows counting periodic light emission phenomena by integrating their signals after DMA transfer.

Anyone can easily make the initial settings since the M9003-01 is PnP (plug and play) compatible. You can start making measurements right away after the M9003-01 is unpacked, by just using the sample software that comes supplied with the unit.

Specifications

Parameter		Description / Value
Input	Number of Input Signals	2 ch
	Signal Input Level	TTL positive logic
	Signal Pulse Width	8 ns or longer
	Input Impedance (Switchable)	50 Ω (at SW ON), 100 kΩ (at SW OFF)
Counter	Counter Method	Gate mode Ⓑ / Reciprocal mode Ⓒ
	Maximum Count Rate	50 MHz (gate mode) / 20 MHz (reciprocal mode)
	Maximum Count Capacity	2^8 / 2^{16} counts (gate mode) / 2^{31} counts (reciprocal mode)
Gate	Gate Time Resolution	50 ns to 12.75 µs
Trigger	Trigger Method	External trigger / Software trigger
	External Trigger Signal	TTL negative logic
	Trigger Signal Pulse Width	1 µs or more
	Trigger Signal Output Timing	At start of counting by software trigger
General I/O	Input Signal	TTL level signal (3 bits)
	Input Strobe Signal	TTL level signal
	Output Signal	Open collector (4 bits)
	Output Strobe Signal	Open collector
Compatible OS		Windows® 2000 / XP Pro / Vista Business (32-bit)
Bus Type		PCI bus interface (conforms to Rev 2.1)
Data Transfer Method		DMA transfer (scatter-gather method)
Data Transfer Quantity		Maximum 64 Mbytes (data quantity transferable by one DMA.)
Data Transfer Rate		40 Mbytes/sec (depends on CPU and peripherals)
Size		PCI standard (low profile)
Weight		Approx. 80 g
Operating Ambient Temperature / Humidity Ⓐ		+5 °C to +40 °C / Below 80 %
Storage Temperature / Humidity Ⓐ		0 °C to +50 °C / Below 85 %
CE Marking		Conforms to the IEC 61236-1 GROUP 1, CLASS B

NOTE: ⒶNo condensation
ⒷGate counter mode counts the input signal pulses only during each specified gate time.
ⒸReciprocal counter mode counts the number of internal clock pulses generated between input signal pulses.

Supplied: CD-ROM (containing instruction manual, device drivers, sample software*, etc.),
Signal cables E1168-22 × 4 (LEMO-BNC: coaxial 1.5 m), Flat cable plug TXA20A-26PH1-D2P1-D1 (manufactured by JAE)

* Sample software is configured from Lab VIEW™ of National Instruments, Inc.

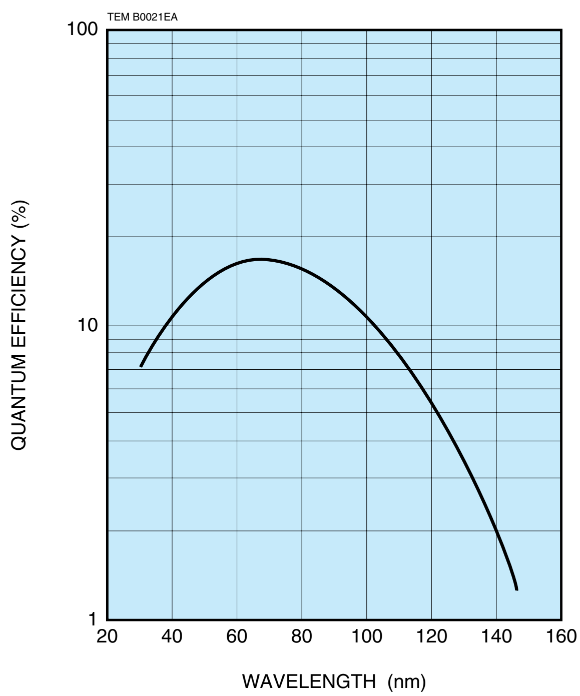
Electron Multipliers

Electron multipliers (also called ion multipliers) are specially designed for the detection and measurement of electrons, ions, charged particles, VUV radiation and soft X-rays. Hamamatsu electron multipliers deliver high gain and low noise, making them ideal for the detection of very small or low energy particles by using the counting method. Especially useful applications include mass spectroscopy, field ion microscopy and electron or VUV spectroscopy such as Auger spectroscopy and ESCA.

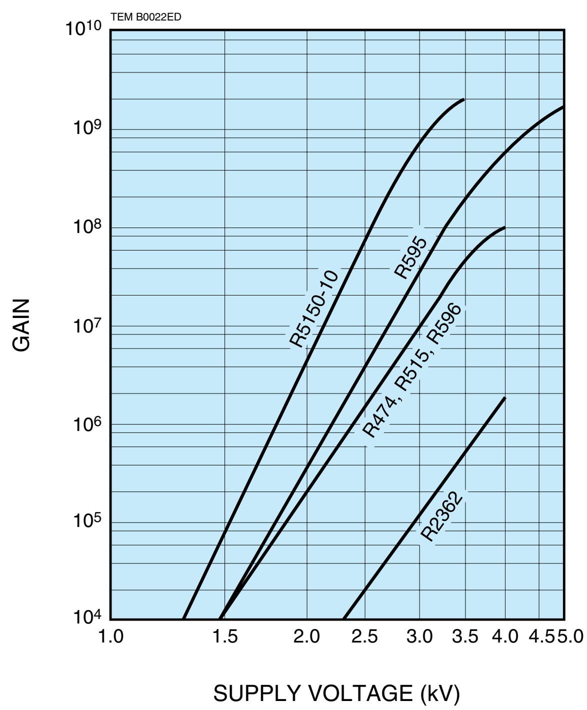
Each type has Cu-BeO dynodes connected by built-in divider resistors of 1 MΩ per stage. The first dynode can be replaced by a photocathode of Cs-I, K-Br, and so on for use in VUV spectroscopy. In applications where the operating vacuum level is inadequate, the R5150-10 is recommended. In TOF-MS applications, the R2362 with mesh dynodes is recommended.

		Dynode				Characteristics				Max. Ratings			
Type No. Ⓐ	Out-line	Number of Stages	Structure	Material	Input Aperture Diameter (mm)	Supply Voltage (V)	Gain Typ.	Rise Time Typ. (ns)	Anode to all Other Electrode Capacitance (pF)	Anode to First Dynode Voltage (V)	Anode to Last Dynode Voltage (V)	Ⓙ Average Anode Current (μA)	Operating Vacuum Level (Pa)
Head-on Type													
R5150-10	❶	17	Box and Line	Cu-BeO	ϕ8	2000	5×10^6	1.7	4.0	3500	350	10	133×10^{-4}
R2362	❷	23	Mesh	Cu-BeO	ϕ20	3450	5×10^5	3.5	23	4000	350	10	133×10^{-4}
R474	❸	16	Box and Grid	Cu-BeO	8×6	2400	1×10^6	9.3	5.0	4000	350	10	133×10^{-4}
R515	❹	16	Box and Grid	Cu-BeO	8×6	2400	1×10^6	9.3	4.0	4000	350	10	133×10^{-4}
R596	❺	16	Box and Grid	Cu-BeO	12×10	2400	1×10^6	10	9.0	4000	400	10	133×10^{-4}
R595	❻	20	Box and Grid	Cu-BeO	12×10	3000	4×10^7	12	9.0	5000	400	10	133×10^{-4}

Spectral Response (Cu-BeO)

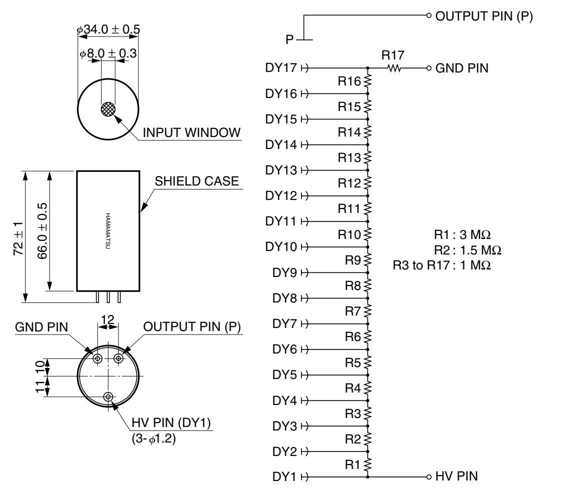


Gain



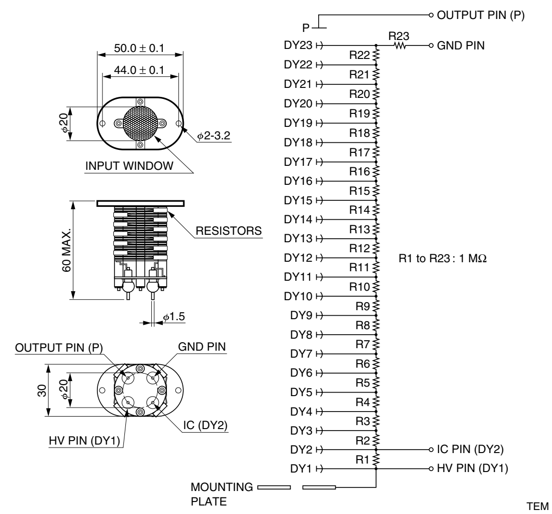
Dimensional Outlines (Unit: mm)

❶ R5150-10



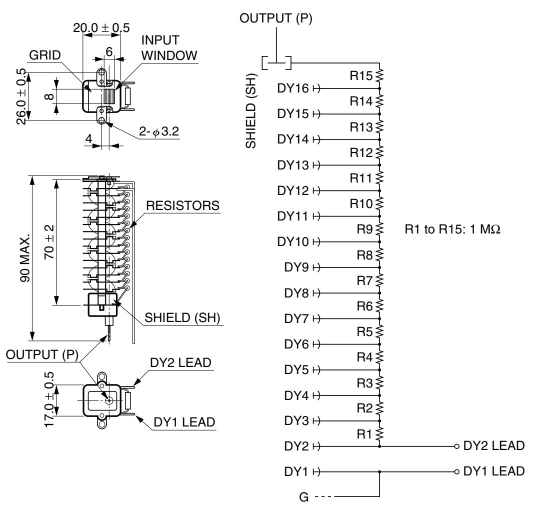
TEM A0015EB

❷ R2362



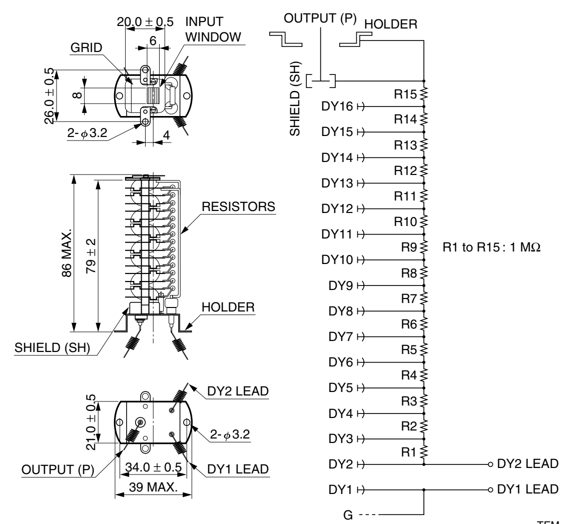
TEM A0009EC

❸ R474



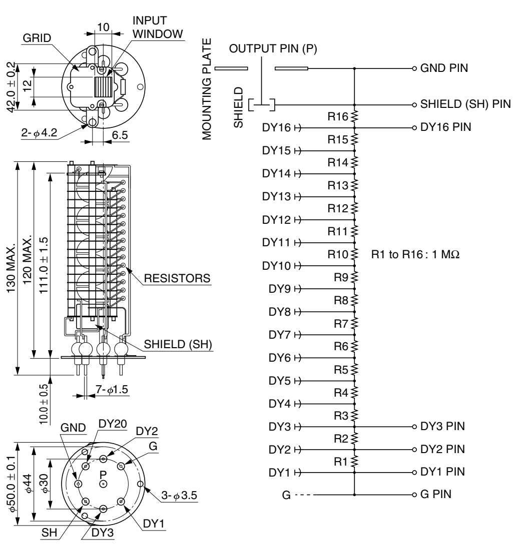
TEM A0005EC

❹ R515



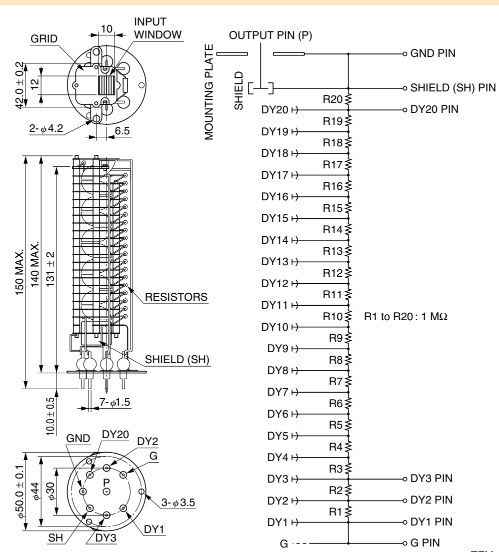
TEM A0006ED

❺ R596



TEM A0007ED

❻ R595



TEM A0008ED

Caution and Warranty

SAFETY PRECAUTIONS

⚠ WARNING

HIGH VOLTAGE

A high voltage is applied to a photomultiplier tube during operation. Always provide adequate safety measures to prevent the operator or service personnel from electrical shock and the equipment from being damaged.

HANDLING PRECAUTIONS

●Handle tubes with extreme care.
Photomultiplier tubes have evacuated glass envelopes. Allowing the glass to be scratched or subjected to shock can cause cracks. Take extreme care during handling, particularly for tubes with graded sealing on synthetic silica bulbs.

●Keep faceplate and base clean.
Do not touch the faceplate and base with bare hands. Dirt and grime on the faceplate causes loss of transmittance and dirt or grime on the base may cause ohmic leakage. If the faceplate becomes soiled wipe it clean using alcohol.

●Do not expose to strong light.
The photocathode of photomultiplier tubes may be damaged if exposed to direct sunlight or intense illumination. Never allow strong light to strike the photocathode.

●Carefully handle tubes with a glass base.
Photomultiplier tubes with a glass base (also called button stem) are less rugged than tubes with a plastic base, so sufficient care must be taken when handling this type of tube. When fabricating a voltage-divider circuit by soldering resistors and capacitors to socket lugs, solder them while the tube is fully inserted into the socket.

●Helium permeation through silica bulb
Helium will permeate through silica bulbs and increase noise, leading to damage that makes photomultiplier tubes unusable. Avoid operating or storing them in an atmosphere where helium is present.

WARRANTY

Hamamatsu photomultiplier tubes and related products are warranted to the original purchaser for a period of 12 months after delivery. The warranty is limited to repair or replacement of a defective product due to defects in workmanship or materials used in its manufacture.
However, even if within the warranty period the warranty shall not apply to failures or damages caused by misoperation, mishandling, modification or accidents such as natural or man-made disasters.
The customer should inspect and test all products as soon as they are delivered.

ORDERING INFORMATION

This catalog lists photomultiplier tubes and related products currently available from Hamamatsu Photonics. Please select those products that best match your design specifications. If you do not find the products you want in this catalog, feel free to contact our sales office nearest you. We will modify our current products or design new types to meet your specific needs.

WHEN DISPOSE THE PRODUCT

When disposing of the product, take appropriate measures in compliance with applicable regulations regarding waste disposal and correctly dispose of it yourself, or entrust disposal to a licensed industrial waste disposal company.
In any case, be sure to comply with the regulations in your country, state, region or province to ensure the product is disposed of legally and correctly.

* Characteristics and specifications in this catalog are subject to change without prior notice due to product improvement or other factors.
Before you design equipment according to the characteristics and specifications of our products listed in this catalog, please contact us to check the product specifications.

Typical Photocathode Spectral Response

	Curve Codes	Photocathode Materials	Window Materials	Luminous (Typ.)	Spectral Response					PMT Examples
					Range	Peak Wavelength				
						Radiant Sensitivity		QE		
				(nm)	(nm)	(mA/W)	(nm)	(%)	(nm)	

Semitransparent Photocathode

○	100M	Cs-I	MgF_2	—	115 to 200	14	140	13	130	R972, R1081, R6835
○	200S	Cs-Te	Synthetic silica	—	160 to 320	29	240	16	210	R759, R821, R6834
○	200M	Cs-Te	MgF_2	—	115 to 320	29	240	17	200	R1080, R6836
	201S	Cs-Te	Synthetic silica	—	160 to 320	31	240	17	210	R2078
○	400K	Bialkali	Borosilicate	95	300 to 650	88	420	27	390	R329-02, R1307, R1548-07, R1635 R1924A, R5611A-01, R11102, etc.
○	400U	Bialkali	UV	95	185 to 650	88	420	27	390	R1584
○	400S	Bialkali	Synthetic silica	95	160 to 650	88	420	27	390	R2496
○	401K	High temp. Bialkali	Borosilicate	40	300 to 650	51	375	17	375	R1288A, R3991A,R4177-01, R4607A-01
○	402K	Low noise Bialkali	Borosilicate	40	300 to 650	54	375	18	375	R2557, R3550A, R5610A
○	500K(S-20)	Multialkali	Borosilicate	150	300 to 850	64	420	20	375	R550, R649, R1513, R1617, R1878 R1925A
○	500U	Multialkali	UV	150	185 to 850	64	420	25	280	R374, R1463
○	500S	Multialkali	Synthetic silica	150	160 to 850	64	420	25	280	R375
○	501K(S-25)	Extended red Multialkali	Borosilicate	200	300 to 900	40	600	8	580	R669, R2066, R2228, R2257
○	502K	Multialkali	Borosilicate (prism)	230	300 to 900	69	420	20	390	R5070A, R5929
○	600K	GaAsP	Borosilicate	700	280 to 720	180	550 to 650	40	480 to 530	R3809U-64
○	601K	Extended red GaAsP	Borosilicate	750	280 to 820	160	550 to 650	36	480 to 530	R3809U-63
○	602K	GaAs	Borosilicate	700	370 to 920	85	750 to 850	12	600 to 750	R3809U-61
○	700K(S-1)	Ag-O-Cs	Borosilicate	20	400 to 1200	2.2	800	0.36	740	R5108
○	900S	InP/InGaAsP(CS)	Synthetic silica	—	950 to 1200	18	1100	2	1000 to 1100	H10330-25*
○	901S	InP/InGaAs(CS)	Synthetic silica	—	950 to 1700	24	1500	2	1000 to 1550	H10330-75*

Semitransparent Photocathode (UBA [Ultra Bialkali], SBA [Super Bialkali])

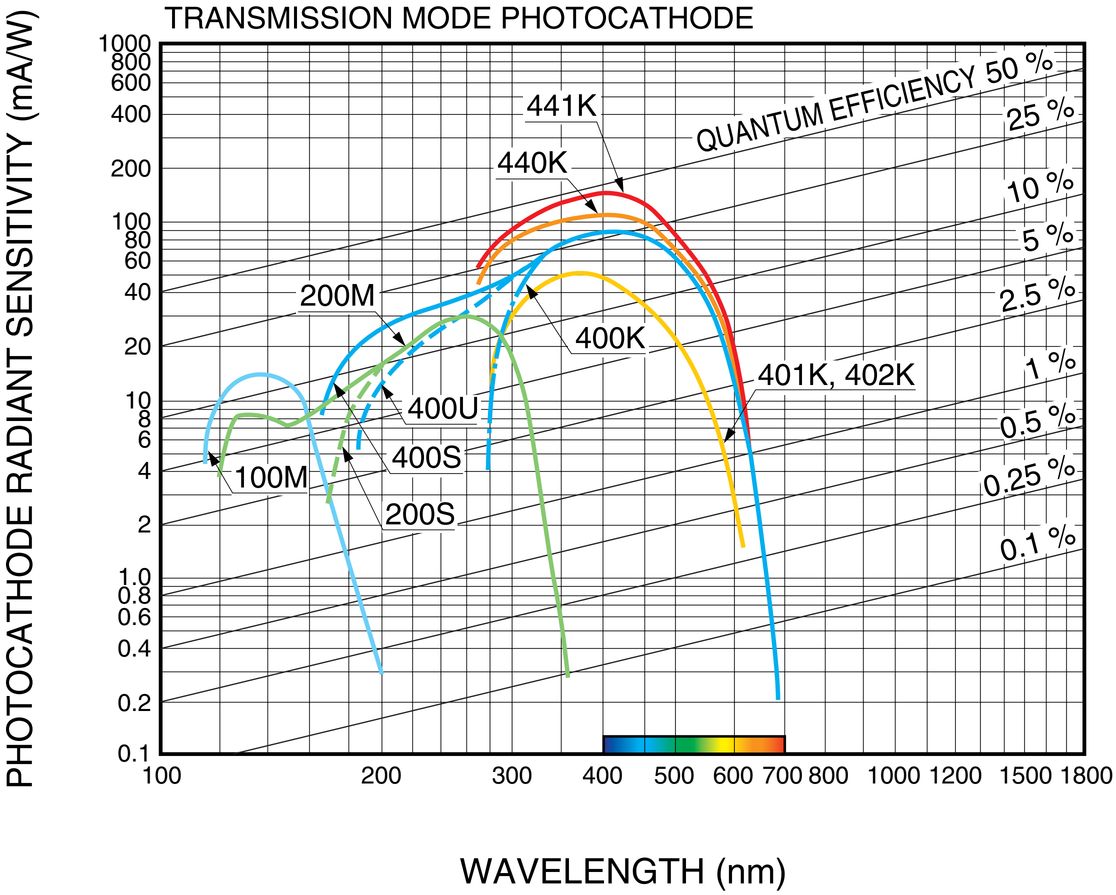
○	440K	Super Bialkali	Borosilicate	105	300 to 650	110	400	35	350	R7600U-100, R7600U-100-M4,R5900U-100-L16, etc.
○	441K	Ultra Bialkali	Borosilicate	135	300 to 650	130	400	43	350	R7600U-200, R7600U-200-M4,R5900U-200-L16, etc.
	442K	Super Bialkali	Borosilicate	105	230 to 700	110	400	35	350	R9880U-110
	443K	Ultra Bialkali	Borosilicate	135	230 to 700	130	400	43	350	R9880U-210

Reflection Mode Photocathode

○	150M	Cs-I	MgF_2	—	115 to 195	25.5	130	26	125	R8487, R10825
○	250S	Cs-Te	Synthetic silica	—	160 to 320	62	230	37	210	R6354, R7154
○	250M	Cs-Te	MgF_2	—	115 to 320	63	200	35	220	R8486, R10824
○	350U(S-5)	Sb-Cs	UV	40	185 to 650	48	340	20	280	R6350
○	452U	Bialkali	UV	120	185 to 750	90	420	30	260	R3788, R6352
	453K	Bialkali	Borosilicate	60	300 to 650	60	400	20	370	R11558
	453U	Bialkali	UV	60	185 to 650	60	400	23	330	R11568
○	456U	Low noise Bialkali	UV	60	185 to 680	60	400	19	300	R1527, R4220, R5983, R6353, R7518
	550U	Multialkali	UV	150	185 to 850	45	530	15	250	R6355
○	552U	Multialkali	UV	200	185 to 900	68	400	26	260	R2949
○	555U	Multialkali	UV	525	185 to 900	90	450	30	260	R3896, R9110, R9220
	556U	Multialkali	UV	200	185 to 850	80	430	27	280	R4632
	557U	Multialkali	UV	650	185 to 900	109	450	35	260	R10699
	561U	Multialkali	UV	200	185 to 830	70	530	24	250	R6358
○	562U	Multialkali	UV	300	185 to 900	76	400	26	260	R928, R5984
○	650U	GaAs	UV	550	185 to 930	62	300 to 800	23	300	R636-10
○	650S	GaAs	Synthetic silica	550	160 to 930	62	300 to 800	23	300	R943-02
	850U	InGaAs	UV	100	185 to 1010	40	400	14	330	R2658
○	851K	InGaAs	Borosilicate	150	300 to 1040	50	400	16	370	R3310-02*
○	950K	InP/InGaAsP(Cs)	Borosilicate	—	300 to 1400	21	1300	2	1000 to 1300	R5509-43*
○	951K	InP/InGaAs(Cs)	Borosilicate	—	300 to 1700	24	1500	2	1000 to 1500	R5509-73*

⁎ : Spectral response characteristics vary from tube to tube, so the above values may differ from actual data.
○: Spectral response curves are shown on page 132, 133
* : Products marked are not listed in this catalog.

SEMITRANSPARENT PHOTOCATHODE SPECTRAL RESPONSE CHARACTERISTICS



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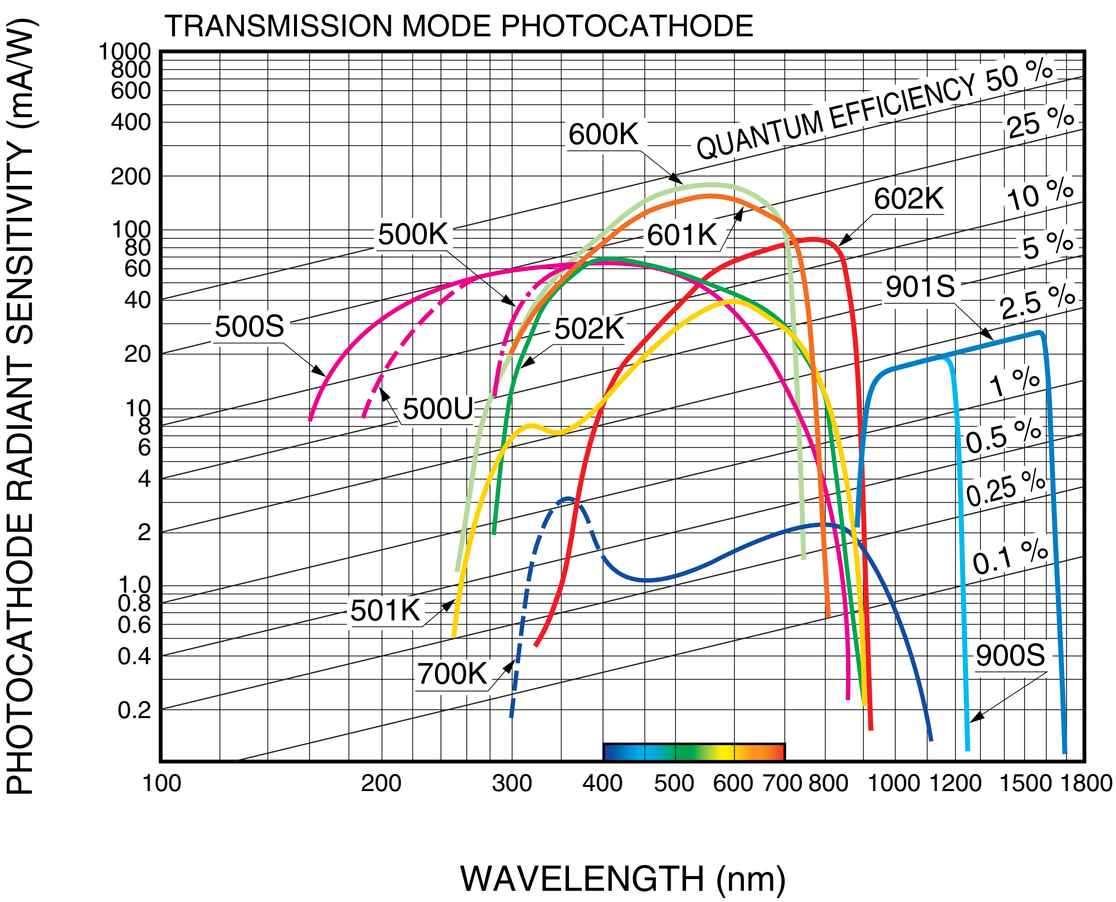

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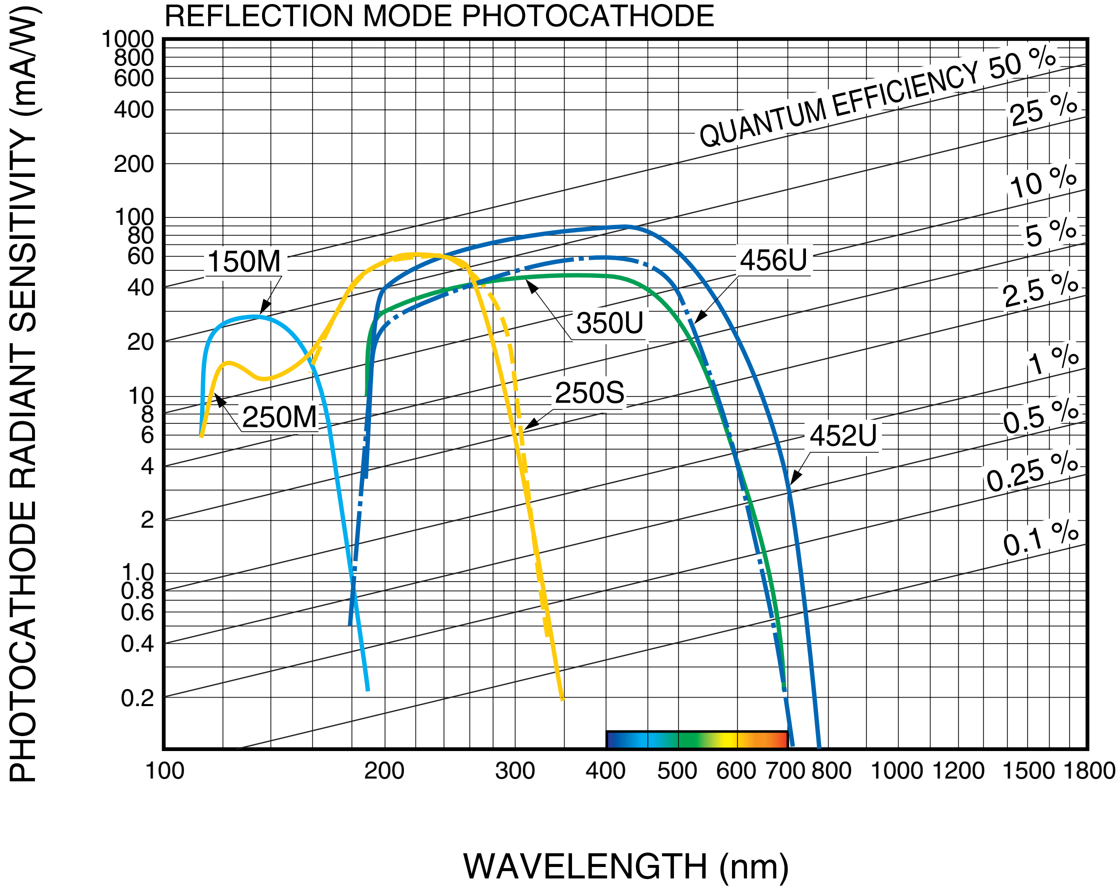
OPAQUE PHOTOCATHODE SPECTRAL RESPONSE CHARACTERISTICS



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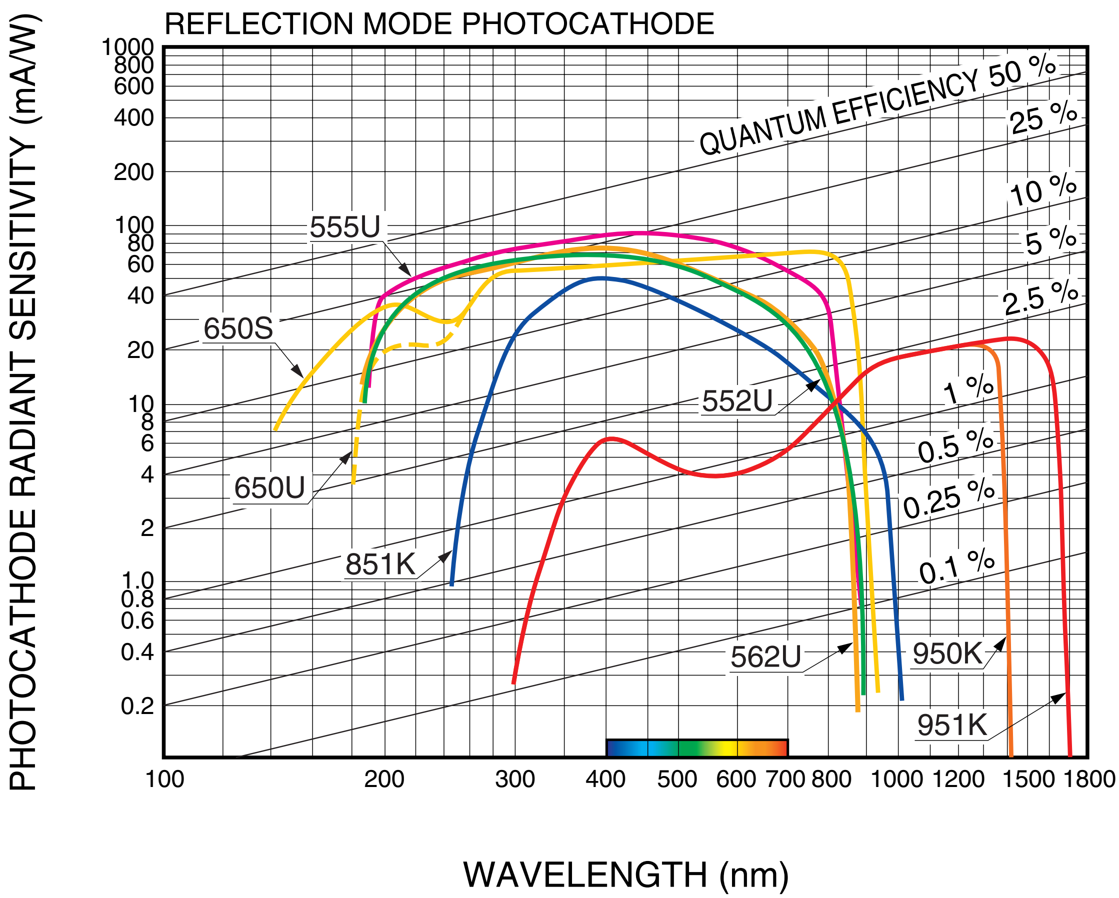


TPMOB0080EJ

Notes

Ⓐ Types marked * are newly listed in this catalog.

Ⓑ See pages 132 and 133 for typical spectral response charts.

Ⓒ Photocathode materials

BA :	Bialkali
LBA :	Low noise bialkali
HBA :	High temperature bialkali
SBA :	Super bialkali
UBA :	Ultra bialkali
MA :	Multialkali
EMA :	Extended red multialkali
DIA :	Diamond

Other photocathodes are indicated by the element symbols.

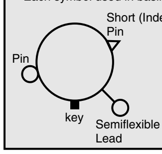
Ⓓ Window materials

MF :	MgF_2
Q :	Quartz (Fused silica or synthetic silica)
K :	Borosilicate glass
U :	UV glass

Ⓔ Base diagram

BASING DIAGRAM SYMBOLS

All base diagrams show terminals viewed from the base end of the tube.
Each symbol used in basing diagrams signifies the following.



DY : Dynode
G : Grid
ACC : Accelerating electrode
K : Photocathode
P : Anode
SH : Shield
IC : Internal connection (Do not use.)
NC : No connection (Do not use.)

Ⓕ Dynode structure

B :	Box-and-grid
VB :	Venetian blind
CC :	Circular-cage
L :	Linear-focused
B + L :	Box and linear-focused
C + L :	Circular and Linear-focused
FM :	Fine mesh
CM :	Coarse mesh
MC :	Metal channel

Ⓖ See page 92, 93 for suitable socket assemblies.
See page 76, 77 for suitable sockets E678 series.
*: A socket will be supplied with the tube.
No mark: Sockets may be obtained from electronics supply houses or our sales office.

Ⓗ Operating ambient temperature range for the photomultiplier itself is -30 °C to +50 °C except for some types of tubes.
However, when photomultiplier tubes are operated below -30 °C at their base section, please consult us in advance.

Ⓙ Averaged over any interval of 30 seconds maximum.

Ⓚ Measured at the peak sensitivity wavelength.

Ⓛ See page 74 for voltage distribution ratio.

Ⓜ Anode characteristics are measured with the supply voltage and voltage distribution ratio specified by Note L.

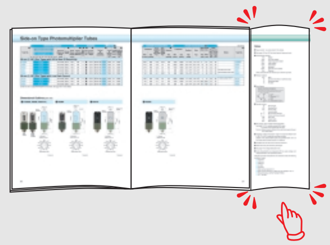
Cathode and anode characteristics are measured under the following conditions if noted.

ⓐ at 122 nm
ⓑ at 254 nm
ⓒ at 852 nm
ⓓ at 4 A/lm
ⓔ at 10 A/lm
ⓕ Dark count per second (s^{-1})
ⓖ Dark count per second (s^{-1}) after one hour storage at -20 °C
ⓗ Measured using a red filter Toshiba IR-D80A
ⓘ at 1×10^6 gain

How to Use This Folding Page

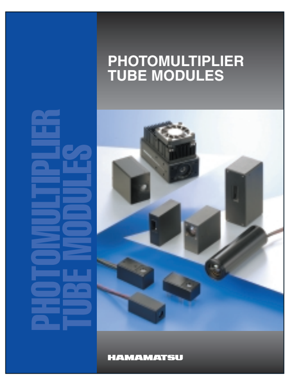
To read this catalog, open this page as shown below.

●"NOTES" are listed on the inside of this page so that you can refer to them while looking at the specification tables.



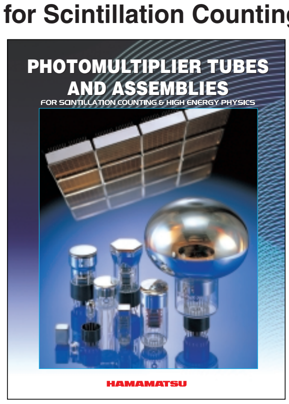
Related Product Catalogs

Photomultiplier Tube Modules



The photomultiplier tube module is basically comprised of a photomultiplier tube, a high-voltage power supply circuit to operate the photomultiplier tube, and a voltage divider circuit to distribute the optimum voltage to each dynode, all integrated into a compact case. In addition to these basic configurations, Hamamatsu also provides modules having various added functions such as signal conversion, photon counting, cooling and interfacing to a PC.

Photomultiplier Tubes and Assemblies
for Scintillation Counting & High Energy Physics



This catalog is a selection guide for Hamamatsu photomultiplier tubes and assemblies specially fabricated and selected for scintillation counting and high energy physics applications. These photomultiplier tubes offer high quantum efficiency, high energy resolution, wide dynamic range and fast time response, as well as remarkable resistance to harsh environments ranging from strong magnetic fields to high temperatures. A wide variety of products are listed here ranging in diameter from 3/8 inches up to 20 inches.

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Main Products

Electron Tubes
Photomultiplier Tubes
Photomultiplier Tube Modules
Microchannel Plates
Image Intensifiers
Xenon Lamps / Mercury Xenon Lamps
Deuterium Lamps
Light Source Applied Products
Laser Applied Products
Microfocus X-ray Sources
X-ray Imaging Devices

Opto-semiconductors
Si photodiodes
APD
Photo IC
Image sensors
PSD
Infrared detectors
LED
Optical communication devices
Automotive devices
X-ray flat panel sensors
Mini-spectrometers
Opto-semiconductor modules

Imaging and Processing Systems
Cameras / Image Processing Measuring Systems
X-ray Products
Life Science Systems
Medical Systems
Semiconductor Failure Analysis Systems
FPD / LED Characteristic Evaluation Systems
Spectroscopic and Optical Measurement Systems

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Information in this catalog is believed to be reliable. However, no responsibility is assumed for possible inaccuracies or omission. Specifications are subject to change without notice. No patent rights are granted to any of the circuits described herein.

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Quality, technology, and service are part of every product.

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