

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 50 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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Construction and Operating Characteristics

INTRODUCTION

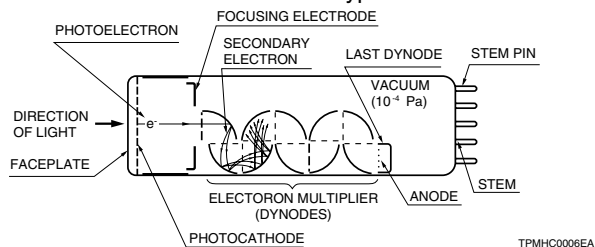
Among photosensitive devices in use today, the photomultiplier tube (or PMT) is a versatile device providing ultra-fast response and extremely high sensitivity. A typical photomultiplier tube consists of a photoemissive cathode (photocathode) followed by focusing electrodes, an electron multiplier and 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

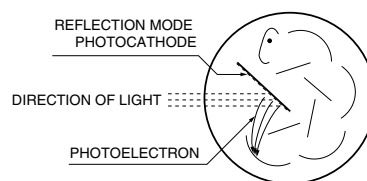


b) Head-on Type



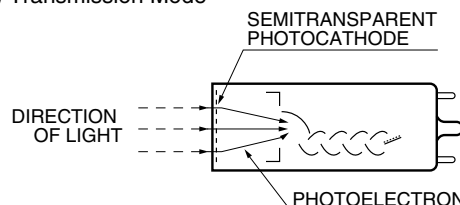
Figure 3: Types of Photocathode

a) Reflection Mode



TPMSC0029EA

b) Transmission Mode



TPMHC0084EB

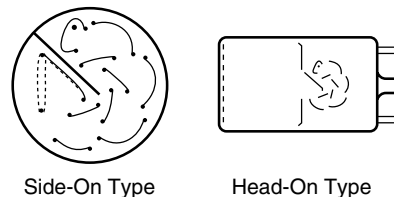
ELECTRON MULTIPLIER

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

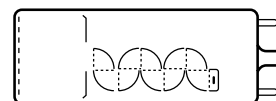
The circular cage is generally used for the side-on type of photomultiplier tube. The prime features of the circular-cage are compactness, fast response and high gain obtained at a relatively low supply voltage.



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2) Box-and-grid type

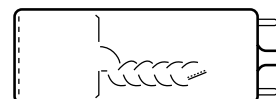
This type consists of a train of quarter cylindrical dynodes and is widely used in head-on type photomultiplier tubes because of good electron collection efficiency and excellent uniformity.



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3) Linear-focused type

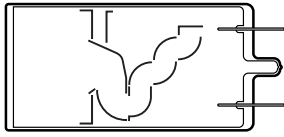
The linear-focused type features extremely fast response time and is widely used in applications where time resolution and pulse linearity are important. This type also has the advantage of providing a large output current.



TPMOC0079EA

4) Box-and-line type

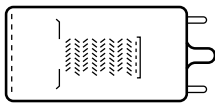
This structure consists of a combination of box-and-grid and linear-focus dynodes. Compared to box-and-grid type, this structure has advantages in time response, time resolution, pulse linearity, and electron collection efficiency.



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5) Venetian blind type

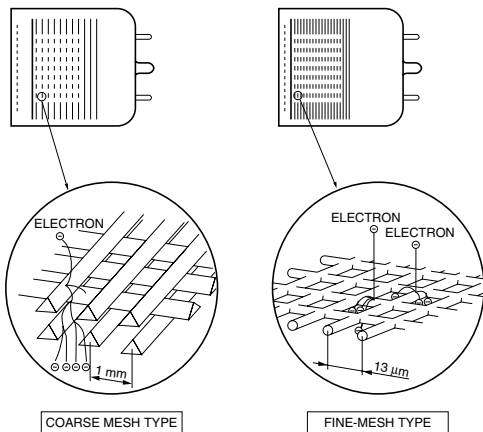
The venetian blind type has a large dynode area and is primarily used for tubes with large photocathode areas. It offers better uniformity and a larger output current. This structure is usually used when time response is not a prime consideration.



TPMOC0080EA

6) Mesh type

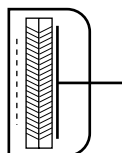
The mesh type has a structure of fine mesh electrodes stacked in close proximity. There are two mesh types of dynode: a coarse mesh type and a fine mesh type. Both types provide improved pulse linearity and high resistance to magnetic fields. The mesh type also has position-sensitive capability when 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.



TPMOC0081EB

7) Microchannel plate (MCP) (see page 66)

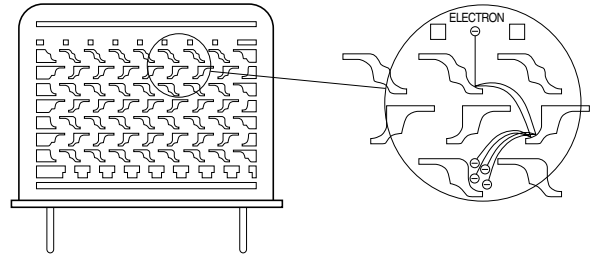
The MCP is a thin disk consisting of millions of microglass tubes (channels) fused in parallel with each other. Each channel acts as an independent electron multiplier. The MCP offers much faster time response than other discrete dynodes. It also features good immunity from magnetic fields and two-dimensional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



TPMOC0082EA

7) 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.



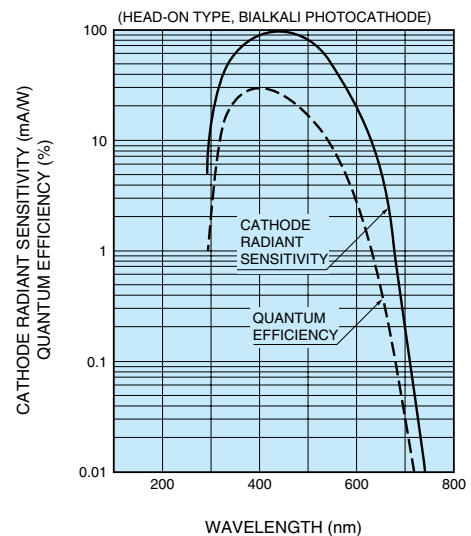
TPMOC0084EA

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 128 and 129. 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



TPMOB0070EA

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 nm and 850 nm.

3) GaAsP

GaAsP (gallium arsenide phosphide) 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 nm 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.

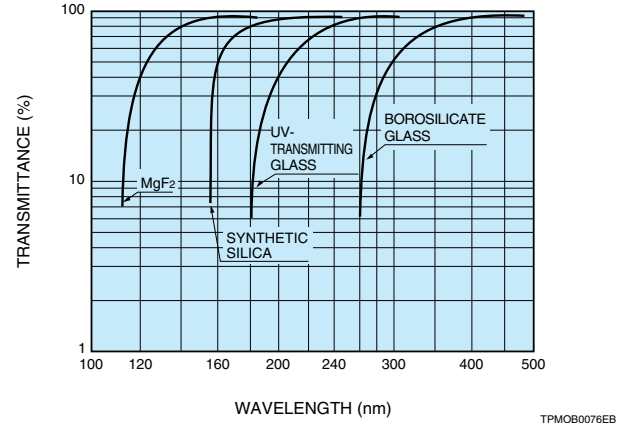
3) Synthetic silica

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) MgF₂ (magnesium fluoride)

Crystals of alkali halide are superior in transmitting ultraviolet radiation, but have the disadvantage of deliquescence. Among these crystals, MgF₂ 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).

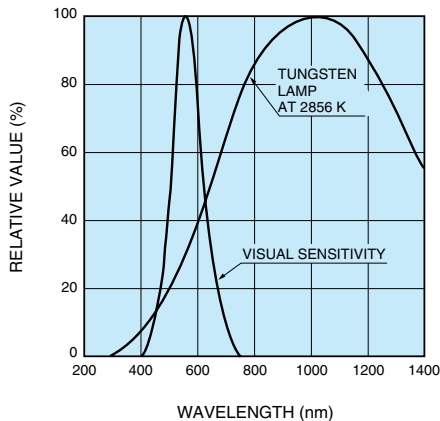
LUMINOUS SENSITIVITY

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 $\mu\text{A/lm}$ (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



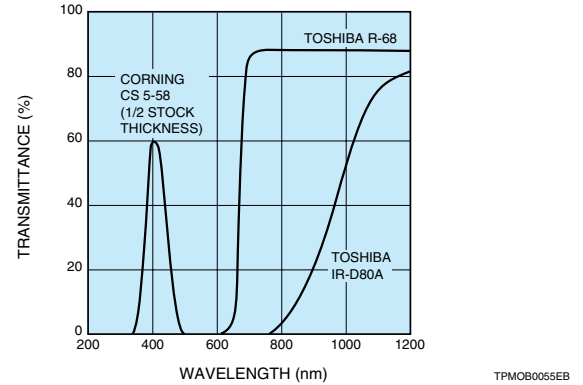
BLUE SENSITIVITY INDEX AND RED/WHITE RATIO

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.

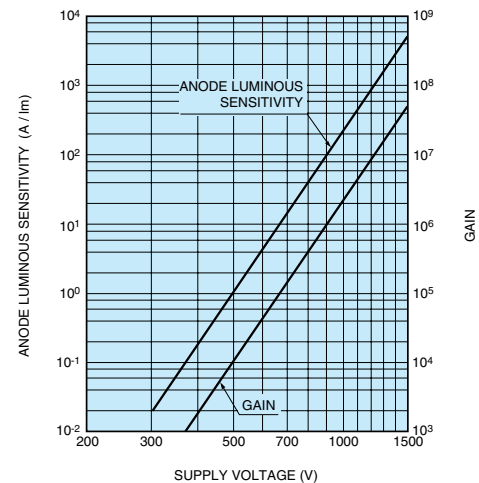
When a voltage V is applied between the cathode and the anode of a photomultiplier tube having n dynode stages, the gain μ , becomes

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

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

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 108).

Figure 8: Typical Gain vs. Supply Voltage

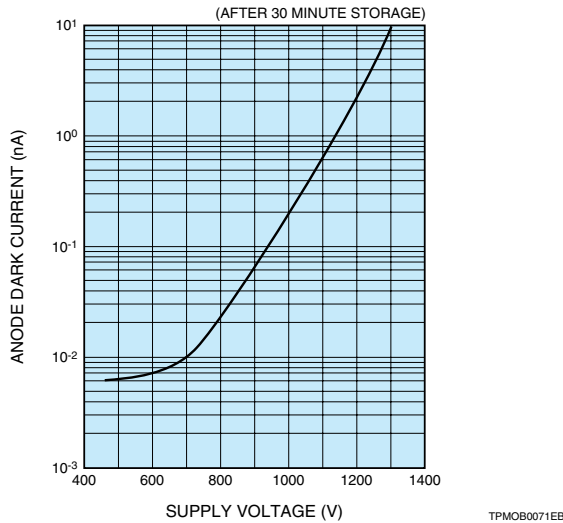


Construction and Operating Characteristics

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:

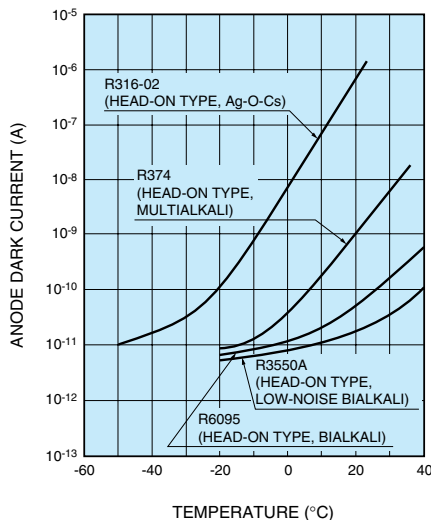
1) Thermionic emission of electrons

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 114, 116).

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 coating" in which the glass bulb is coated with a conductive paint making the same electrical potential as the cathode (see "GROUND POLARITY AND HA COATING" 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:

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

where q = electronic charge (1.60×10^{-19} coul.)

I_{db} = anode dark current in amperes after 30 minute storage in darkness

g = gain

Δf = bandwidth of the system in hertz (usually 1 hertz)

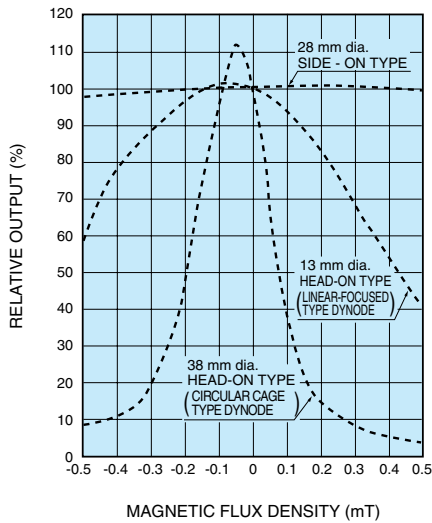
S = anode radiant sensitivity in amperes per watt at the wavelength of interest

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

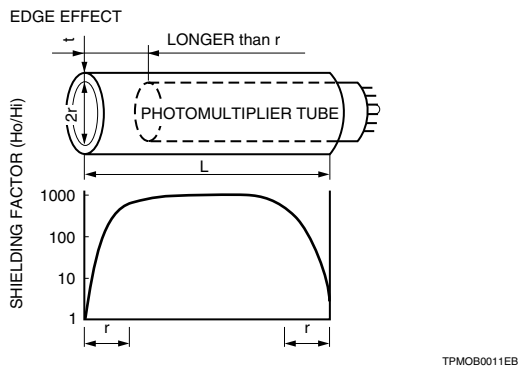


When a photomultiplier tube has to be operated in magnetic fields, it may be necessary to shield the tube with a magnetic shield case. (Hamamatsu provides a variety of magnetic shield cases. See page 118). The magnetic shielding factor is used to express the effect of a magnetic shield case. This is the ratio of the strength of the magnetic field outside the shield case or H_{out} , to that inside the shield case or H_{in} . 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.

$$\frac{H_{out}}{H_{in}} = \frac{3 \mu t}{4 r}$$

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 tube diameter is recommended.

Figure 12: Edge Effect of Magnetic Shield Case



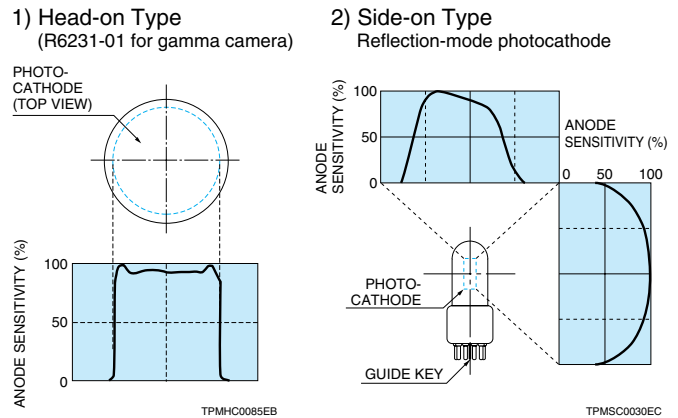
Hamamatsu provides photomultiplier tubes using fine-mesh type dynodes (see page 62). These photomultiplier tubes exhibit much higher resistance to external magnetic fields than the photomultiplier tubes with other dynodes. When the light level to be measured is high, "triode" and "tetrode" type tubes 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

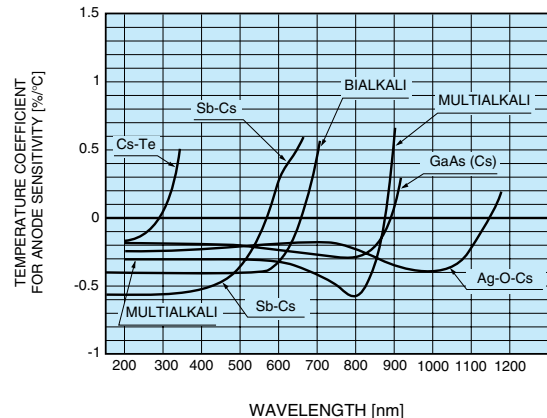


TEMPERATURE CHARACTERISTICS

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.)



Construction and Operating Characteristics

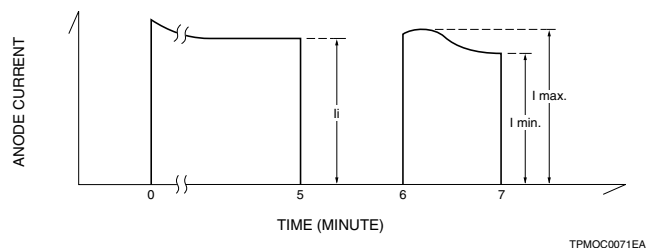
HYSTERESIS

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

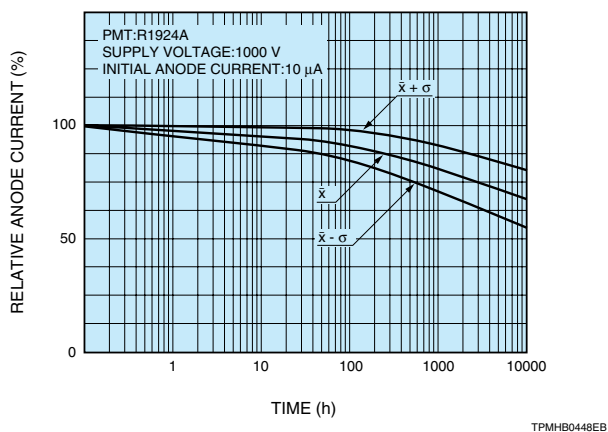


DRIFT AND LIFE CHARACTERISTIC

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

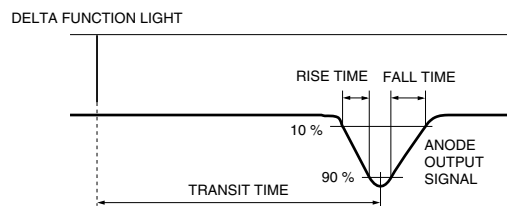


Figure 18: Electron Transit Time Spread (T.T.S.)

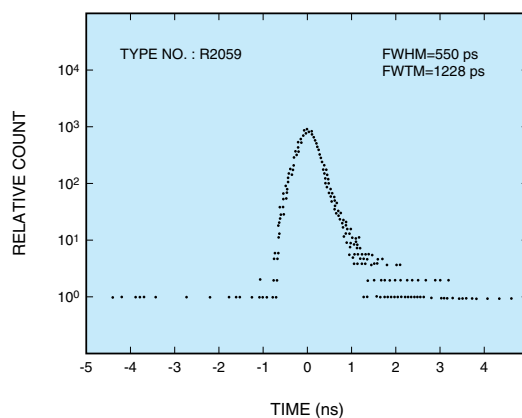
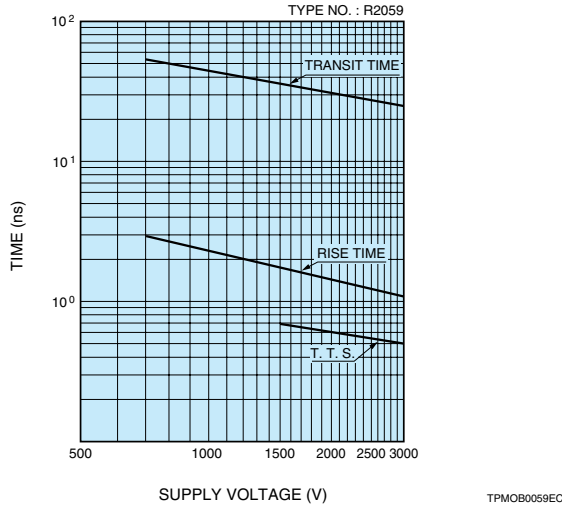


Figure 19: Time Response Characteristics vs. Supply Voltage

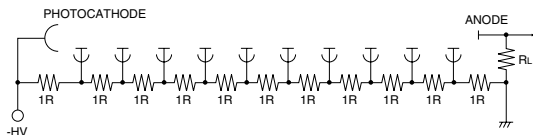


VOLTAGE-DIVIDER CIRCUITS

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

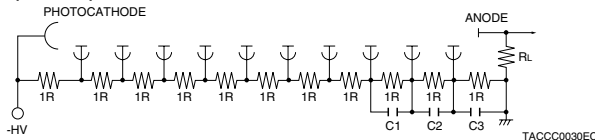
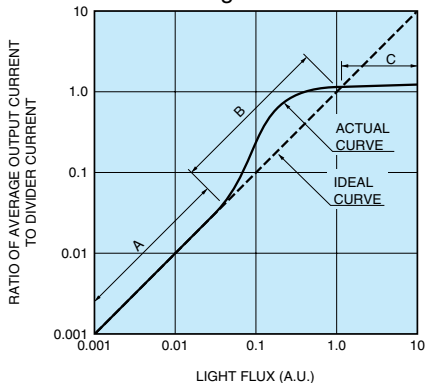


Figure 21: Output Characteristics of PMT Using Voltage-Divider Circuit of figure 20

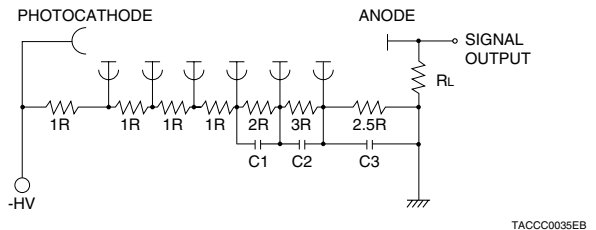


Generally high output current is required in pulsed light applications. In order to maintain dynode potentials at a constant value during pulse durations and obtain high peak currents, capacitors are placed in parallel with the divider resistors as shown in Figure 20 (b). The capacitor values depend 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 COATING

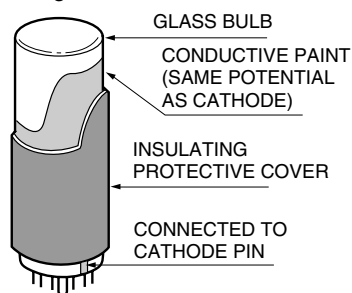
The general technique used for voltage-divider circuits is to ground the anode with a high negative voltage applied to the cathode, as shown in Figure 20. This scheme facilitates the connection of such circuits as ammeters or current-to-voltage conversion operational amplifiers to the photomultiplier 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 Coating" (see Figure 23).

Construction and Operating Characteristics

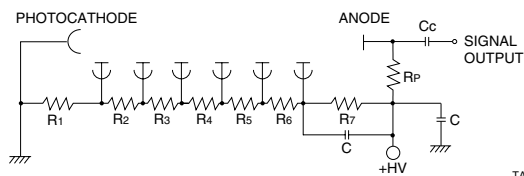
As mentioned above, the HA coating can be effectively used to eliminate the effects of external potential on the side of the bulb. However, if a grounded object is located on the photocathode faceplate, there are no effective countermeasures. Glass scintillation, if occurring in the faceplate, has adverse 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 C_c 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 Coating



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Figure 24: Cathode Ground Scheme

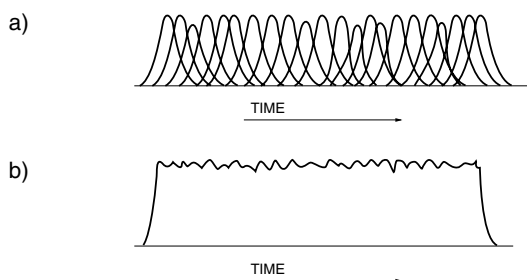


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PHOTON COUNTING

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).

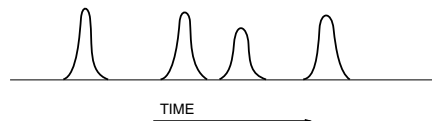
Figure 25: Overlapping Output Pulses



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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.

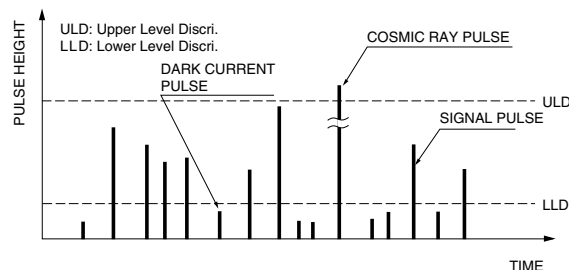
Figure 26: Discrete Output Pulses (Single Photon Event)



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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 pulses by thermal electrons emitted from the photocathode cannot be eliminated.)

Figure 27: Output Pulse and Discrimination Level

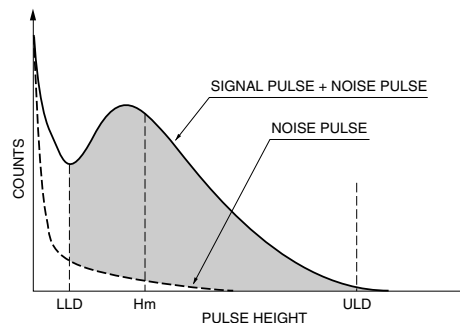


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A typical pulse height distribution (PHD) for a photomultiplier tube output is shown in Figure 28. In this PHD, the lower level discrimination (LLD) is set at the valley trough and the upper level discrimination (ULD) at the foot where there are very 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, H_m is the mean height of the pulses. The LLD should be set at $1/3$ of H_m and the ULD at triple H_m . 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

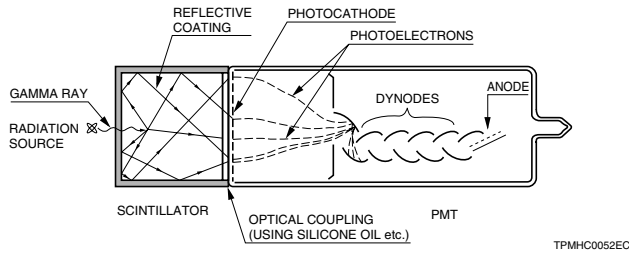


TPMOC0076EA

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

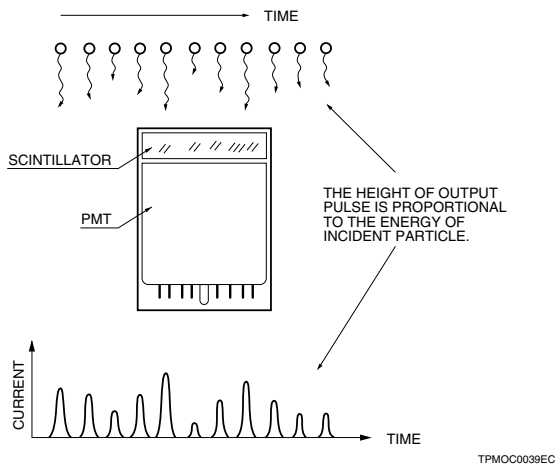
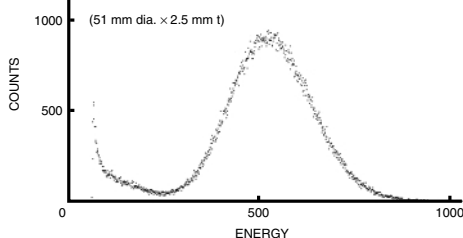
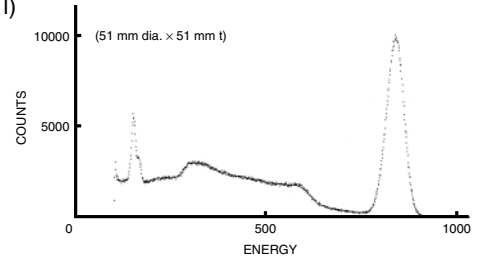


Figure 31: Typical Pulse Height Distributions (Energy Spectra)

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



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



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

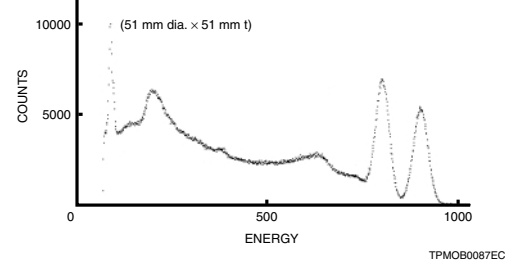
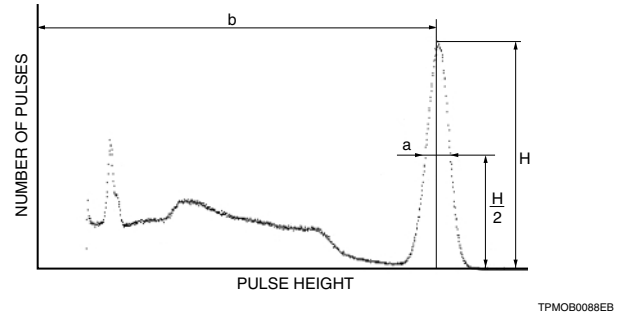
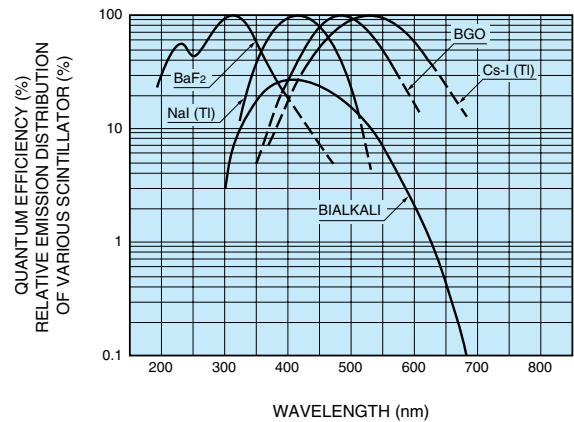


Figure 32: Definition of Pulse Height Resolution (FWHM)



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

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 bi-alkali photocathode is widely used since its spectral response matches the NaI(Tl) scintillator spectrum.

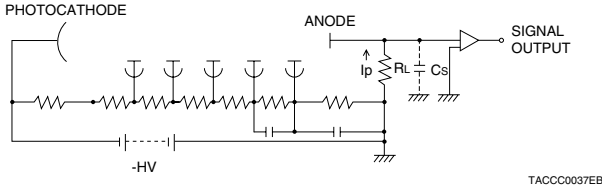
Connections to External Circuits

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

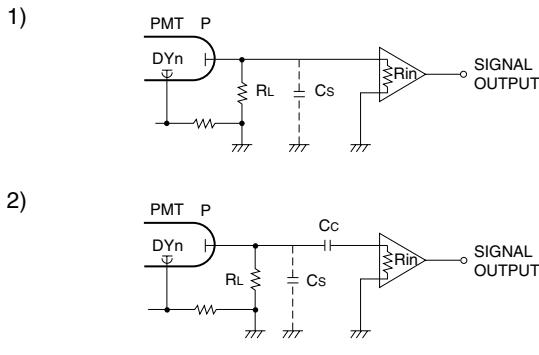


In the circuit of Figure 34, if we let the load resistance be R_L and the total capacitance of the photomultiplier tube anode to all other electrodes including stray capacitance such as wiring capacitance be C_s , then the cutoff frequency f_c is expressed by the following relationship.

$$f_c = \frac{1}{2\pi C_s \cdot R_L}$$

This relationship indicates that even if the photomultiplier tube and amplifier have very fast response, the response will be limited to the cutoff frequency f_c 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

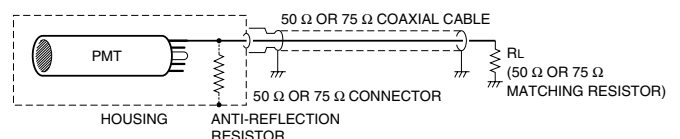
When detecting high-speed and pulsed light signals, a coaxial cable is used to make the connection between the photomultiplier tube and the electronic circuit. Since commonly used cables have characteristic impedances of 50 Ω , this cable must be terminated in a pure resistance equal to the characteristic 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.

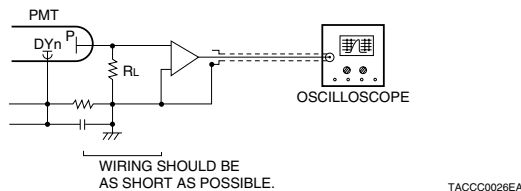
Figure 36: Connection to Prevent Ringing



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.

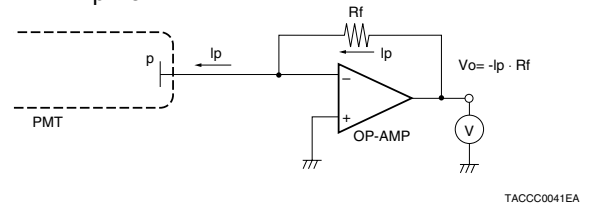
OPERATIONAL AMPLIFIERS

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.

$$V_o = -R_f \cdot I_p$$

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 R_f and subsequently to the operational amplifier output circuit. The output voltage V_o is therefore given by the expression $-R_f \times I_p$. 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.

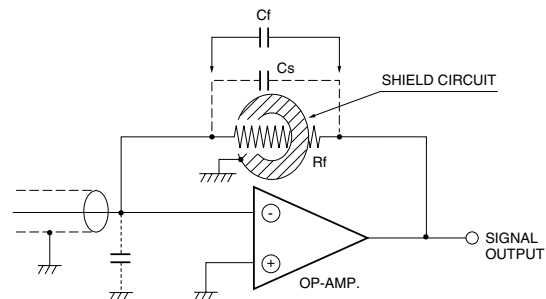
Figure 38: Current-Voltage Conversion Using Operational Amplifier



If the operational amplifier has an offset current (I_{os}), the above-described output voltage becomes $V_o = -R_f (I_p + I_{os})$, 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 R_f , 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	R928, R955, R3896 R7639 R374
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, R7311 1P28, R212, R1527 R7446, R8487
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 R1463P, R649 R943-02 R9110
Other Spectrophotometric Equipment Using Photomultiplier Tubes • Liquid or gas chromatography • X-ray diffractometers, X-ray fluorescence analyzers • Electron microscopes		R3788, R4220 R647-01, R1166, R6095, R580 R647 R7400U-01, R5900U-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 R105, 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 R105, R7400U-01 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= R6095, R3788, R1527 R5983
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 R7400U-01, R7400U-20 R5900U-01, R5900U-01-M4 R5900U-20, R5900U-20-M4 R5900U-20-L16 H7260-20 H7564B-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	R1635 , R8900U-00-C12 R1450 R7899 R1548-07 R6427 H8500C , H9500 R9420* , R9797* , R9800*
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 of 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 (Chemiluminoassay) 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 , R6357 R4220 , R928 , R3788 , R3896 R647 , R1463 R1925A , R1924A , R3550A R6095 , R374 R7400U-01 R7400U-02 R7400U-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 931A , R105

* Individual data sheets are available.

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 R329-02 R1307 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 R7400U
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 an 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 R9722 R4607-01
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
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 R7400U-01 R7400U-04 R7400U-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	R7400U 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.		R7400U Series, R7600U Series R7899, R1635 (H3164-10) R1450 (H6524), R4998 (H6533) R1828-01 (H1949-51) R2083 (H2431-50)
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.	3) Resistance to magnetic fields (when used in magnetic fields)	R5505-70 (H6152-70) R7761-70 (H8409-70) R5924-70 (H6614-70)
	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
Calorimeter The calorimeter measures the accurate energy of secondary particles generated by the collision reaction of particles.	5) Resistance to magnetic fields (when used in magnetic fields)	R5505-70 (H6152-70) R7761-70 (H8409-70) R5924-70 (H6614-70)
	1) Good pulse linearity 2) High energy resolution 3) High stability	R580 (H3178-51) R7600U Series R329-02 (H6410)
	4) Resistance to magnetic fields	R5924 (H6614-70) R6091 (H6559)
●Neutrino and Proton Decay Experiment, Cosmic Ray Detection		
Neutrino Experiment Research on solar neutrinos or particle astrophysics 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.		
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.		R1166 (H6520) R580 (H3178-51) R329-02 (H6410) R6091 (H6559) R1250 (H6527) R6234

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

The assembly type is given in parentheses.

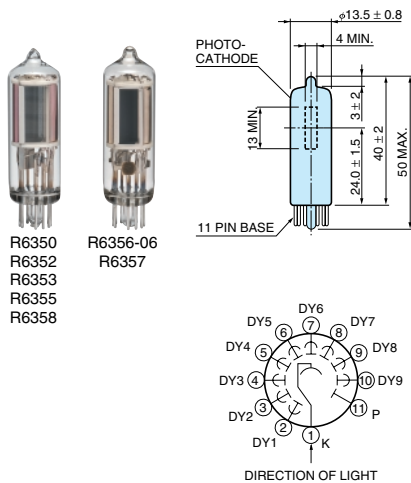
Applications	Required Major Characteristics	Applicable PMT
Aerospace		
Astronomical X-ray Measurement X-rays from outer space include information on the enigmas of space. As an example, the X-ray observation satellite "Asuka" developed by a group of the ISAS (Institute of Space and Astronomical Science - 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 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 it 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 R3234-01 R7400U-20, R3896
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 R5900U-01, R5900U-01-M4 R5900U-20, R5900U-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	R2257 R1104 R943-02

Side-on Type Photomultiplier Tubes

Spectral Response										Remarks				Max. Ratings		
Type No.	Effective Area (mm)		Spectral Response Range (nm)	Curve Code	Peak Wavelength (nm)	Photo-cathode Material	Window Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)			
	← Wavelength (nm) →															
	100	200 300 400 500 600 700 800 900 1000 1100 1200														
13 mm (1/2") Dia. Types																
R6350	4 × 13		185 to 650	350U	340	Sb-Cs	U	①	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			
R6352	4 × 13		185 to 750	452U	420	BA	U	①	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			
R6353	4 × 13		185 to 680	456U	400	LBA	U	①	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			
R6355	4 × 13		185 to 850	550U	530	MA	U	①	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			
R6356-06	4 × 13		185 to 900	—	400	MA	U	①	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			
R6357	4 × 13		185 to 900	—	450	MA	U	①	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			
R6358	4 × 13		185 to 830	561U	530	MA	U	①	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			
13 mm (1/2") Dia. Subminiature Types																
R3810	3 × 4		185 to 650	350U	340	Sb-Cs	U	②	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			
R3811	3 × 4		185 to 850	550U	530	MA	U	②	CC / 9	E678-11U* ① ②	1250	0.01	1000 ⑨			

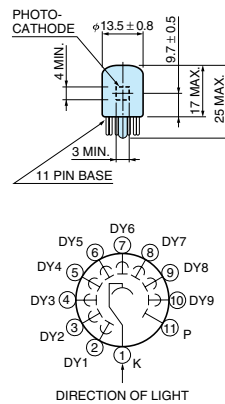
Dimensional Outlines (Unit: mm)

① R6350, R6352, R6353 etc.



TPMSA0034EE

② R3810, R3811



TPMSA0013EC

Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μ A/lm)	Typ. (μ A/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
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 Dark count 30 s ⁻¹ (Max.) 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 Dark count 30 s ⁻¹ (Max.)	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	2000	5.2×10^5	6.7×10^6	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 Dark count 300 s ⁻¹ (Max.)	R6358
20	40	5.0	—	48	50	300	3.6×10^5	7.5×10^6	0.5	5	1.4	15	For photon counting: R3810P Dark count 30 s ⁻¹ (Max.)	R3810
50	150	6.0	0.15	45	50	200	5.9×10^4	1.3×10^6	1	10	1.4	15		R3811

Side-on Type Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings						
Type No.	Effective Area (mm)											Spectral Response Range (nm)	Curve Code	Peak Wavelength (nm)	Photo-cathode Material	Window Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)		
	← Wavelength (nm) →																							
	100	200	300	400	500	600	700	800	900	1000	1100	1200												
28 mm (1-1/8") Dia. Types with UV to Visible Sensitivity																								
931A				8 × 24									300 to 650	350K	400	Sb-Cs	K	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
931B				8 × 24									300 to 650	453K	400	BA	K	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
1P21				8 × 24									300 to 650	350K	400	Sb-Cs	K	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R105				8 × 24									300 to 650	350K	400	Sb-Cs	K	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
1P28				8 × 24									185 to 650	350U	340	Sb-Cs	U	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R212				8 × 24									185 to 650	350U	340	Sb-Cs	U	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R1527				8 × 24									185 to 680	456U	400	LBA	U	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R4220				8 × 24									185 to 710	456U	410	LBA	U	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R3788				8 × 24									185 to 750	452U	420	BA	U	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R2693				18 × 16									185 to 650	430U	375	LBA	U	②	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R5983				10 × 24									185 to 710	456U	410	LBA	U	③	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R6925				8 × 24									185 to 730	351U	410	BA	U	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨
R7518				8 × 24									185 to 730	456U	410	LBA	U	①	CC / 9	E678-11A	③ ④ ⑤	1250	0.1	1000 ⑨

Dimensional Outlines (Unit: mm)

① 931A, 1P21, R105, R212 etc.

931A
931B
1P21
R105
1P28
R212
R6925

R1527
R4220
R3788
R7518

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② R2693

R2693

TPMSA0007ED

③ R5983

R5983

TPMSA0035EC

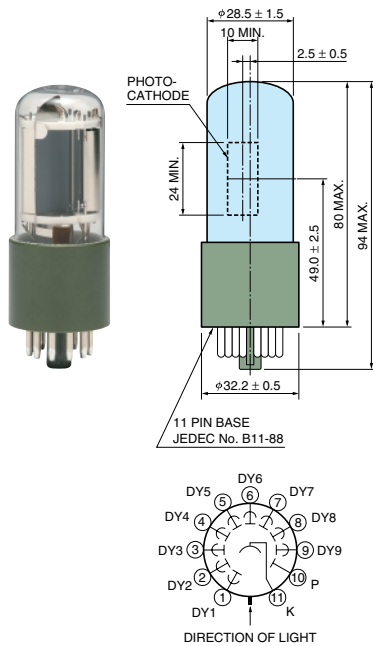
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
25	40	5.0	—	48	50	400	4.8×10^5	1.0×10^7	5	50	2.2	22		931A
30	60	7.1	—	60	50	600	6.6×10^5	1.0×10^7	5	50	2.2	22		931B
25	40	5.0	—	48	50	250	3.0×10^5	6.3×10^6	1	5	2.2	22		1P21
25	40	5.0	—	48	50	400	4.8×10^5	1.0×10^7	1	10	2.2	22		R105
25	40	5.0	—	48	20	400	4.8×10^5	1.0×10^7	5	50	2.2	22		1P28
25	40	5.0	—	48	50	300	3.6×10^5	7.5×10^6	1	10	2.2	22		R212
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
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
30	50	7.0	—	62	100	300	3.7×10^5	6.0×10^6	0.5	5	1.2	18	For photon counting: R2693P	R2693
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
40	70	—	0.01	68	200	500	4.8×10^5	7.1×10^6	5	50	2.2	22		R6925
120	130	10	—	85	1200	1560	1.0×10^6	1.2×10^7	0.2	2.0	2.2	22	For photon counting: R7518P	R7518

Side-on Type Photomultiplier Tubes

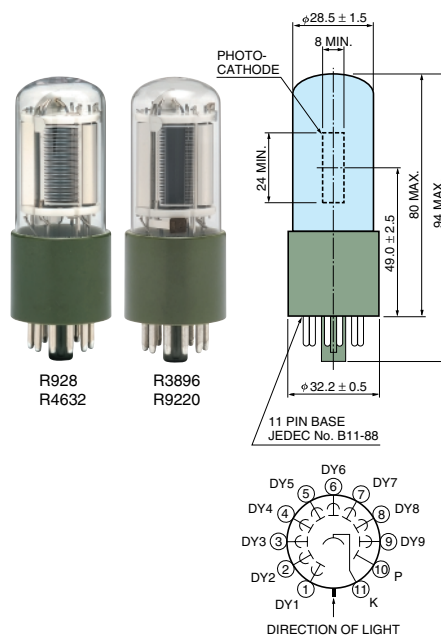
Spectral Response												Remarks					Max. Ratings							
Type No.	Effective Area (mm)										Spectral Response Range (nm)	Curve Code	Peak Wave-length (nm)	Photo-cathode Material	Win-dow Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)			
	100	200	300	400	500	600	700	800	900	1000												1100	1200	
28 mm (1-1/8") Dia. Types with UV to Near IR Sensitivity																								
R5984			10 × 24									185 to 900	562U	400	MA	U	①	CC / 9	E678-11A	③④⑤	1250	0.1	1000	⑨
R928			8 × 24									185 to 900	562U	400	MA	U	②	CC / 9	E678-11A	③④⑤	1250	0.1	1000	⑨
R2949			8 × 6									185 to 900	552U	400	MA	U	③	CC / 9	E678-11A	③④⑤	1250	0.1	1000	⑨
R3896			8 × 24									185 to 900	555U	450	MA	U	②	CC / 9	E678-11A	③④⑤	1250	0.1	1000	⑨
R4632			8 × 24									185 to 850	556U	430	MA	U	②	CC / 9	E678-11A	③④⑤	1250	0.1	1000	⑨
R9110			8 × 6									185 to 900	555U	450	MA	U	④	CC / 9	E678-11A	③④⑤	1250	0.1	1000	⑨
R9220			8 × 24									185 to 900	555U	450	MA	U	②	CC / 9	E678-11A	③④⑤	1250	0.1	1000	⑨

Dimensional Outlines (Unit: mm)

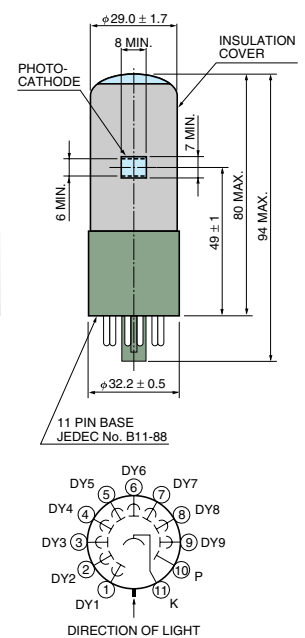
① R5984



② R928, R3896, R4632, R9220

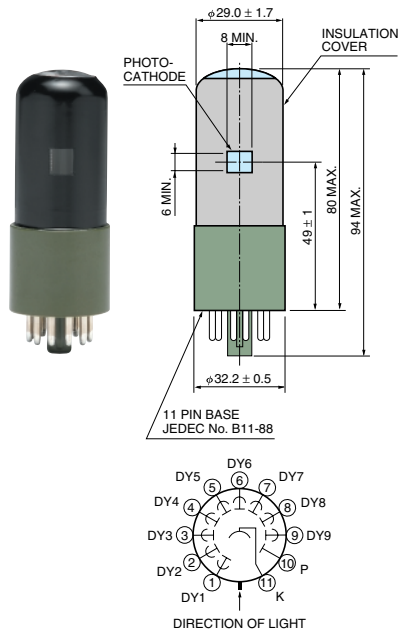


③ R2949



Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
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
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	200	7.5	0.3	68	1000	2000	6.8×10^5	1.0×10^7	300 ^f	500 ^f	2.2	22		R2949
475	525	15.0	0.4	90	3000	5000	8.6×10^5	9.5×10^6	10	50	2.2	22		R3896
140	200	7.5	0.15	80	300	700	2.8×10^5	3.5×10^6	50 ^f	100 ^f	2.2	22		R4632
400	525	15.0	0.4	90	4000	10000	1.7×10^6	1.9×10^7	5	15	2.2	22		R9110
375	450	12.5	0.4	85	1000	4500	8.5×10^5	1.0×10^7	10	50	2.2	22		R9220

4 R9110

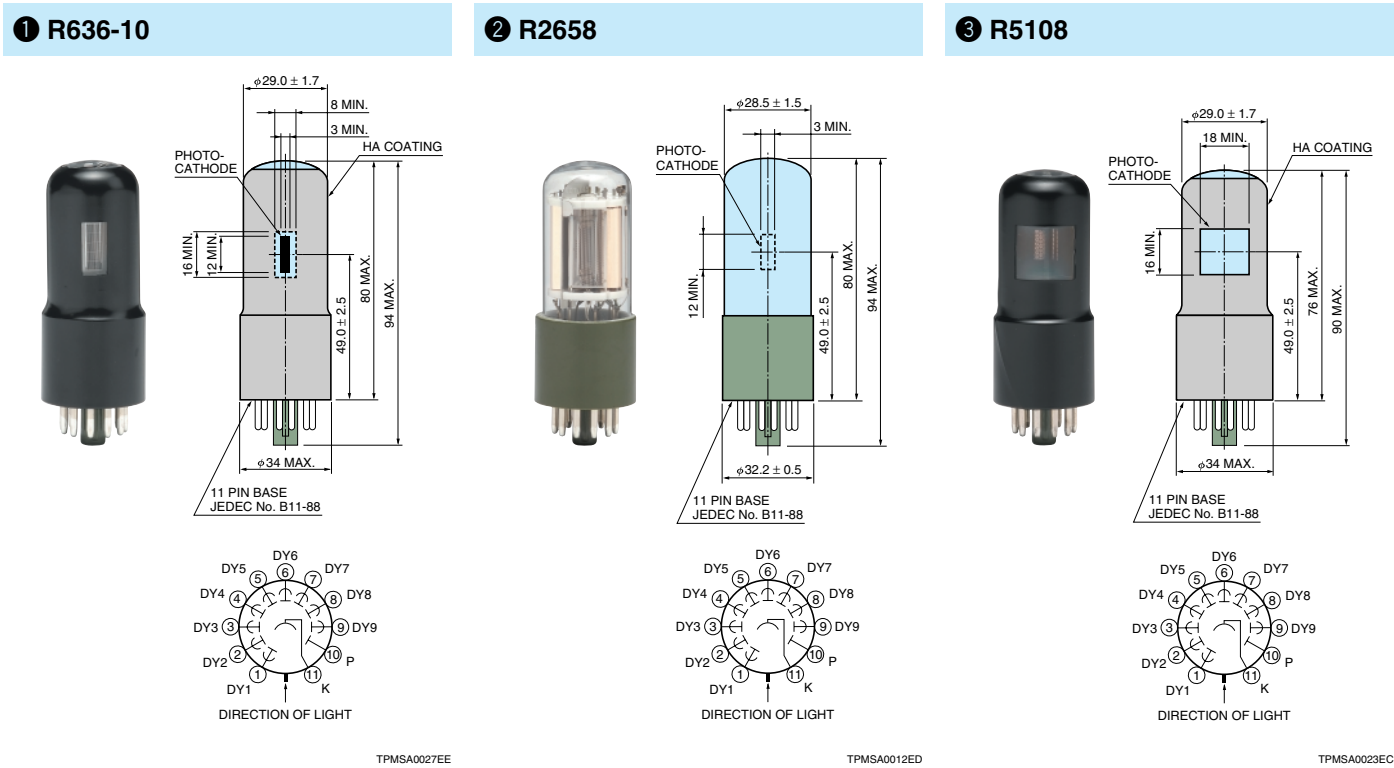


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Side-on Type Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings ^H							
Type No.	Effective Area (mm) ← Wavelength (nm) →												Spectral Response Range (nm)	Curve Code	Peak Wavelength (nm)	Photo-cathode Material	Window Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)		
	100	200	300	400	500	600	700	800	900	1000	1100	1200													
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

Dimensional Outlines (Unit: mm)



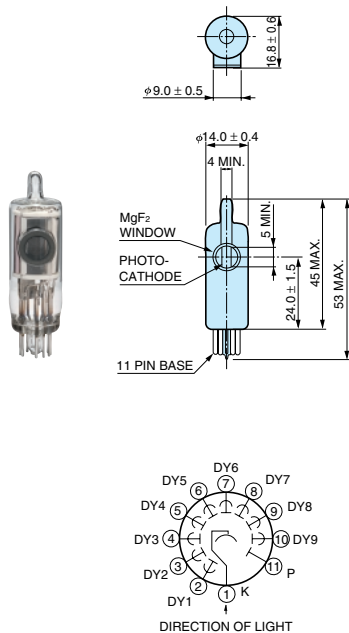
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μ A/lm)	Typ. (μ A/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
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 ^d	1000 ^d	1.1	17		R5108

Side-on Type Photomultiplier Tubes

Spectral Response										Remarks				Max. Ratings		L						
Type No.	Effective Area (mm)										Spectral Response Range (nm)	Curve Code	Peak Wavelength (nm)	Photo-cathode Material	Window Material		Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)
	Wavelength (nm)																					
	100	200	300	400	500	600	700	800	900	1000												
13 mm (1/2") Dia. Types with Solar Blind Response																						
R7511	4 × 5											115 to 195	150M	130	Cs-I	MF	①	CC / 9	E678-11U*	1250	0.01	1000
R6354	4 × 13											160 to 320	250S	230	Cs-Te	Q	②	CC / 9	E678-11U* ① ②	1250	0.01	1000
R7311	4 × 5											115 to 320	250M	200	Cs-Te	MF	①	CC / 9	E678-11U*	1250	0.01	1000
28 mm (1-1/8") Dia. Types with Solar Blind Response																						
R8487	8 × 12											115 to 195	150M	130	Cs-I	MF	③	CC / 9	E678-11A	1250	0.1	1000
R7154	8 × 24											160 to 320	250S	230	Cs-Te	Q	④	CC / 9	E678-11A ③ ④ ⑤	1250	0.1	1000
R7639	3 × 12											115 to 230	—	155	DIA	MF	⑤	CC / 9	E678-11A	1250	0.1	1000
R8486	8 × 12											115 to 320	250M	200	Cs-Te	MF	③	CC / 9	E678-11A	1250	0.1	1000
*R10454	8 × 12											115 to 195	150M	130	Cs-I	MF	③	CC / 9	E678-11A	1250	0.1	1000

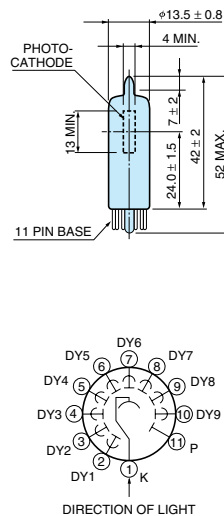
Dimensional Outlines (Unit: mm)

① R7511, R7311



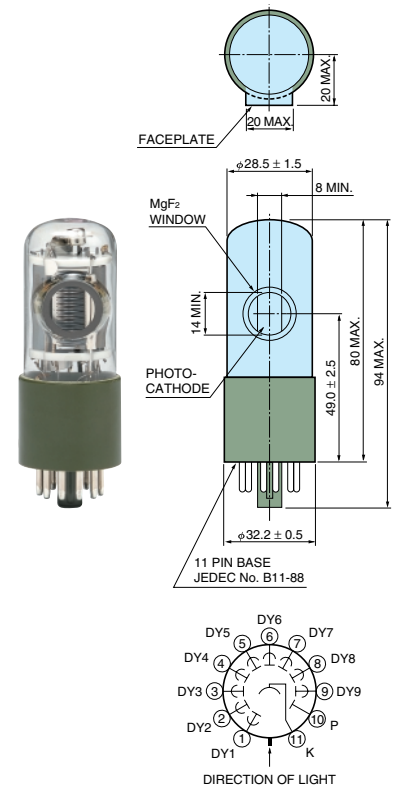
TPMSA0038ED

② R6354



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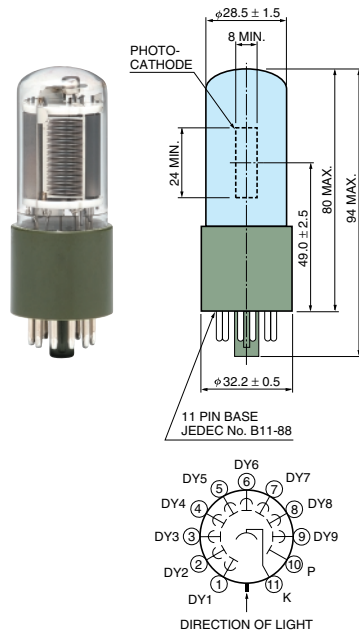
③ R8487, R8486, R10454



TPMSA0042EB

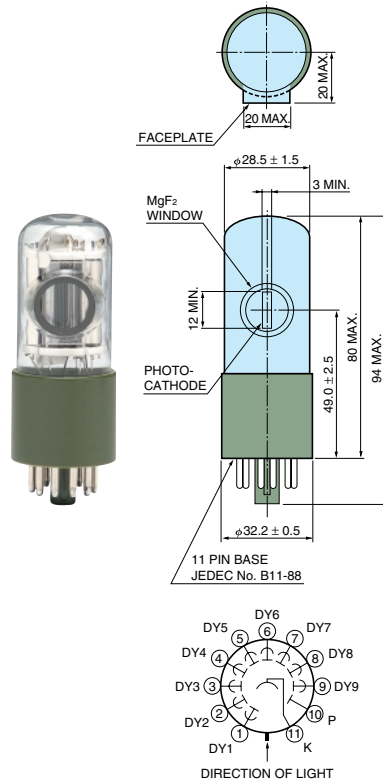
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
—	—	—	—	23 ^a	—	—	4.6×10^4 ^a	2.0×10^6	0.3	3	1.4	15		R7511
—	—	—	—	50 ^b	—	—	2.0×10^5 ^b	4.0×10^6	0.5	5	1.4	15		R6354
—	—	—	—	40 ^b	—	—	2.8×10^5 ^b	7.0×10^6	0.3	3	1.4	15		R7311
—	—	—	—	25.5 ^a	—	—	1.0×10^5 ^a	3.9×10^6	0.1	—	2.2	22		R8487
—	—	—	—	62 ^b	—	—	6.2×10^5 ^b	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 ^b	—	—	5.2×10^5 ^b	1.0×10^7	1	10	2.2	22		R8486
—	—	—	—	25.5 ^a	—	—	1.0×10^5 ^a	3.9×10^6	0.1	—	2.2	22	Better solar-blind characteristics	R10454*

4 R7154



TPMSA0001EA

5 R7639



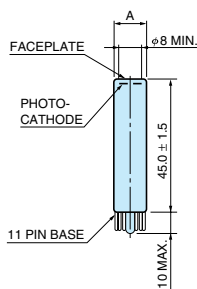
TPMSA0004EB

Head-on Type Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings					
Type No.	Effective Area (mm)												Spectral Response Range (nm)	Curve Code	Peak Wavelength (nm)	Photo-cathode Material	Window Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)
	← Wavelength (nm) →																						
	100	200	300	400	500	600	700	800	900	1000	1100	1200											
10 mm (3/8") Dia. Types																							
R1893		φ8											160 to 320	200S	240	Cs-Te	Q	①	L / 8	E678-11N* ⑥	1500	0.01	1250 ①
R2496		φ8											160 to 650	400S	420	BA	Q	①	L / 8	E678-11N* ⑦ ⑧	1500	0.03	1250 ④
R1635			φ8										300 to 650	400K	420	BA	K	①	L / 8	E678-11N* ⑥	1500	0.03	1250 ①
R1894			φ8										300 to 850	500K	420	MA	K	①	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	②	L / 10	E678-12A*	2250	0.01	2000 ⑪
R1080	φ6												115 to 320	200M	240	Cs-Te	MF	②	L / 10	E678-12A*	1250	0.01	1000 ⑪
R759	φ10												160 to 320	200S	240	Cs-Te	Q	③	L / 10	E678-13F* ⑨ ⑩	1250	0.01	1000 ⑪
R647			φ10										300 to 650	400K	420	BA	K	③	L / 10	E678-13F* ⑨ ⑩	1250	0.1	1000 ⑪
R4124			φ10										300 to 650	400K	420	BA	K	④	L / 10	E678-13F* ⑪	1250	0.03	1000 ⑰
R2557			φ10										300 to 650	402K	375	LBA	K	③	L / 10	E678-13F* ⑫	1500	0.03	1250 ⑭
R4177-01			φ10										300 to 650	401K	375	HBA	K	⑤	L / 10	E678-13E*	1800	0.02	1500 ⑪
R1463		φ10											185 to 850	500U	420	MA	U	③	L / 10	E678-13F* ⑨ ⑩	1250	0.03	1000 ⑪

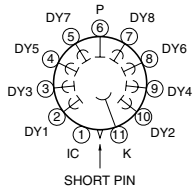
Dimensional Outlines (Unit: mm)

① R1893, R2496, R1635, R1894



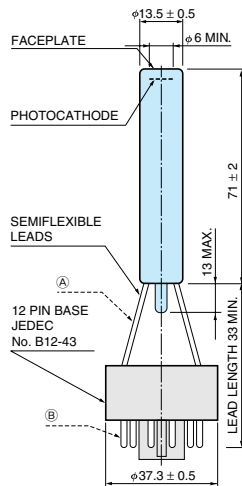
	R1635, R1894	R1893, R2496
A	φ9.7 ± 0.4	φ10.5 ± 0.5

R2496 has a plano-concave faceplate.

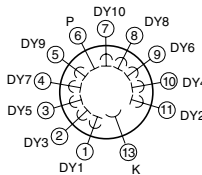


TPMHA0100EB

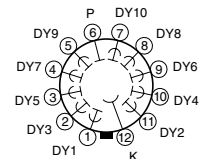
② R1081, R1080



(A) Temporary Base Removed

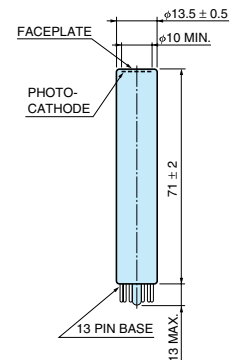


(B) Bottom View



TPMHA0207EA

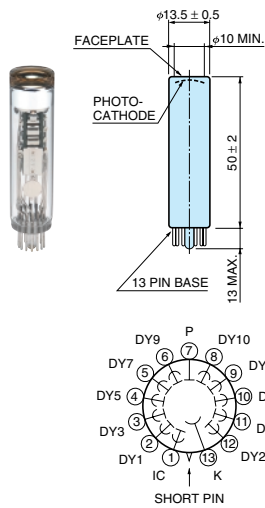
③ R759, R647, R2557, R1463



TPMHA0014EA

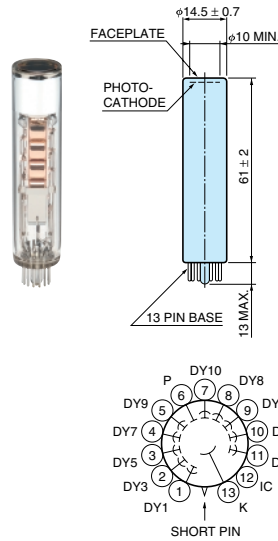
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
—	—	—	—	24 ^b	1.2×10^3 (A/W) ^b	—	3.6×10^3 ^b	1.5×10^5	0.5	2.5	0.8	7.8		R1893
60	100	10	—	80	30	100	8.0×10^4	1.0×10^6	2	50	0.7	9.0		R2496
60	100	10	—	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
80	120	—	0.2	51	10	50	2.1×10^4	4.2×10^5	2	20	0.8	7.8		R1894
—	—	—	—	12 ^a	2×10^2 (A/W) ^a	—	1.2×10^3 ^a	1.0×10^5	0.03	0.05	1.8	18		R1081
—	—	—	—	28 ^b	4×10^3 (A/W) ^b	—	1.4×10^4 ^b	5.0×10^5	0.3	1	2.5	24	For photon counting: R1080P	R1080
—	—	—	—	28 ^b	4×10^3 (A/W) ^b	—	1.4×10^4 ^b	5.0×10^5	0.3	1	2.5	24		R759
40	110	10	—	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	—	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

④ R4124



TPMHA0102EA

⑤ R4177-01



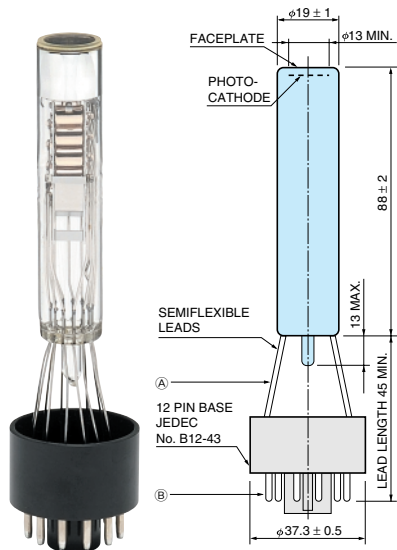
TPMHA0006EA

Head-on Type Photomultiplier Tubes

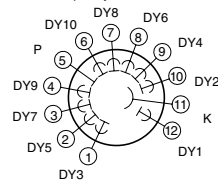
Spectral Response													Remarks					Max. Ratings					
Type No.	Effective Area (mm)												Spectral Response Range (nm)	Curve Code	Peak Wave-length (nm)	Photo-cathode Material	Win-dow Mate-rial	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)
	← Wavelength (nm) →																						
	100	200	300	400	500	600	700	800	900	1000	1100	1200											
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
R821	φ15												160 to 320	200S	240	Cs-Te	Q	②	L / 10	E678-12L* ⑬⑭⑮	1250	0.01	1000
R1166			φ15										300 to 650	400K	420	BA	K	②	L / 10	E678-12L* ⑬⑭⑮	1250	0.1	1000
R1450			φ15										300 to 650	400K	420	BA	K	②	L / 10	E678-12L* ⑰	1800	0.1	1500
R3478			φ15										300 to 650	400K	420	BA	K	③	L / 8	E678-12L* ⑰⑱	1800	0.1	1700
R5610A			φ15										300 to 650	402K	375	LBA	K	④	L / 10	E678-12T*	1250	0.1	1000
R5611A-01			φ15										300 to 650	400K	420	BA	K	⑤	L / 10	E678-12A*	1250	0.1	1000
R3991A			φ15										300 to 650	401K	375	HBA	K	⑤	L / 10	E678-12R*	1800	0.02	1500
R1617			φ15										300 to 850	500K	420	MA	K	②	L / 10	E678-12L* ⑬⑭⑮	1250	0.1	1000
R1878			φ4										300 to 850	500K	420	MA	K	⑥	L / 10	E678-12L* ⑲	1250	0.1	1000

Dimensional Outlines (Unit: mm)

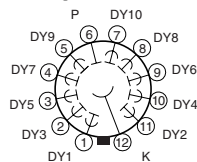
① R972



(A) Temporary Base Removed

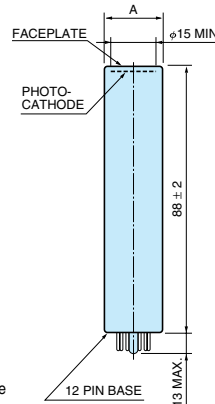


(B) Bottom View

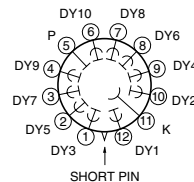


TPMHA0208EA

② R821, R1166, R1450, R1617

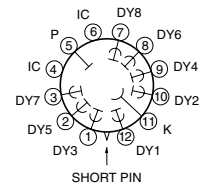
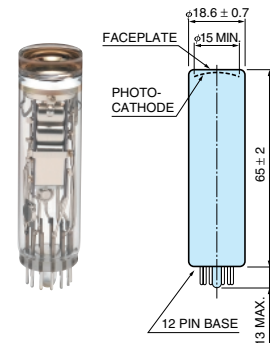


R1450 has a plano-concave faceplate.



TPMHA0012EB

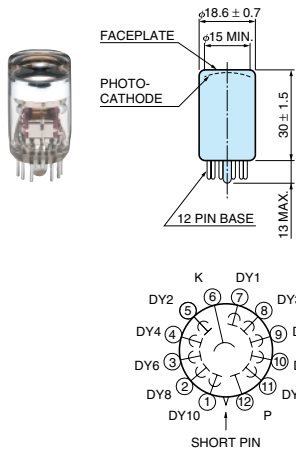
③ R3478



TPMHA0119EB

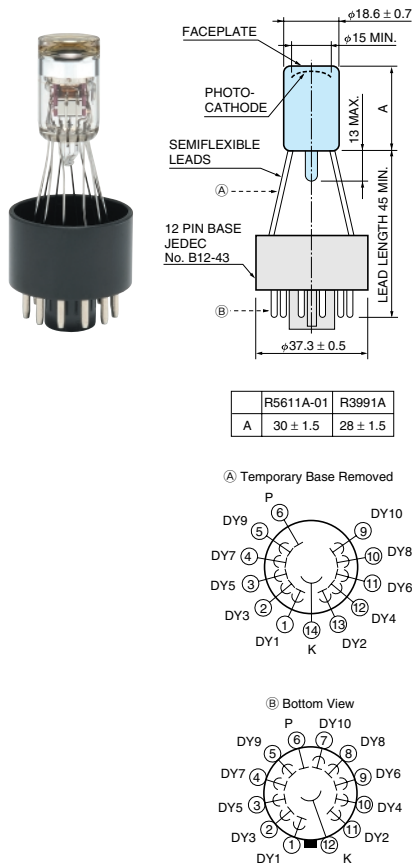
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
—	—	—	—	12 ^a	2×10^2 (A/W) ^a	—	1.2×10^3 ^a	1.0×10^5	0.03	0.05	1.6	17		R972
—	—	—	—	28 ^b	4×10^3 (A/W) ^b	—	1.0×10^4 ^b	3.6×10^5	0.3	0.5	2.5	27	MgF ₂ window: R976 (Dimensional Outline: ①)	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 Semiflexible lead: R1450-13	R1166
70	115	11.0	—	88	100	200	1.5×10^5	1.7×10^6	3	50	1.8	19		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	15	1.9×10^4	3.8×10^5	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 ^f	250 ^f	1.7	24	Alkali photocathode: R2295	R1878

④ R5610A



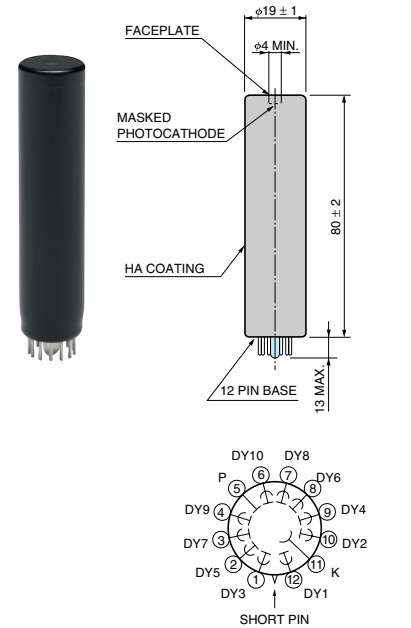
TPMHA0269EA

⑤ R5611A-01, R3991A



TPMHA0036EC

⑥ R1878



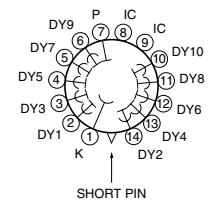
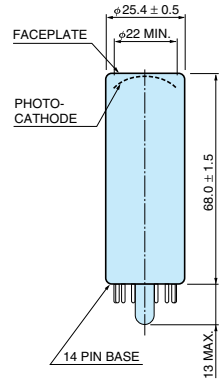
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Head-on Type Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings					
Type No.	Effective Area (mm)											Spectral Response Range (nm)	Curve Code	Peak Wave-length (nm)	Photo-cathode Material	Window Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)	
	100	200	300	400	500	600	700	800	900	1000	1100												1200
25 mm (1") Dia. Types																							
R7899				φ22									300 to 650	400K	420	BA	K	①	L / 10	E678-14C* ②③	1800	0.1	1250 ①⑦
R4998				φ20									300 to 650	400K	420	BA	K	②	L / 10	E678-12A*	2500	0.1	2250 ②⑧
R2078			φ21										160 to 320	201S	240	Cs-Te	Q	③	CC / 10	E678-12A*	2000	0.015	1500 ③⑨
R1924A				φ22									300 to 650	400K	420	BA	K	④	L / 10	E678-14C* ②①②②③	1250	0.1	1000 ④⑩
R3550A				φ22									300 to 650	402K	375	LBA	K	④	L / 10	E678-14C* ②①②②③	1250	0.1	1000 ④⑩
R1288A				φ22									300 to 650	401K	375	HBA	K	③	L / 10	E678-12R*	1800	0.02	1500 ③⑨
R1925A				φ22									300 to 850	500K	420	MA	K	④	L / 10	E678-14C* ②①②②③	1250	0.1	1000 ④⑩
R5070A				φ21									300 to 900	502K	420	MA	K	⑤	L / 10	E678-14C* ②①②②③	1250	0.1	1000 ④⑩

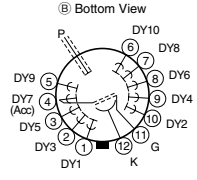
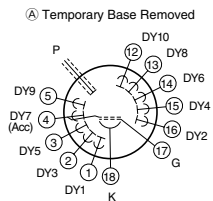
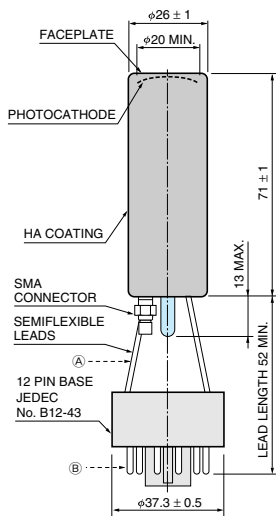
Dimensional Outlines (Unit: mm)

① R7899



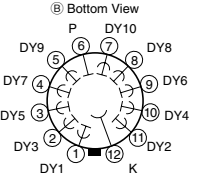
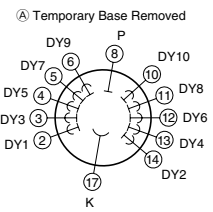
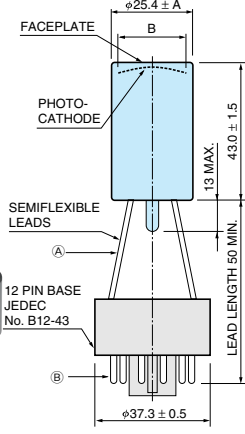
TPMH40492EA

② R4998



TPMH40093ED

③ R2078, R1288A

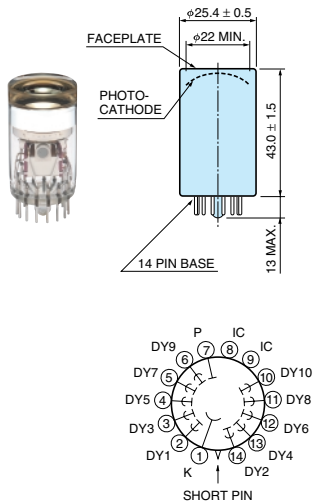


	R2078	R1288A
A	0.8	0.5
B	φ21	φ22

TPMH40039EB

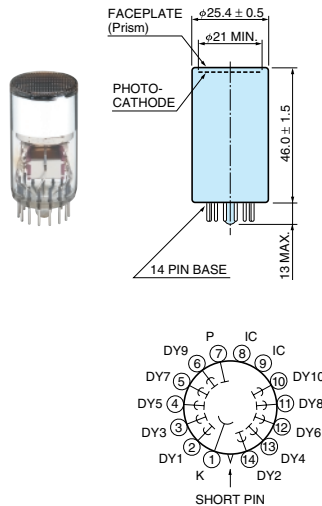
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
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
—	—	—	—	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 Anode sensitivity ratio (254 /365): 8000 Photon counting: R1924P	R2078
60	90	10.5	—	85	40	180	1.7×10^5	2.0×10^6	3	20	1.5	17		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	15	1.9×10^4	3.8×10^5	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 ^b	65	20	100	2.8×10^4	4.3×10^5	3	20	2.2	19	Prism window	R5070A

④ R1924A, R3550A, R1925A



TPMHA0040EC

⑤ R5070A



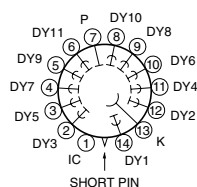
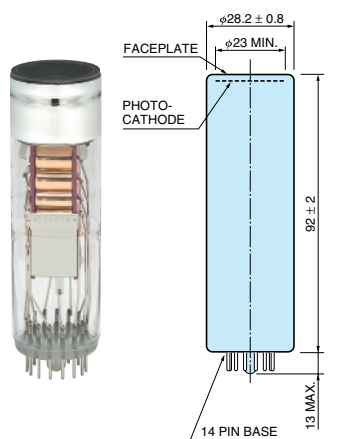
TPMHA0491EB

Head-on Type Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings ^(H)					
Type No. ^(A)	Effective Area (mm)										Spectral Response Range (nm)	Curve Code ^(B)	Peak Wave-length (nm)	Photo-cathode Material ^(C)	Window Material ^(D)	Out-line No. ^(E)	Dynode Structure / Stages ^(F)	Socket & Socket Assembly ^(G)	Anode to Cathode Voltage (V) ^(J)	Average Anode Current (mA) ^(K)	Anode to Cathode Supply Voltage (V) ^(L)		
	← Wavelength (nm) →																						
	100	200	300	400	500	600	700	800	900	1000	1100	1200											
28 mm (1-1/8") Dia. Types																							
R6835	φ23												115 to 200	100M	140	Cs-I	MF	①	B+L / 11	E678-14C*	2500	0.01	2000 ⁽²⁴⁾
R6836	φ23												115 to 320	200M	240	Cs-Te	MF	①	B+L / 11	E678-14C*	1500	0.01	1000 ⁽²⁴⁾
R6834	φ25												160 to 320	200S	240	Cs-Te	Q	②	B+L / 11	E678-14C* ⁽²⁴⁾⁽²⁵⁾⁽²⁶⁾	1500	0.01	1000 ⁽²⁴⁾
R6095			φ25										300 to 650	400K	420	BA	K	③	B+L / 11	E678-14C* ⁽²⁴⁾⁽²⁵⁾⁽²⁶⁾	1500	0.1	1000 ⁽²⁴⁾
R6094			φ25										300 to 650	400K	420	BA	K	④	B+L / 11	E678-14C* ⁽²⁴⁾⁽²⁵⁾⁽²⁶⁾	1500	0.1	1000 ⁽²⁴⁾
R6427			φ25										300 to 650	400K	420	BA	K	⑤	L / 10	E678-14C* ⁽²⁷⁾⁽²⁸⁾⁽²⁹⁾	2000	0.2	1500 ⁽¹⁹⁾
R374			φ25										185 to 850	500U	420	MA	U	③	B / 11	E678-14C* ⁽²⁴⁾⁽²⁵⁾⁽²⁶⁾	1500	0.1	1000 ⁽²⁴⁾

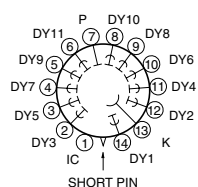
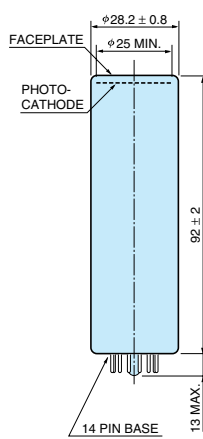
Dimensional Outlines (Unit: mm)

① R6835, R6836



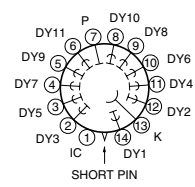
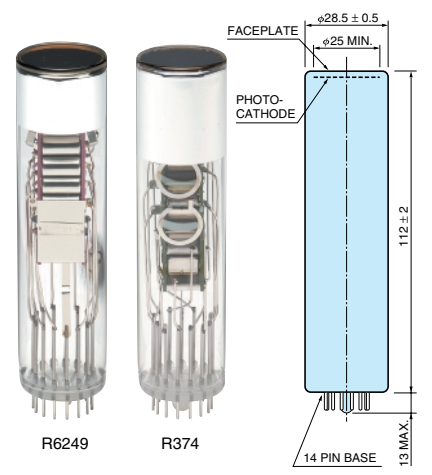
TPMHA0115EC

② R6834



TPMHA0226EC

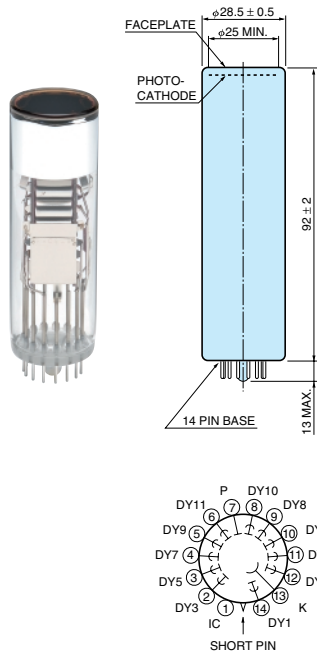
③ R6095, R374



TPMHA0482EA

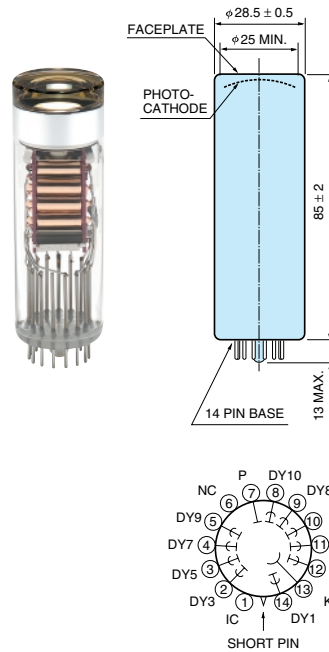
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
—	—	—	—	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	30		R6836
—	—	—	—	28 ^b	—	4×10^3 (A/W) ^b	1.4×10^4 ^b	5.0×10^5	0.3	1	4	30		R6834
60	95	11.0	—	88	50	200	1.8×10^5	2.1×10^6	2	10	4	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	30	For photon counting: R6094P-01	R6094
60	95	11.0	—	88	—	475	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



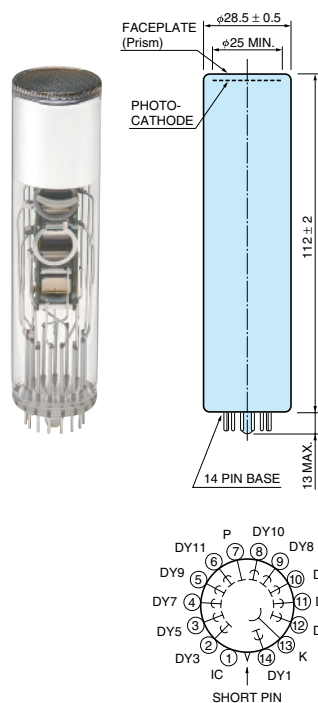
TPMHA0387EA

Head-on Type Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings						
Type No.	Effective Area (mm)												Spectral Response Range (nm)	Curve Code	Peak Wave-length (nm)	Photo-cathode Material	Win-dow Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)	
	← Wavelength (nm) →																							
	100	200	300	400	500	600	700	800	900	1000	1100	1200												
28 mm (1-1/8") Dia. Types																								
R5929				φ25									300 to 900	502K	420	MA	K	①	B / 11	E678-14C*	24 25 26	1500	0.1	1000 24
R2228				φ25									300 to 900	501K	600	MA	K	①	B / 11	E678-14C*	24 25 26	1500	0.1	1000 24
R7205-01				φ10									300 to 650	400K	420	BA	K	②	B+L / 11	E678-14C*	30	1500	0.01	1000 26
R7206-01				φ10									300 to 850	500K	420	MA	K	②	B+L / 11	E678-14C*	30	1500	0.01	1000 26
R3998-02				φ25									300 to 650	400K	420	BA	K	③	B+L / 9	E678-14C*	31	1500	0.1	1000 10
R7111				φ25									300 to 650	400K	420	BA	K	④	L / 10	E678-14C*	21 22 23	1250	0.1	1000 16

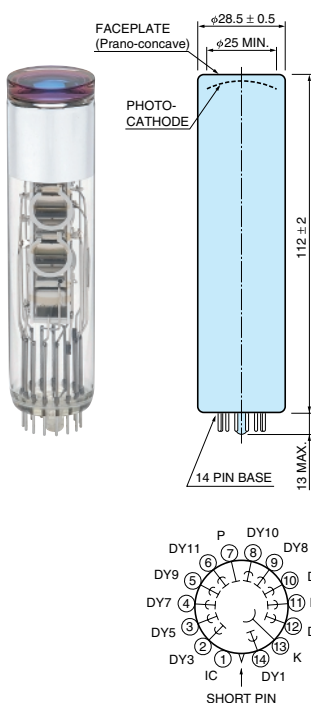
Dimensional Outlines (Unit: mm)

① R5929



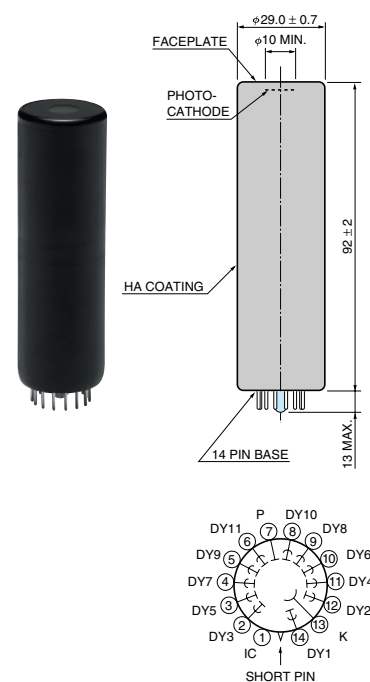
TPMHA0532EA

② R2228



TPMHA0533EA

③ R7205-01, R7206-01

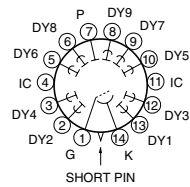
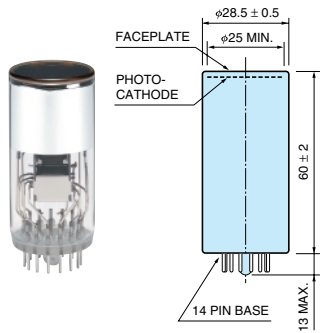


TPMHA0412EC

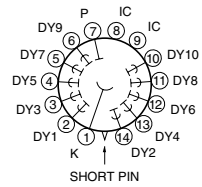
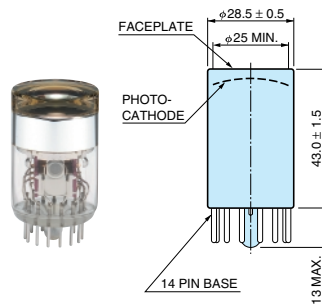
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
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 ^f	30 ^f	1.7	26	Silica glass window: R7207-01	R7205-01
80	150	—	0.2	64	—	1500	6.4×10^5	1.0×10^7	300 ^f	1000 ^f	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

④ R3998-02

⑤ R7111



TPMHA0114EA



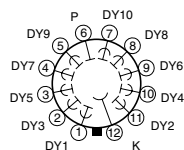
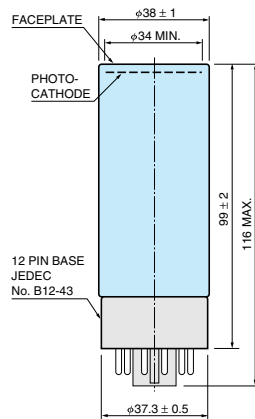
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Head-on Type Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings											
Type No.	Effective Area (mm)										Spectral Response Range (nm)	Curve Code	Peak Wave-length (nm)	Photo-cathode Material	Window Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)								
	← Wavelength (nm) →																												
	100	200	300	400	500	600	700	800	900	1000	1100	1200																	
38 mm (1-1/2") Dia. Types																													
R980				φ 34									300 to 650	400K	420	BA	K	①	CC / 10	E678-12A* ③②③	1250	0.1	1000 ⑭						
R3886				φ 34									300 to 650	400K	420	BA	K	②	CC / 10	E678-12A* ③②③	1250	0.1	1000 ⑭						
R580				φ 34									300 to 650	400K	420	BA	K	③	L / 10	E678-12A* ③②③	1750	0.1	1250 ⑭						
R9722				φ 34									300 to 650	401K	375	HBA	K	④	CC / 10	E678-12R ③②③	1800	0.02	1500 ⑭						
R1387				φ 34									300 to 850	500K	420	MA	K	①	CC / 10	E678-12A* ③②③	1250	0.2	1000 ⑭						
R2066				φ 34									300 to 900	501K	600	MA	K	①	CC / 10	E678-12A* ③②③	1500	0.2	1000 ⑭						

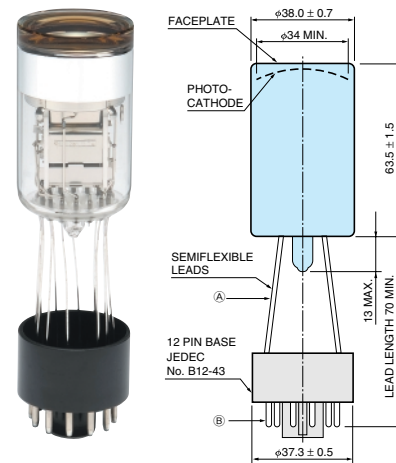
Dimensional Outlines (Unit: mm)

1 R980, R1387, R2066

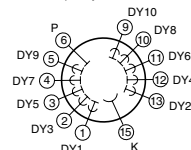


TPMHA0228EA

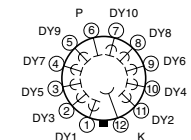
2 R3886



(A) Temporary Base Removed



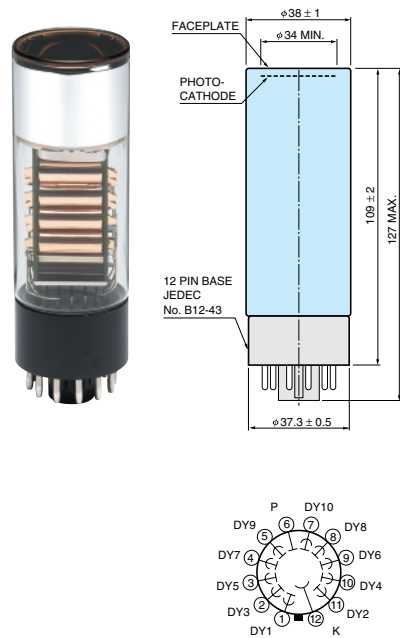
(B) Bottom View



TPMHA0104EA

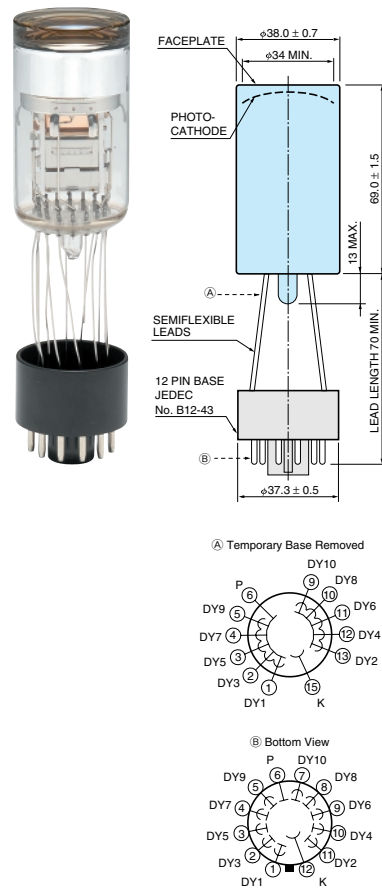
Cathode Characteristics					Anode Characteristics ^(M)								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^(K) Typ.	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^(A)
Min. (μA/lm)	Typ. (μA/lm)			(mA/W)	Min. (A/lm)	Typ. (A/lm)	Typ. (A/W)	Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
70	100	11.5	—	90	10	100	9.0×10^4	1.0×10^6	3	5	2.8	40		R980
60	90	10.5	—	85	10	45	4.3×10^4	5.0×10^5	3	5	2.5	32		R3886
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	2.0	32	High temp. operation (Maximum Temp.: +175 °C)	R9722*
80	150	—	0.2	64	10	50	2.1×10^4	3.3×10^5	4	25	2.8	40	UV glass window: R1508 Silica glass window: R1509	R1387
120	200	—	0.3	40	20	50	1.0×10^4	2.5×10^5	8	30	2.8	40		R2066

3 R580



TPMHA0121EA

4 R9722



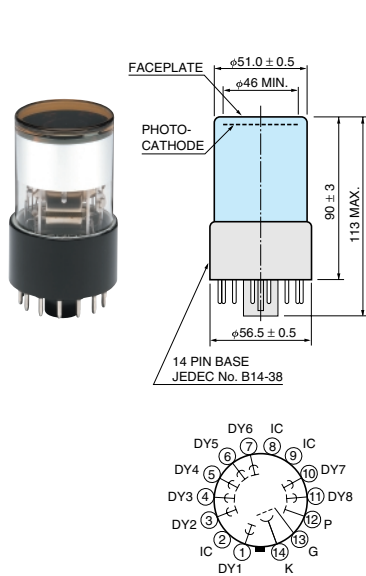
TPMHA0042EB

Head-on Type Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings ^H					
Type No. ^A	Effective Area (mm)												Spectral Response Range (nm)	Curve Code ^B	Peak Wavelength (nm)	Photo-cathode Material ^C	Win-dow Material ^D	Out-line No. ^E	Dynode Structure / Stages ^F	Socket & Socket Assembly ^G	Anode to Cathode Voltage (V) ^H	Average Anode Current (mA) ^I	Anode to Cathode Supply Voltage (V) ^J
	100	200	300	400	500	600	700	800	900	1000	1100	1200											
51 mm (2") Dia. Types with Plastic Base																							
R6231				φ46									300 to 650	400K	420	BA	K	①	B+L / 8	E678-14W ③④⑤	1500	0.1	1000 ⑥
R1306				φ46									300 to 650	400K	420	BA	K	②	B / 8	E678-14W ③⑥⑦	1500	0.1	1000 ②
R2154-02				φ46									300 to 650	400K	420	BA	K	③	L / 10	E678-14W ③⑧	1750	0.1	1250 ④
R1828-01				φ46									300 to 650	400K	420	BA	K	④	L / 12	E678-20A* ③⑨	3000	0.2	2500 ⑦
*R10131				φ46									300 to 650	400K	420	BA	K	⑤	B+L / 8	E678-14W	1500	0.1	1000 ⑧
R550				φ46									300 to 850	500K	420	MA	K	⑥	L / 10	E678-14W ④①②③④④	1500	0.3	1000 ⑫

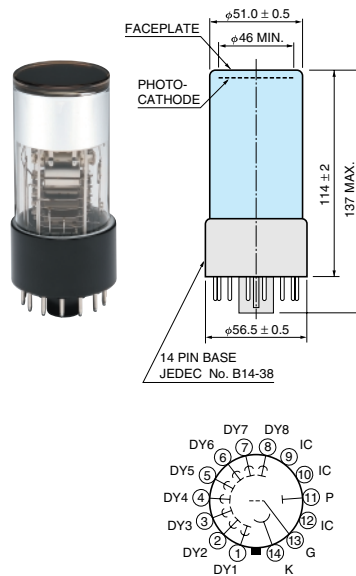
Dimensional Outlines (Unit: mm)

① R6231



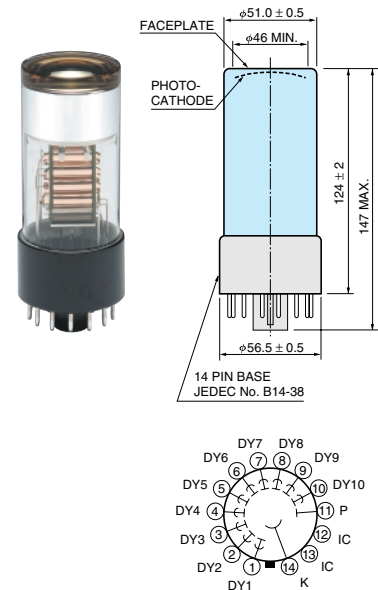
TPMHA0388EB

② R1306



TPMHA0089EC

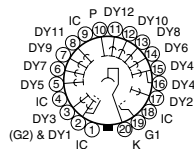
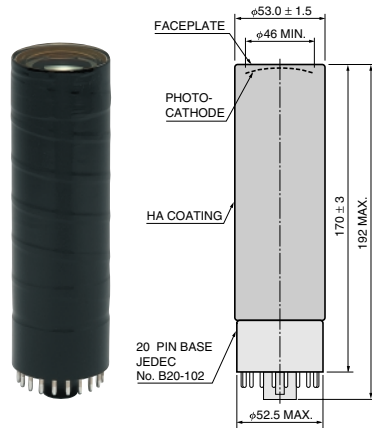
③ R2154-02



TPMHA0296EA

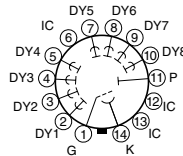
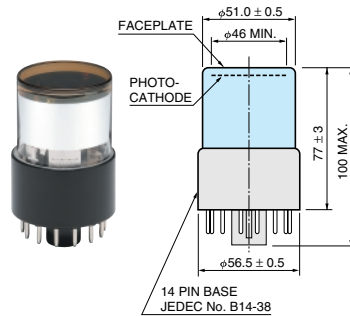
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)			Typ. (mA/W)	Min. (A/lm)	Typ. (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	5.0	48	Flying 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	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
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	7.3	51	Flying lead: R10131-01	R10131*
100	150	—	0.2	64	20	100	4.3×10^4	6.7×10^5	10	30	9.0	70		R550

4 R1828-01



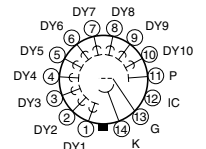
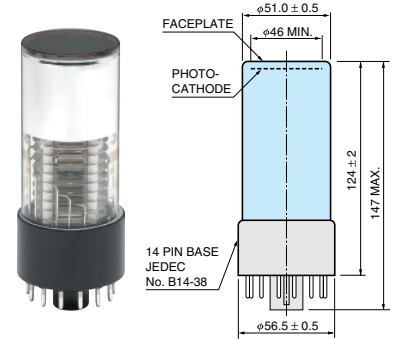
TPMHA0064EC

5 R10131



TPMHA0535EA

6 R550



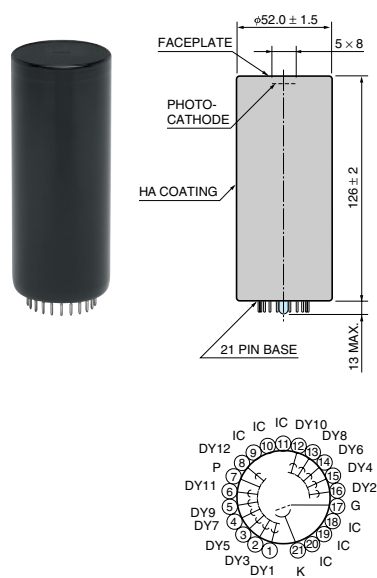
TPMHA0210EB

Head-on Type Photomultiplier Tubes

Spectral Response										Remarks						Max. Ratings				
Type No.	Effective Area (mm)								Spectral Response Range (nm)	Curve Code	Peak Wavelength (nm)	Photo-cathode Material	Window Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)	
	Wavelength (nm)																			
	100	200	300	400	500	600	700	800	900	1000	1100	1200								
51 mm (2") Dia. Types with Glass Base																				
R464			5 × 8							300 to 650	400K	420	BA	K	①	B / 12	E678-21C* ④5	1500	0.01	1000 ②9
R329-02			φ46							300 to 650	400K	420	BA	K	②	L / 12	E678-21C* ④6④7④8	2700	0.2	1500 ②8
R331-05			φ46							300 to 650	400K	420	BA	K	③	L / 12	E678-21C* ④6④7④8	2500	0.2	1500 ②8
R2083			φ46							300 to 650	400K	420	BA	K	④	L / 8	E678-19J*	3500	0.2	3000 ③
R4607-01			φ46							300 to 650	401K	375	HBA	K	⑤	CC / 10	E678-15C*	1800	0.02	1500 ①4
R649			5 × 8							300 to 850	500K	420	MA	K	①	B / 12	E678-21C* ④5	1500	0.01	1000 ②9

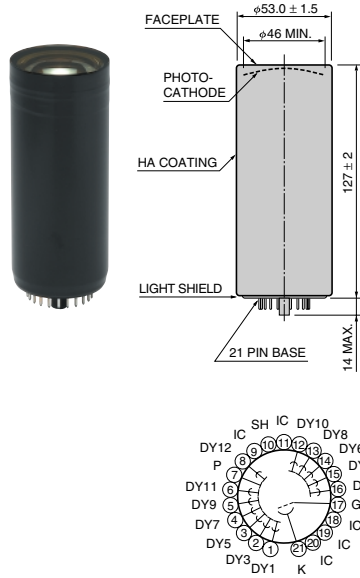
Dimensional Outlines (Unit: mm)

① R464, R649



TPMHA0216EC

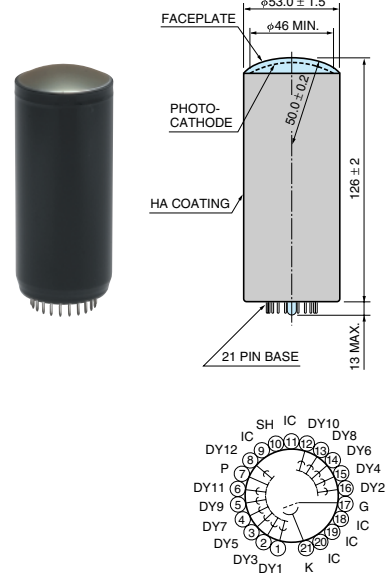
② R329-02



*CONNECT SH TO DY5

TPMHA0123EE

③ R331-05

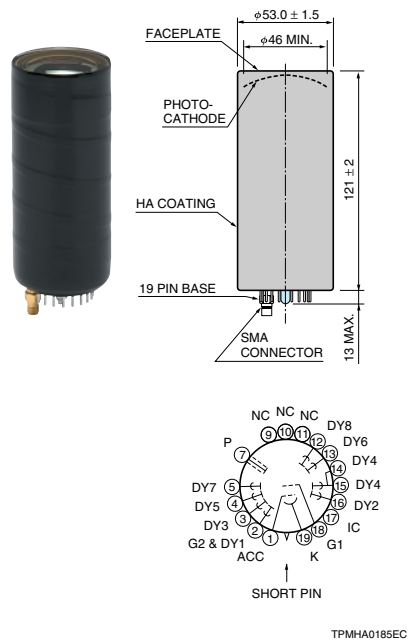


*CONNECT SH TO DY5

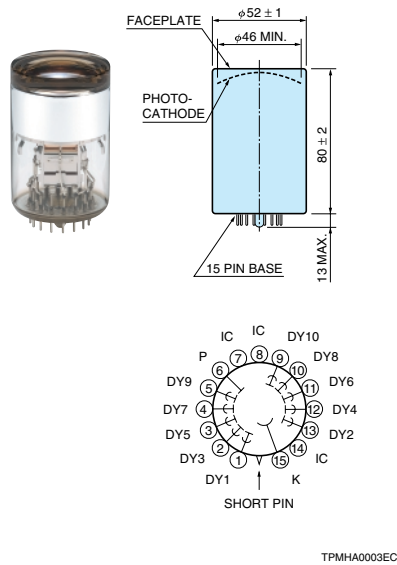
TPMHA0072EC

Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
30	50	—	—	50	100	300	3.0×10^5	6.0×10^6	5 ^f	15 ^f	13	70	Silica glass window: R585	R464
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	200 ^f	600 ^f	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	2.5	29	High temp. operation (Maximum Temp.: +175 °C)	R4607-01
80	120	—	0.2	51	100	800	3.4×10^5	6.7×10^6	200 ^f	350 ^f	13	70		R649

④ R2083



⑤ R4607-01



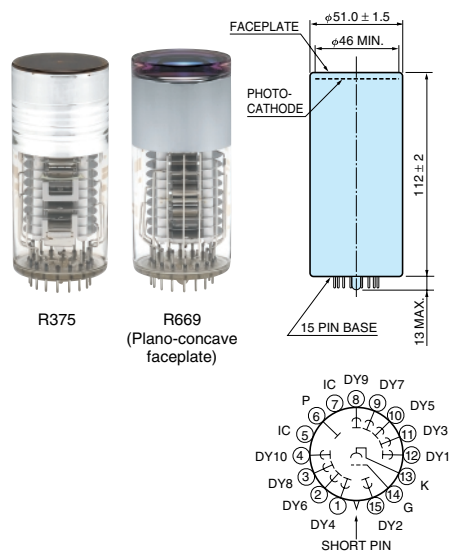
Head-on Type Photomultiplier Tubes

Spectral Response													Remarks				Max. Ratings						
Type No.	Effective Area (mm)												Spectral Response Range (nm)	Curve Code	Peak Wavelength (nm)	Photo-cathode Material	Window Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)
	Wavelength (nm)																						
	100	200	300	400	500	600	700	800	900	1000	1100	1200											
51 mm (2") Dia. Types with Glass Base																							
R375	φ46												160 to 850	500S	420	MA	Q	①	B / 10	E678-15C* ④⑨	1500	0.1	1000 ⑫
R669	φ46												300 to 900	501K	600	EMA	K	①	B / 10	E678-15C* ④⑨	1500	0.1	1000 ⑫
R943-02	□10												160 to 930	650S	300-800	GaAs	Q	②	L / 10	(NOTE) E678-21C*	2200	0.001	1500 ⑮
R3310-02	□10												300 to 1040	851K	400	InGaAs	K	②	L / 10	(NOTE) E678-21C*	2200	0.001	1500 ⑮
R2257	φ46												300 to 900	501K	600	EMA	K	③	L / 12	E678-21C* ④⑥⑦⑧	2700	0.2	1500 ⑮

(NOTE) For cooling operation, another ceramic socket, type number E678-21D (sold separately) is recommended.

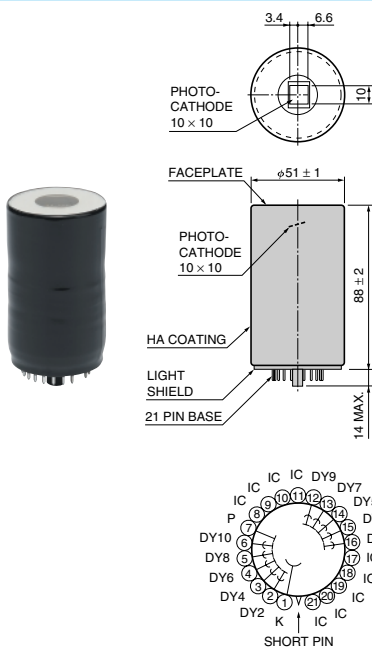
Dimensional Outlines (Unit: mm)

① R375, R669



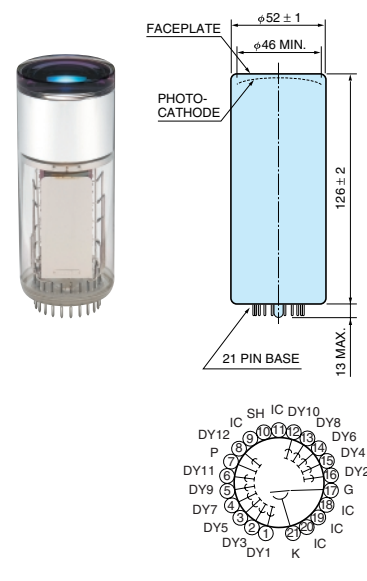
TPMHA0211FA

② R943-02, R3310-02



TPMHA0021FE

③ R2257



* CONNECT SH TO DY5

TPMHA0359FB

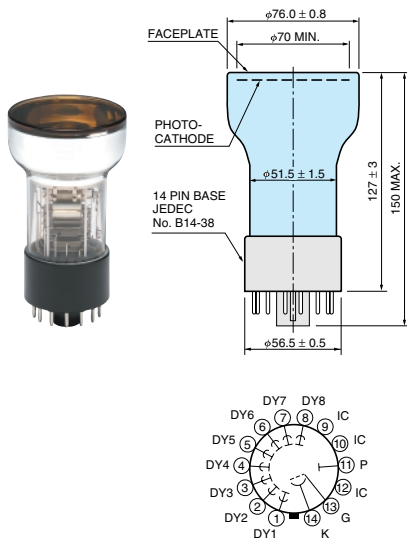
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μ A/lm)	Typ. (μ A/lm)				Min. (A/lm)	Typ. (A/lm)			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 ^G	50 ^G	3.0	23	For photon counting	R943-02
80	150	—	0.4	9.4 ^G	15	50	3.1×10^3	3.3×10^5	30 ^G	150 ^G	3.0	23	For photon counting	R3310-02
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

Spectral Response										Remarks					Max. Ratings				
Type No.	Effective Area (mm)								Spectral Response Range (nm)	Curve Code	Peak Wavelength (nm)	Photo-cathode Material	Win-dow Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)
	← Wavelength (nm) →																		
100 200 300 400 500 600 700 800 900 1000 1100 1200																			
76 mm (3") Dia. Types																			
R1307				φ 70					300 to 650	400K	420	BA	K	①	B / 8	E678-14W ③⑥⑦	1500	0.1	1000 ②
R6233				φ 70					300 to 650	400K	420	BA	K	②	B+L / 8	E678-14W ③④⑤	1500	0.1	1000 ⑥
*R10133				φ 70					300 to 650	400K	420	BA	K	③	B+L / 8	E678-14W	1500	0.1	1000 ⑧
R4143				φ 65					300 to 650	400K	420	BA	K	④	L / 12	E678-20A*	3000	0.2	2500 ⑩
R6091				φ 65					300 to 650	400K	420	BA	K	⑤	L / 12	E678-21C* ④⑥④⑦⑧	2500	0.2	1500 ⑫

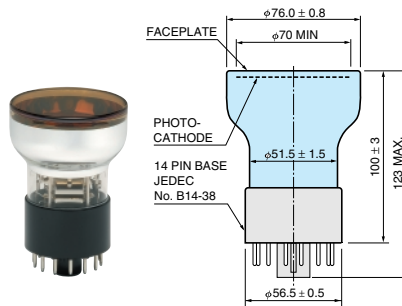
Dimensional Outlines (Unit: mm)

① R1307



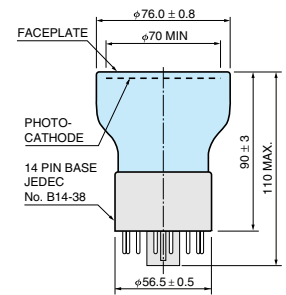
TPMHA0078EA

② R6233



TPMHA0389EB

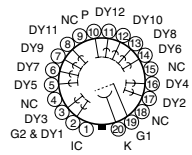
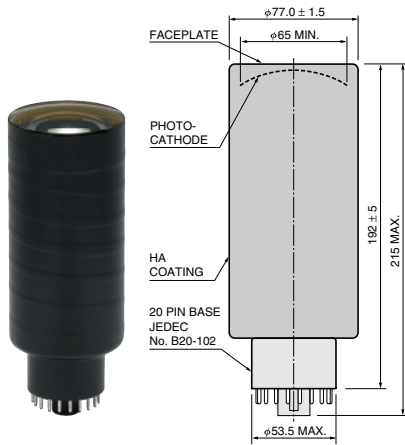
③ R10133



TPMHA0536EA

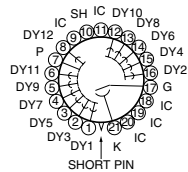
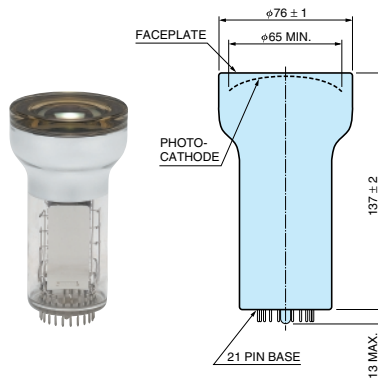
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			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	8.0	64	Flying lead: R1307-01	R1307
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	6.0	52	Flying lead: R6233-01	R6233
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	8.3	59	Flying lead: R10133-01	R10133*
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

4 R4143



TPMHA0112EB

5 R6091



TPMHA0285EB

Head-on Type Photomultiplier Tubes

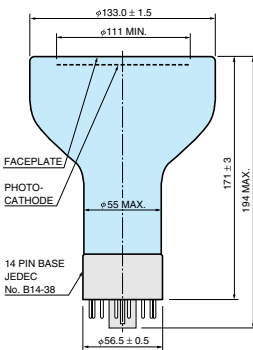
Spectral Response											Remarks					Max. Ratings ^H								
Type No. ^A	Effective Area (mm)										Spectral Response Range (nm)	Curve Code ^B	Peak Wavelength (nm)	Photo-cathode Material ^C	Window Material ^D	Out-line No. ^E	Dynode Structure / Stages ^F	Socket & Socket Assembly ^G	Anode to Cathode Voltage (V)	Average Anode Current (mA) ^J	Anode to Cathode Supply Voltage (V) ^L			
	← Wavelength (nm) →																							
127 mm (5") Dia. Types																								
R877				φ111							300 to 650	400K	420	BA	K	①	B / 10	E678-14W	④1④2④3④4	1500	0.1	1250	⑩2	
R1250				φ120							300 to 650	400K	420	BA	K	②	L / 14	E678-20A*	⑤0	3000	0.2	2000	③4	
R1513				φ111								300 to 850	500K	420	MA	K	①	VB / 10	E678-14W	④1④2④3④4	2000	0.1	1500	⑩2
R1584				φ120							185 to 650	400U	420	BA	U	③	L / 14	E678-20A*	⑤0	3000	0.2	2000	③4	

Dimensional Outlines (Unit: mm)

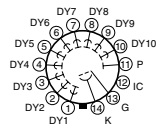
① R877, R1513



R877R1513



FACEPLATE
PHOTO-CATHODE
14 PIN BASE
JEDEC
No. B14-38

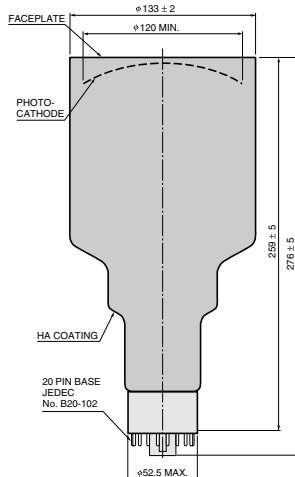


DY6 DY7 DY8 DY9
DY5 DY4 DY3 DY2
DY1 IC P
G K

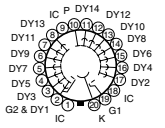
TPMHA0074EC

② R1250





FACEPLATE
PHOTO-CATHODE
HA COATING
20 PIN BASE
JEDEC
No. B20-102

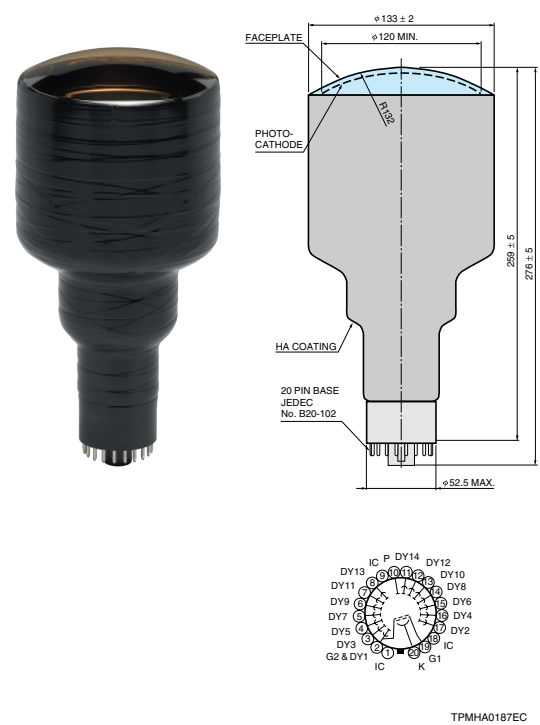


IC P DY14 DY12
DY13 DY11 DY10
DY9 DY8
DY7 DY6
DY5 DY4
DY3 DY2
G2 & DY1 IC K G1

TPMHA0018EC

Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
60	95	11.0	—	88	20	40	3.7×10^4	4.2×10^5	10	50	20	90	K-free borosilicate glass: R877-01	R877
55	70	9.0	—	72	300	1000	1.0×10^6	1.4×10^7	50	300	2.5	54		R1250
100	150	—	0.2	64	10	50	2.1×10^4	3.3×10^5	30	150	7.0	82		R1513
55	70	9.0	—	72	300	1000	1.0×10^6	1.4×10^7	50	300	2.5	54		R1584

3
R1584

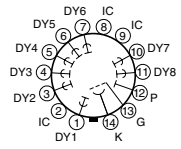
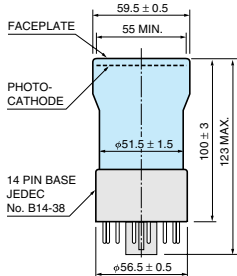
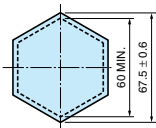


Hexagonal Type, Rectangular Type Photomultiplier Tubes

Spectral Response												Remarks					Max. Ratings ^H						
Type No. ^A	Effective Area (mm)											Spectral Response Range (nm)	Curve Code ^B	Peak Wave-length (nm)	Photo-cathode Material ^C	Win-dow Material ^D	Out-line No. ^E	Dynode Structure / Stages ^F	Socket & Socket Assembly ^G	Anode to Cathode Voltage (V)	Average Anode Current (mA) ^I	Anode to Cathode Supply Voltage (V) ^L	
	← Wavelength (nm) →																						
	100	200	300	400	500	600	700	800	900	1000	1100	1200											
Hexagonal Types																							
R6234				55 (6)									300 to 650	400K	420	BA	K	①	B+L / 8	E678-14W ③⑤	1500	0.1	1000 ⑥
R6235				70 (6)									300 to 650	400K	420	BA	K	②	B+L / 8	E678-14W ③⑤	1500	0.1	1000 ⑥
Rectangular Types																							
R6236				□54									300 to 650	400K	420	BA	K	③	B+L / 8	E678-14W ③⑤	1500	0.1	1000 ⑥
R6237				□70									300 to 650	400K	420	BA	K	④	B+L / 8	E678-14W ③⑤	1500	0.1	1000 ⑥
R2248				□8									300 to 650	400K	420	BA	K	⑤	L / 8	E678-11N* ⑥	1500	0.03	1250 ①
R1548-07				8 × 18 × (2)									300 to 650	400K	420	BA	K	⑥	L / 10	E678-17A*	1750	0.1	1250 ⑱

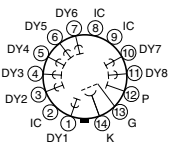
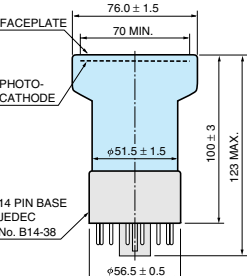
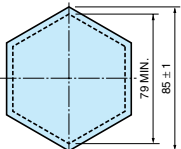
Dimensional Outlines (Unit: mm)

① R6234



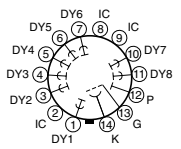
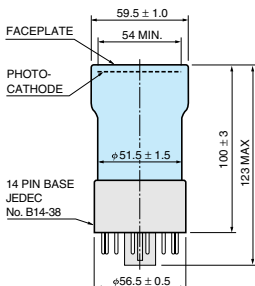
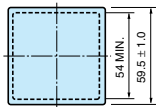
TPMHA0390EB

② R6235



TPMHA0391EB

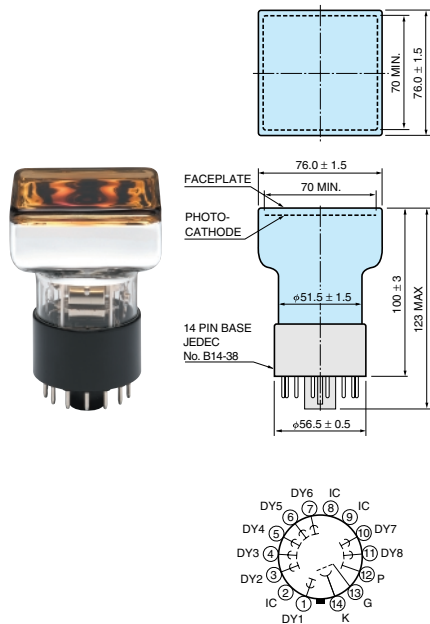
③ R6236



TPMHA0392EB

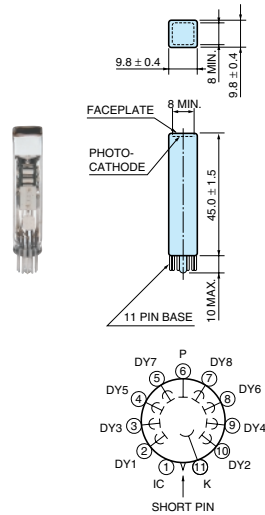
Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ.	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			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	6.0	52	Flying lead: R6234-01	R6234
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	6.0	52	Flying lead: R6235-01	R6235
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	6.0	52	Flying lead: R6236-01	R6236
80	110	12.0	—	95	3	30	2.6×10^4	2.7×10^5	2	20	6.0	52	Flying 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

4 R6237



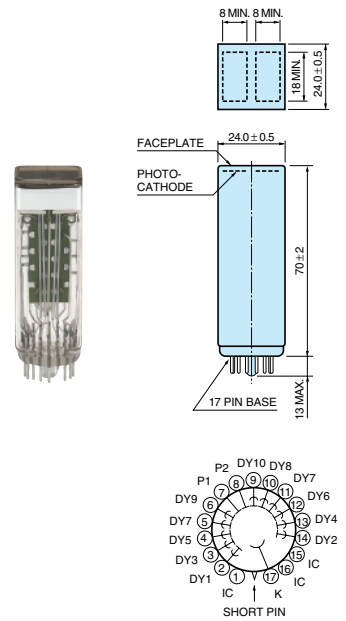
TPMHA0393EB

5 R2248



TPMHA0098EB

6 R1548-07



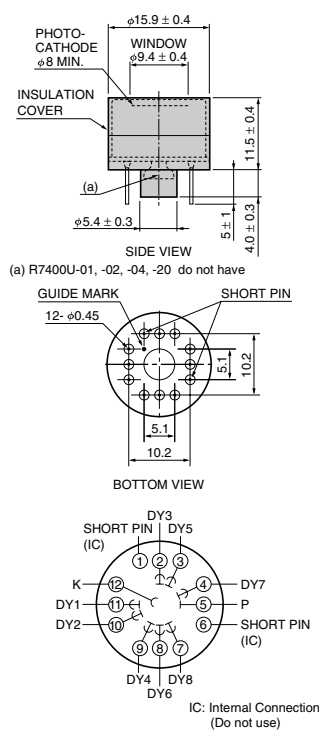
TPMHA0223EA

Metal Package Photomultiplier Tubes

Spectral Response													Remarks				Max. Ratings					
Type No.	Effective Area (mm) ← Wavelength (nm) →												Spectral Response Range (nm)	Peak Wave-length (nm)	Photo-cathode Material	Win-dow Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)
	100	200	300	400	500	600	700	800	900	1000	1100	1200										
R7400U			φ 8										300 to 650	420	BA	K	①	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦
R7400U-01			φ 8										300 to 850	400	MA	K	①	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦
R7400U-02			φ 8										300 to 880	500	MA	K	①	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦
R7400U-03			φ 8										185 to 650	420	BA	U	①	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦
R7400U-04			φ 8										185 to 850	400	MA	U	①	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦
R7400U-06			φ 8										160 to 650	420	BA	Q	②	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦
R7400U-09			φ 8										160 to 320	240	Cs-Te	Q	②	MC / 8	E678-12V ⑤	1000	0.01	800 ⑦
R7400U-20			φ 8										300 to 920	630	MA	K	①	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦
R7401			φ 8										300 to 650	420	BA	K	③	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦
R7402			φ 8										300 to 850	400	MA	K	③	MC / 8	E678-12V ⑤	1000	0.1	800 ⑦

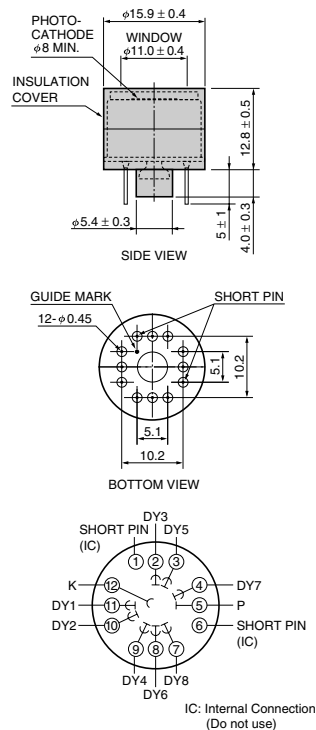
Dimensional Outlines (Unit: mm)

① R7400U, -01, -02, -03, -04, -20



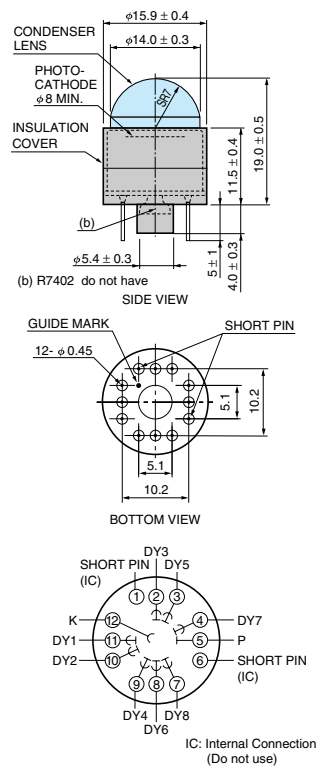
TPMHA0411EE

② R7400U-06, -09



TPMHA0410ED

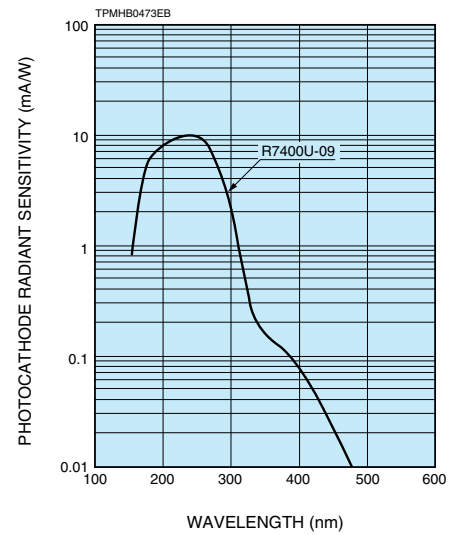
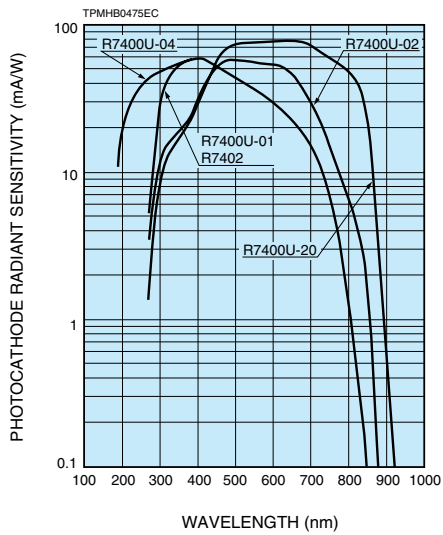
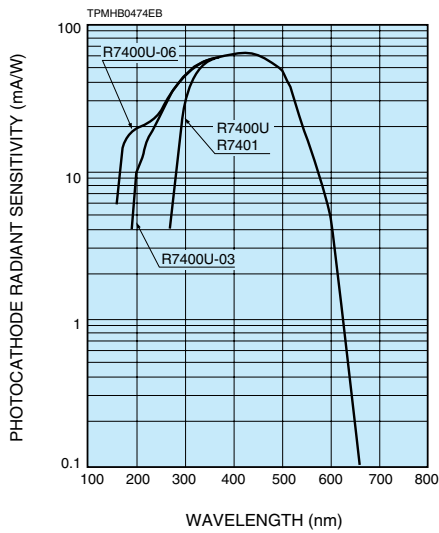
③ R7401, R7402



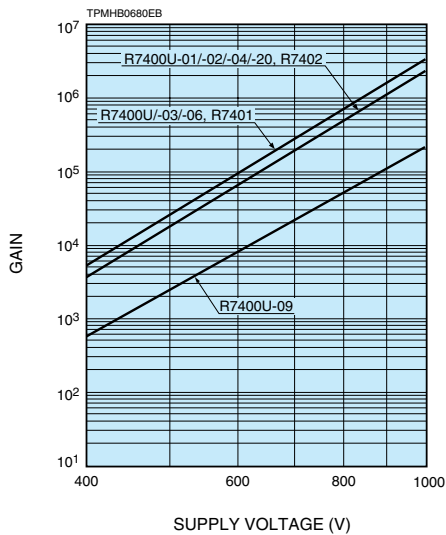
TPMHA0415EE

Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ.	Luminous		Radiant Typ.	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
40	70	8.0	—	62	10	50	4.3×10^4	7.0×10^5	0.2	2	0.78	5.4	For photon counting: R7400P	R7400U
80	150	—	0.2	60	15	75	3.0×10^4	5.0×10^5	0.4	4	0.78	5.4		R7400U-01
200	250	—	0.25	58	25	125	2.9×10^4	5.0×10^5	2.0	20	0.78	5.4	With condenser lens: R7402-02	R7400U-02
40	70	8.0	—	62	10	50	4.3×10^4	7.0×10^5	0.2	2	0.78	5.4		R7400U-03
80	150	—	0.2	60	15	75	3.0×10^4	5.0×10^5	0.4	4	0.78	5.4		R7400U-04
40	70	8.0	—	62	10	50	4.3×10^4	7.0×10^5	0.2	2	0.78	5.4		R7400U-06
—	—	—	—	10 ^B	—	—	500 ^B	5.0×10^4	0.025	0.5	0.78	5.4		R7400U-09
350	500	—	0.45	78	35	250	3.9×10^4	5.0×10^5	2.0	20	0.78	5.4	With condenser lens: R7402-20	R7400U-20
40	70	8.0	—	62	10	50	4.3×10^4	7.0×10^5	0.2	2	0.78	5.4		R7401
80	150	—	0.2	60	15	75	3.0×10^4	5.0×10^5	0.4	4	0.78	5.4		R7402

Spectral Response



Gain



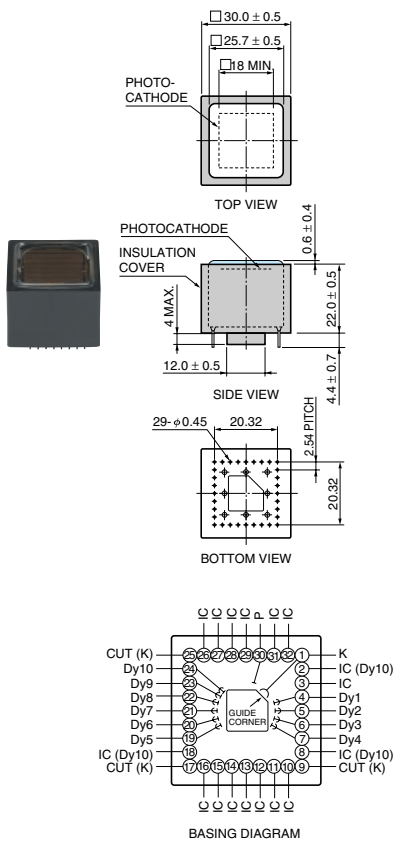
Metal Package Photomultiplier Tubes

Spectral Response													Remarks					Max. Ratings ^H				
Type No.	Effective Area (mm) ← Wavelength (nm) →												Spectral Response Range (nm)	Peak Wave-length (nm)	Photo-cathode Material	Win-dow Material	Out-line No.	Dynode Structure / Stages	Socket & Socket Assembly	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)
	100	200	300	400	500	600	700	800	900	1000	1100	1200										
R7600U			18 × 18										300 to 650	420	BA	K	①	MC / 10	E678-32B ⑤2	900	0.1	800 ②2
R7600U-00-M4			8.9 × 8.9 × (4)										300 to 650	420	BA	K	②	MC / 10	E678-32B ⑤3	900	0.1	800 ②2
R5900U-00-L16			0.8 × 16 × (16)										300 to 650	420	BA	K	③	MC / 10	E678-32B ⑤4	900	0.1	800 ①1
R5900U-01			18 × 18										300 to 850	400	MA	K	①	MC / 10	E678-32B ⑤2	900	0.1	800 ②2
R5900U-01-M4			8.9 × 8.9 × (4)										300 to 850	400	MA	K	②	MC / 10	E678-32B ⑤3	900	0.1	800 ②2
R5900U-01-L16			0.8 × 16 × (16)										300 to 880	420	MA	K	③	MC / 10	E678-32B ⑤4	900	0.1	800 ①1
R5900U-20			18 × 18										300 to 920	530	MA	K	①	MC / 10	E678-32B ⑤2	900	0.1	800 ②2
R5900U-20-M4			8.9 × 8.9 × (4)										300 to 920	530	MA	K	②	MC / 10	E678-32B ⑤3	900	0.1	800 ②2
R5900U-20-L16			0.8 × 16 × (16)										300 to 920	630	MA	K	③	MC / 10	E678-32B ⑤4	900	0.1	800 ①1

Multianode photomultiplier tubes R7600-00-M16 and R7600-00-M64 are listed in the group of photomultiplier tube assemblies on page 74.

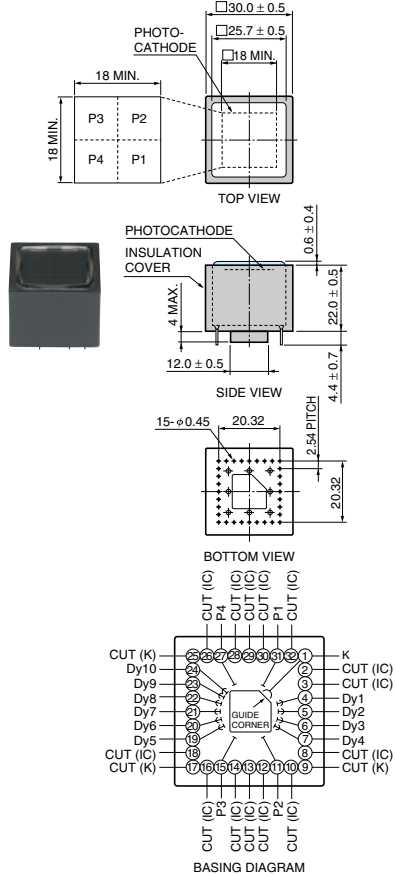
Dimensional Outlines (Unit: mm)

① R7600U, R5900U-01, R5900U-20



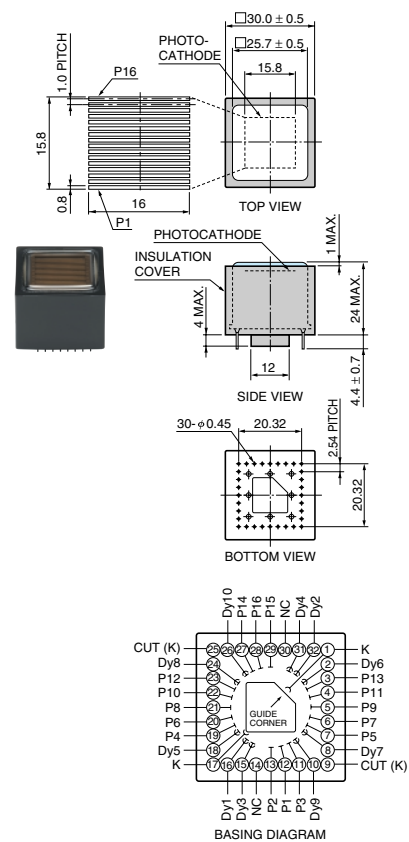
K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
IC : Internal Connection
(Do not Use)

② R7600U-00-M4, R5900U-01-M4, R5900U-20-M4



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

③ R5900U-00-L16, R5900U-01-L16, R5900U-20-L16

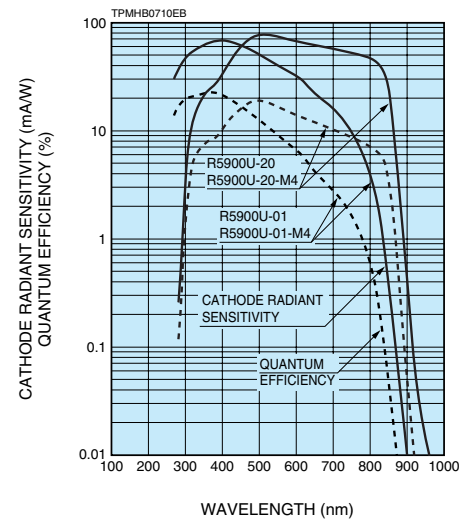
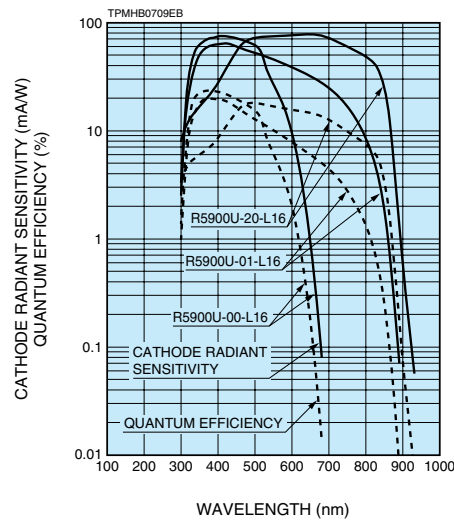
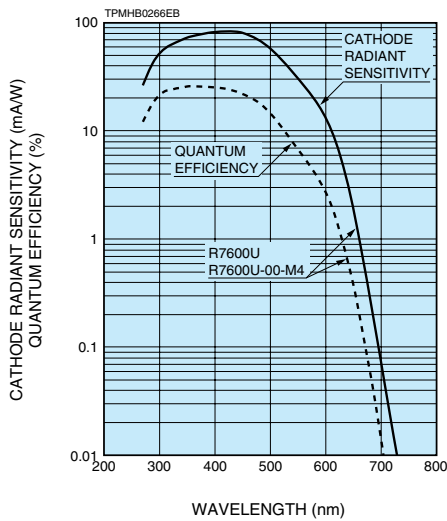


K : Photocathode
Dy : Dynode
P : Anode
CUT : Short Pin
NC : No Connection

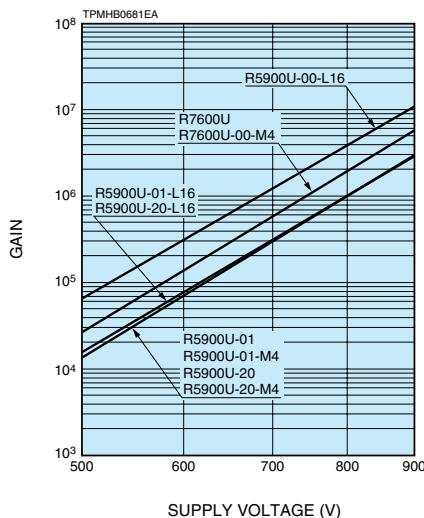
(at 25 °C)

Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
60	80	9.5	—	80	40	140	1.4 × 10 ⁵	1.8 × 10 ⁶	2	20	1.4	9.6	UV glass window: R7600U-03 For photon counting: R7600P	R7600U
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
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	200	—	0.2	65	50	200	7.0 × 10 ⁴	1.0 × 10 ⁶	10	50	1.4	9.6	UV glass window: R5900U-04	R5900U-01
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: R5900U-04-M4	R5900U-01-M4
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	—	0.4	78	100	500	6.5 × 10 ⁴	1.0 × 10 ⁶	20	50	1.4	9.6		R5900U-20
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		R5900U-20-M4
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

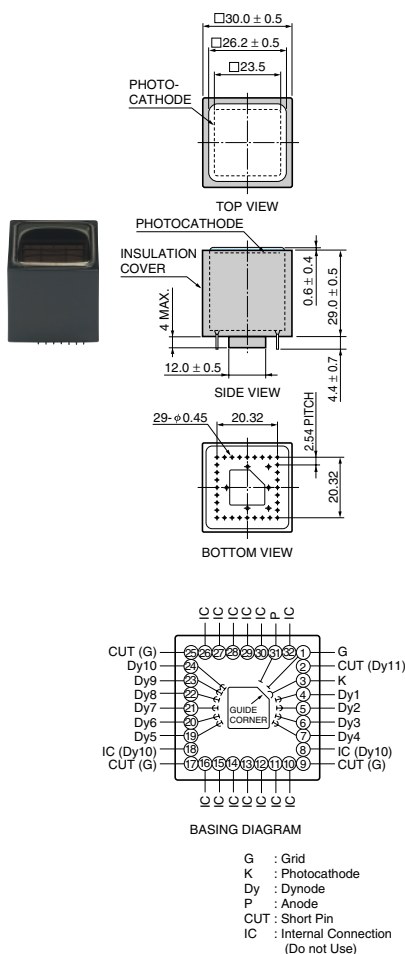


Metal Package Photomultiplier Tubes

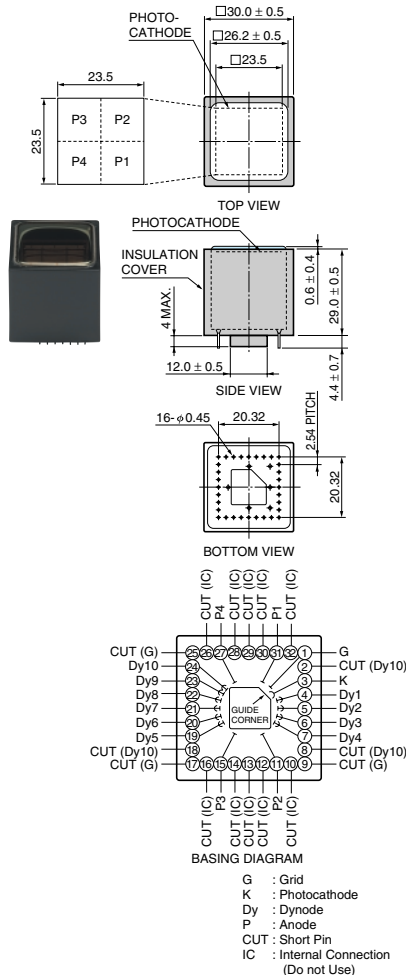
Spectral Response													Remarks				Max. Ratings ^H					
Type No. ^A	Effective Area (mm)												Spectral Response Range (nm)	Peak Wave-length (nm)	Photo-cathode Material ^C	Win-dow Material ^D	Out-line No. ^E	Dynode Structure / Stages ^F	Socket & Socket Assembly ^G	Anode to Cathode Voltage (V) ^J	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V) ^L
	← Wavelength (nm) →																					
	100	200	300	400	500	600	700	800	900	1000	1100	1200										
*R8900U				□23.5									300 to 650	420	BA	K	①	MC / 10	E678-32B ⁵⁵	900	0.1	800 ²³
*R8900U-00-M4				□23.5									300 to 650	420	BA	K	②	MC / 10	E678-32B	900	0.1	800 ²³
*R8900-00-M16				□23.5									300 to 650	420	BA	K	③	MC / 12	— ⁵⁶	1000	0.1	800 ³³
*R8900U-00-C12				□23.5									300 to 650	420	BA	K	④	MC / 11	E678-32B	1000	0.1	800 ²⁵

Dimensional Outlines (Unit: mm)

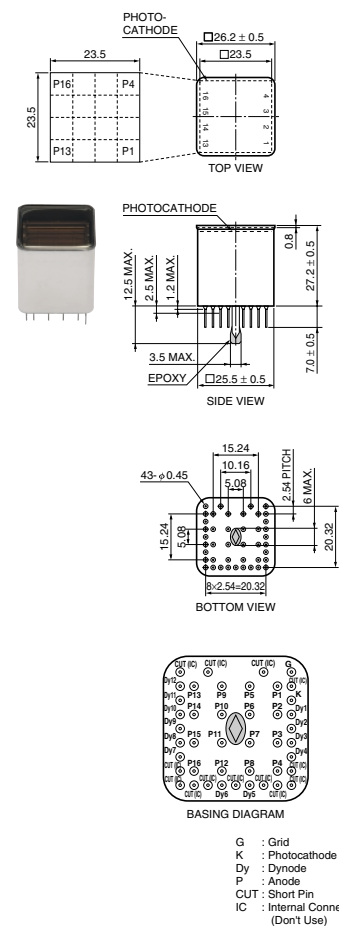
① R8900U



② R8900U-00-M4

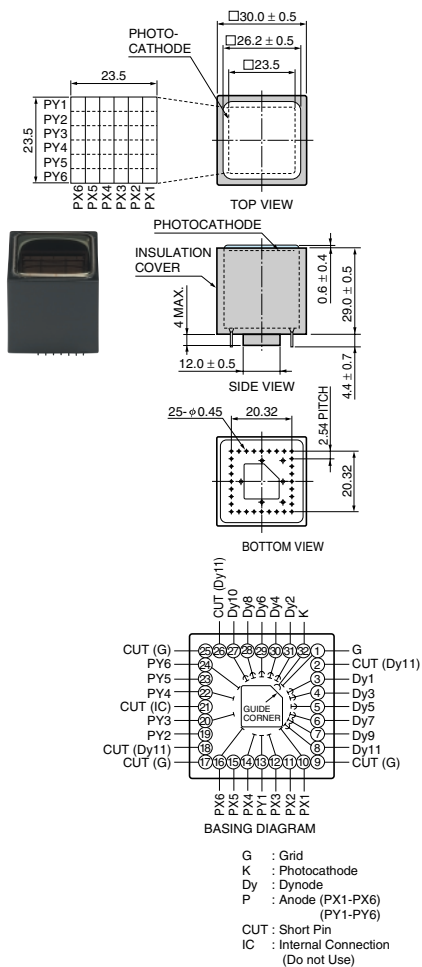


③ R8900-00-M16

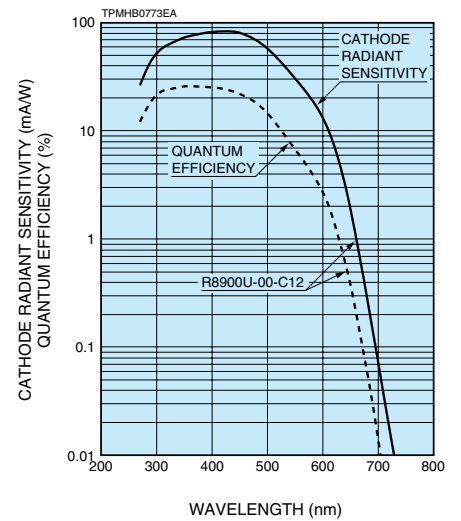
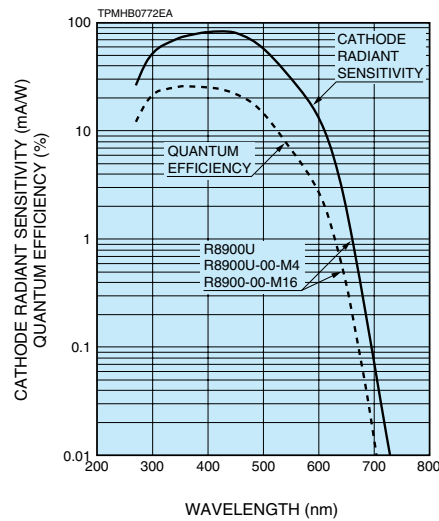


Cathode Characteristics					Anode Characteristics ^(M)								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^(K) Typ.	Luminous		Radiant	Gain	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^(A)
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (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	—	82	15	60	7.4×10^4	0.7×10^6	2	10	2.2	11.9		R8900U-00-C12*

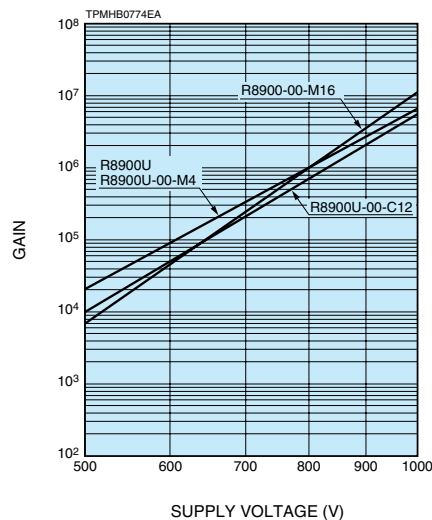
4 R8900U-00-C12



Spectral Response



Gain

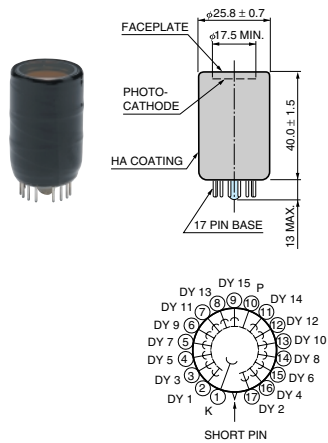


Photomultiplier Tubes for High Magnetic Environments

Type No.	Tube Diameter mm (inch)	Spectral Response											Remarks						Max. Ratings ^H				
		Effective Area (mm)											Spectral Response Range (nm)	Peak Wave-length (nm)	Photo-cathode Material ^C	Window Material ^D	Out-line No. ^E	Dynode Structure / Stages ^F	Socket & Socket Assembly ^G	Anode to Cathode Voltage (V)	Average Anode Current (mA) ^J	Anode to Cathode Supply Voltage (V) ^L	
		← Wavelength (nm) →																					
R5505-70	25 (1)	100	200	300	400	500	600	700	800	900	1000	1100	1200	300 to 650	420	BA	K	①	FM / 15	E678-17A* ⑤7	2300	0.01	2000 ③5
R7761-70	38 (1-1/2)													300 to 650	420	BA	K	②	FM / 19	—	2300	0.01	2000 ③6
R5924-70	51 (2)													300 to 650	420	BA	K	③	FM / 19	—	2300	0.1	2000 ③6

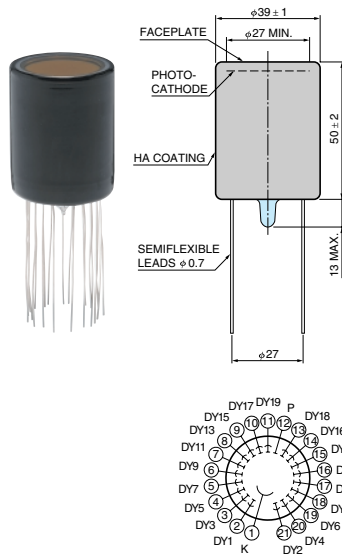
Dimensional Outlines (Unit: mm)

① R5505-70



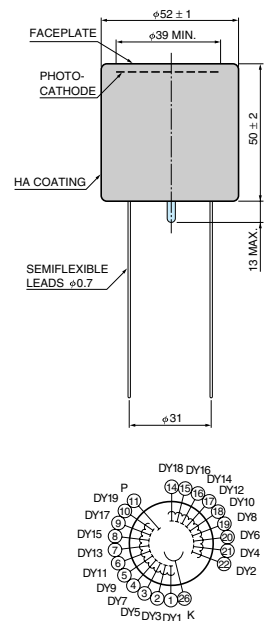
TPMHA0236EA

② R7761-70



TPMHA0469EB

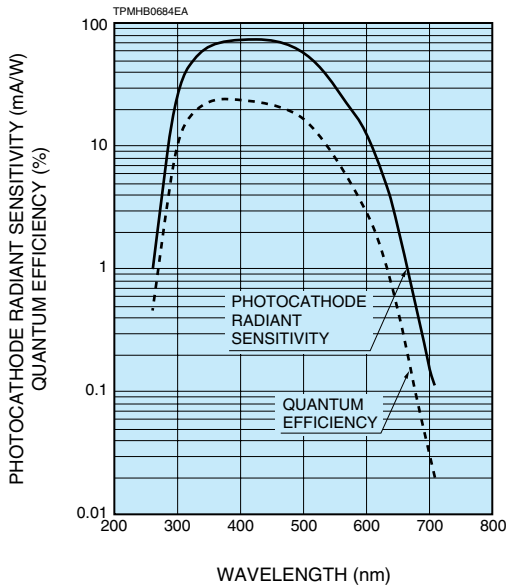
③ R5924-70



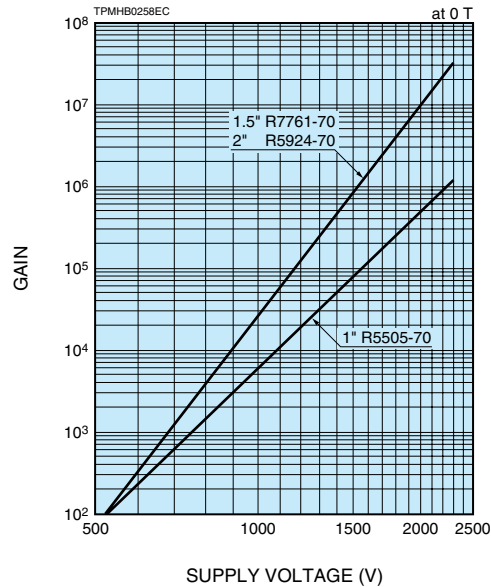
TPMHA0490EA

Cathode Characteristics				Anode Characteristics ^M							(at 25 °C)	
Lumi- nous Typ. (μA/lm)	Blue Sensitivity Index (CS 5-58) Typ.	Radiant ^K Typ. (mA/W)	Lumi- nous Typ. (A/lm)	Gain			Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
				at 0 T Typ.	at 0.5 T Typ.	at 1.0 T Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
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

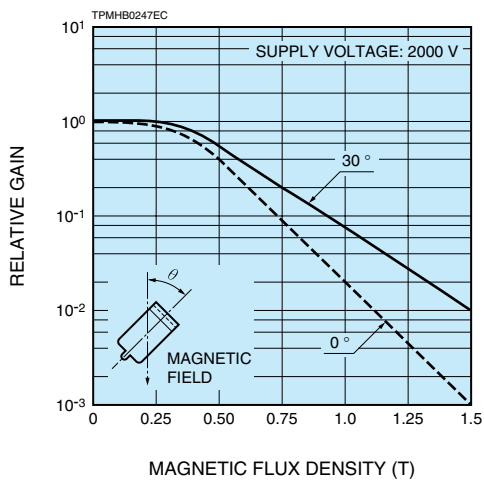
■ Spectral Response



■ Gain



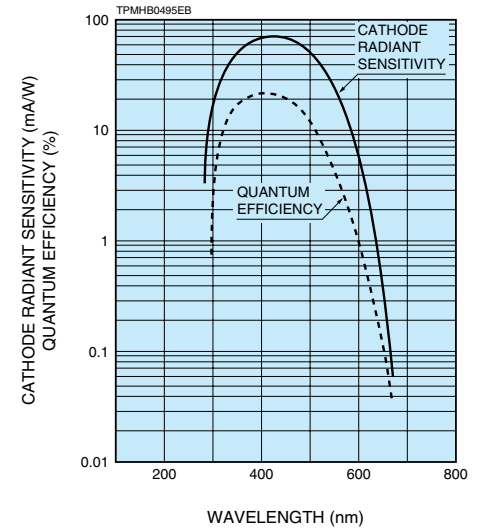
■ R5924-70 Relative Gain in Magnetic Fields



Position Sensitive Type Photomultiplier Tubes

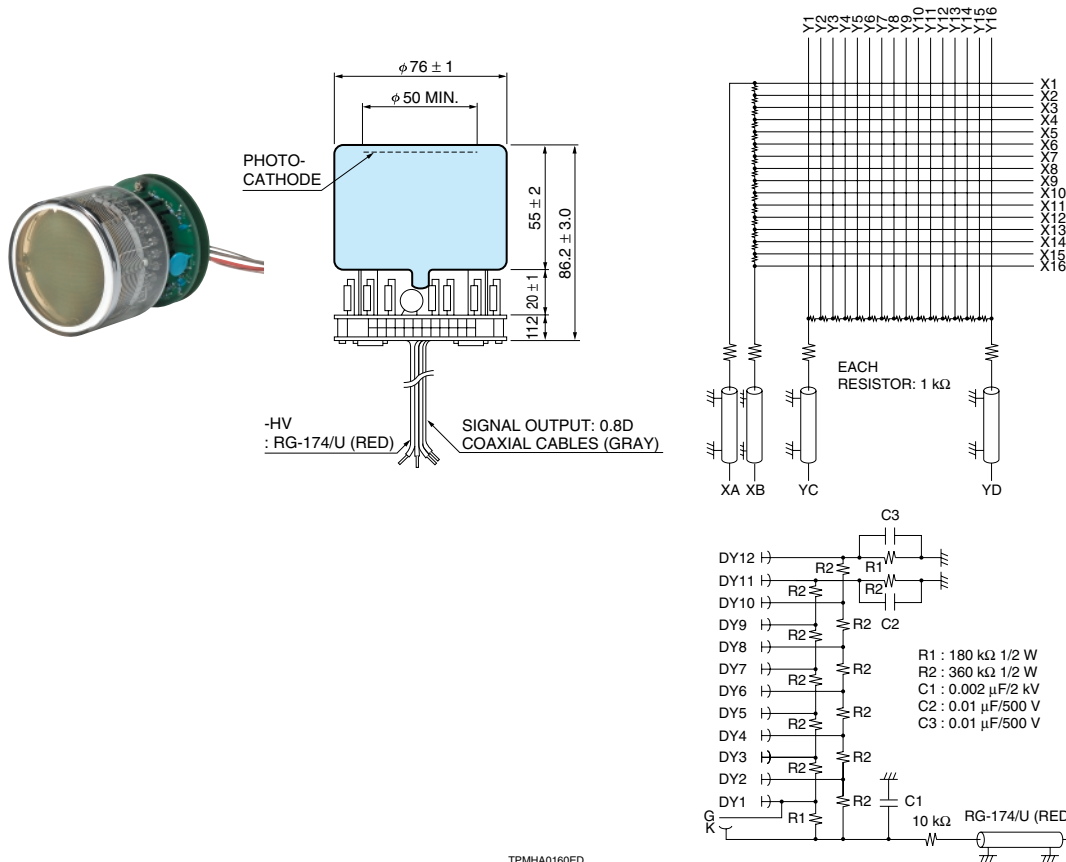
Spectral Response													Remarks				Max. Ratings					
Type No.	Effective Area (mm)												Spectral Response Range (nm)	Peak Wave-length (nm)	Photo-cathode Material	Window Material	Anode Matrixes	Out-line No.	Dynode Structure / Stages	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Anode to Cathode Supply Voltage (V)
	Wavelength (nm)																					
	100	200	300	400	500	600	700	800	900	1000	1100	1200										
R2486-02				φ50									300 to 650	420	BA	K	16(X) + 16(Y)	①	CM / 12	1300	0.06	1250
R3292-02				φ100									300 to 650	420	BA	K	28(X) + 28(Y)	②	CM / 12	1300	0.06	1250

Spectral Response



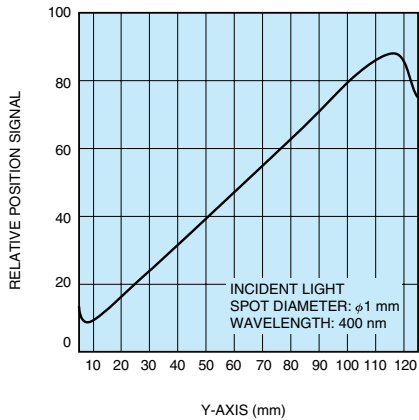
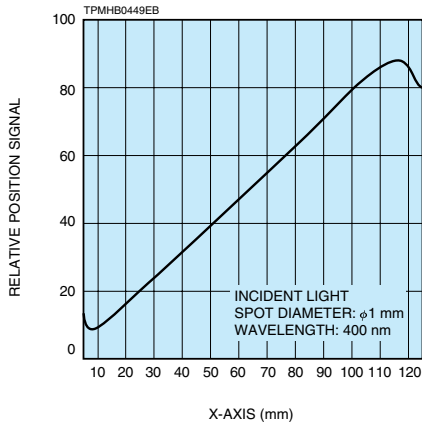
Dimensional Outlines (Unit: mm)

① R2486-02

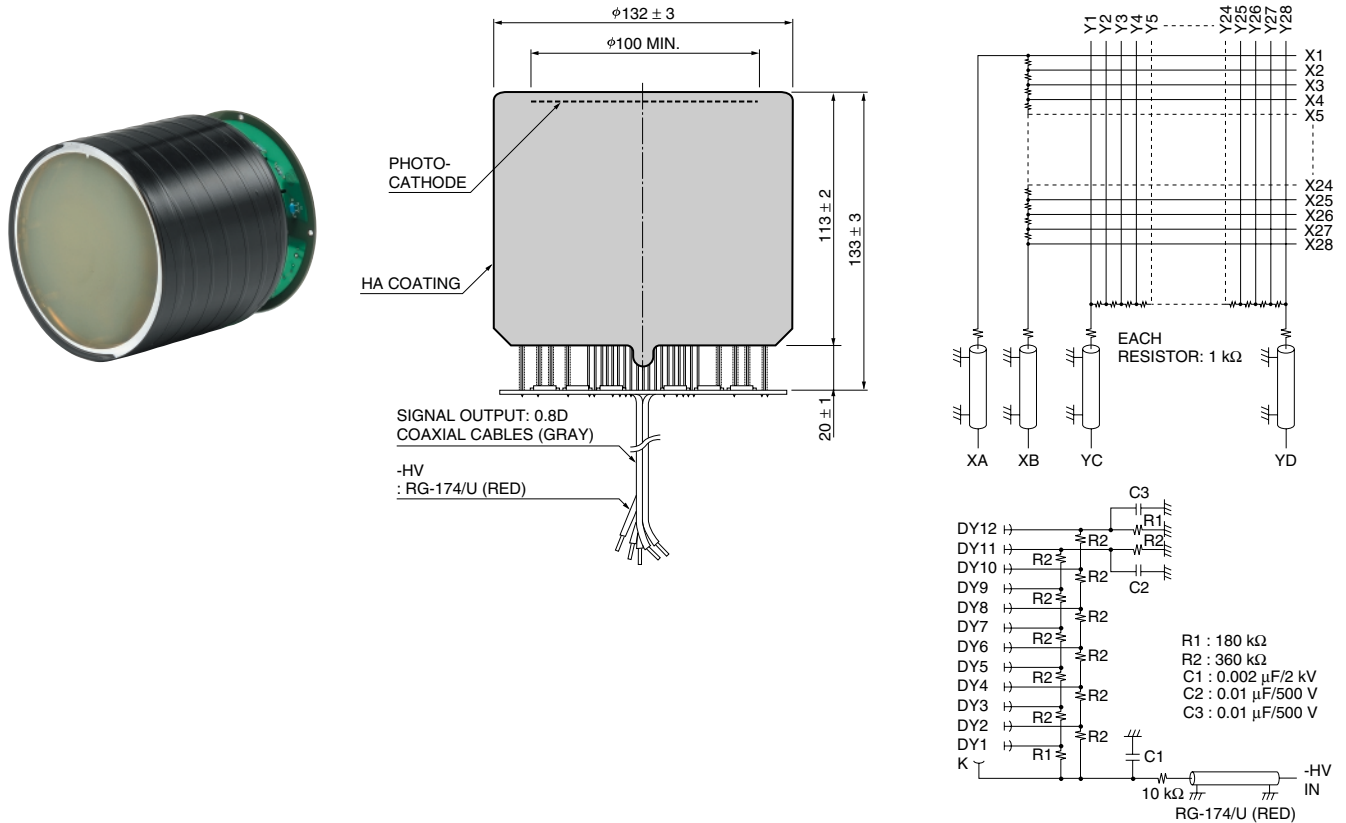


Cathode Characteristics					Anode Characteristics ^M								(at 25 °C)	
Luminous		Blue Sensitivity Index (CS 5-58) Typ.	Red / White Ratio (R-68) Typ.	Radiant ^K Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark Current (After 30 min.)		Time Response		Notes	Type No. ^A
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			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



② R3292-02



Microchannel Plate-Photomultiplier Tubes (MCP-PMTs)

Type No.	Spectral Response												Remarks					Max. Ratings ^H						
	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)	Photo-cathode Material	Window Material	Out-line No.	No. of MCP Stage	-HV Input Terminals	Signal Output Terminals	Anode to Cathode Voltage (V)	Anode Current	
																							Continuous (nA)	Pulsed Peak (mA)

Standard Types

R3809U-50	φ11		160 to 850	500S	430	MA	Q	①	2	SHV-R	SMA-R	-3400	100	350
R3809U-51	φ11		160 to 910	501S	600	EMA	Q	①	2	SHV-R	SMA-R	-3400	100	350
R3809U-52	φ11		160 to 650	403K	400	BA	Q	①	2	SHV-R	SMA-R	-3400	100	350
*R3809U-53	φ11		160 to 320	200S	230-250	Cs-Te	Q	①	2	SHV-R	SMA-R	-3400	100	350
*R3809U-61	φ10		370 to 920	602K	750-850	GaAs	K	①	2	SHV-R	SMA-R	-3400	100	350
*R3809U-63	φ10		280 to 820	601K	550-650	Extended Red GaAsP	K	①	2	SHV-R	SMA-R	-3400	100	350
*R3809U-64	φ10		280 to 720	600K	550-650	GaAsP	K	①	2	SHV-R	SMA-R	-3400	100	350

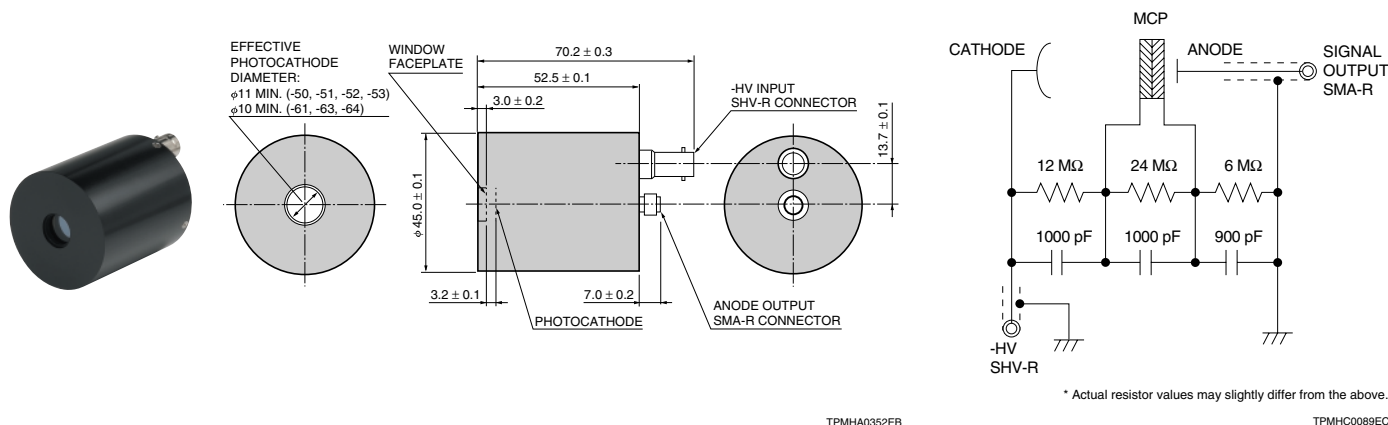
Gated Types

R5916U-50	φ10		160 to 850	500S	430	MA	Q	②	2	SHV-R	SMA-R	-3400	100	350
R5916U-51	φ10		160 to 910	501S	600	EMA	Q	②	2	SHV-R	SMA-R	-3400	100	350
R5916U-52	φ10		160 to 650	403K	400	BA	Q	②	2	SHV-R	SMA-R	-3400	100	350
*R5916U-53	φ10		160 to 320	200S	230-250	Cs-Te	Q	②	2	SHV-R	SMA-R	-3400	100	350

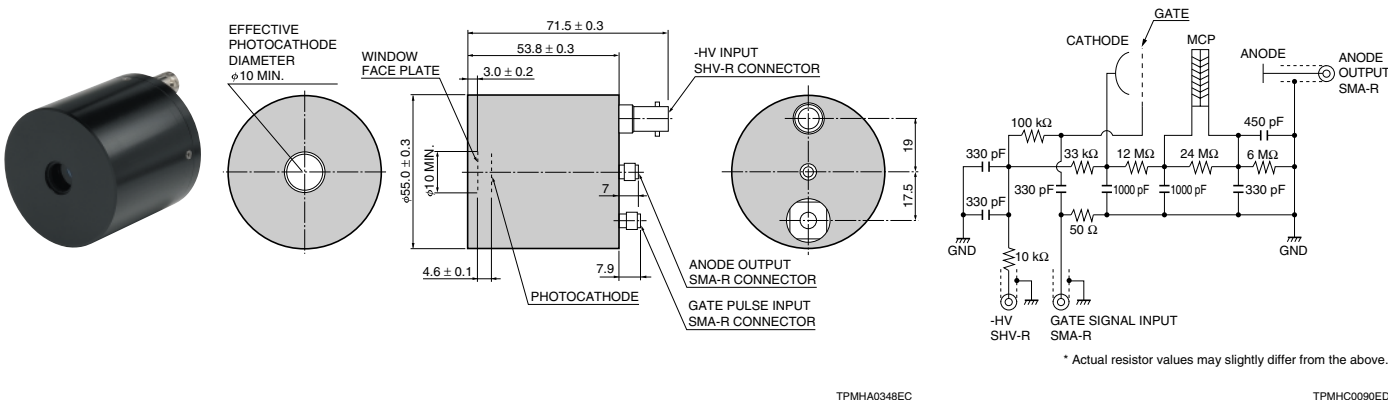
The R5916 series can be gated by input of a +10 V to +50 V gate signal. Standard types are normally OFF, but normally ON types are also available. Gate operation is 5 ns, though this depends on the gate signal input pulse.

Dimensional Outlines (Unit: mm)

① R3809U Series

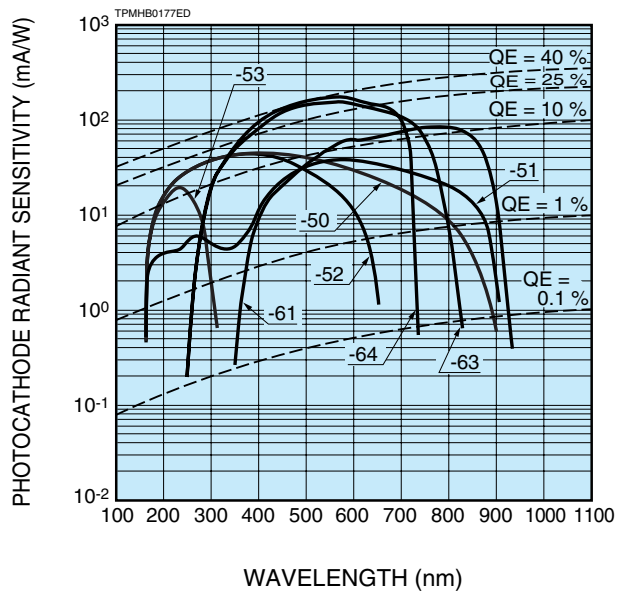


② R5916U Series

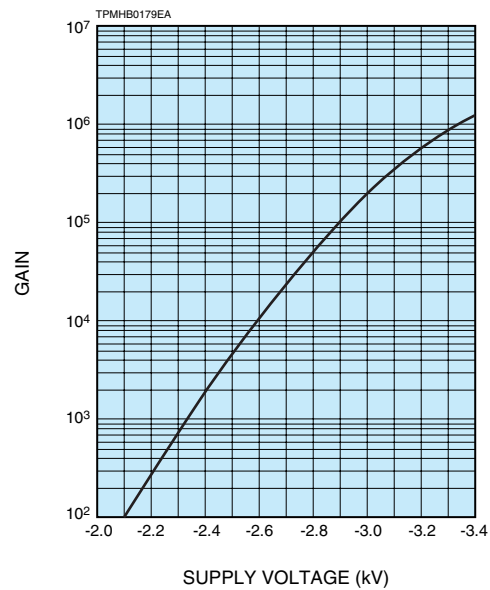


Cathode Characteristics			Anode Characteristics ^M							(at 25 °C)	
Anode to Cathode Supply Voltage (V)	Luminous		Radiant ^K	Luminous	Gain	Dark Current (After 30 min.) Max. (nA)	Time Response			Notes	Type No. ^A
	Min. (μA/lm)	Typ. (μA/lm)	Typ. (mA/W)	Typ. (A/lm)	Typ.		Rise Time Typ. (ns)	Transit Time Typ. (ns)	Transit Time Spread Typ. (ns)		
-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	85	140	2.0×10^5	25	0.2	0.55	0.15		R3809U-61*
-3000	450	750	160	150	2.0×10^5	8	0.18	0.55	0.06		R3809U-63*
-3000	400	700	180	140	2.0×10^5	8	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



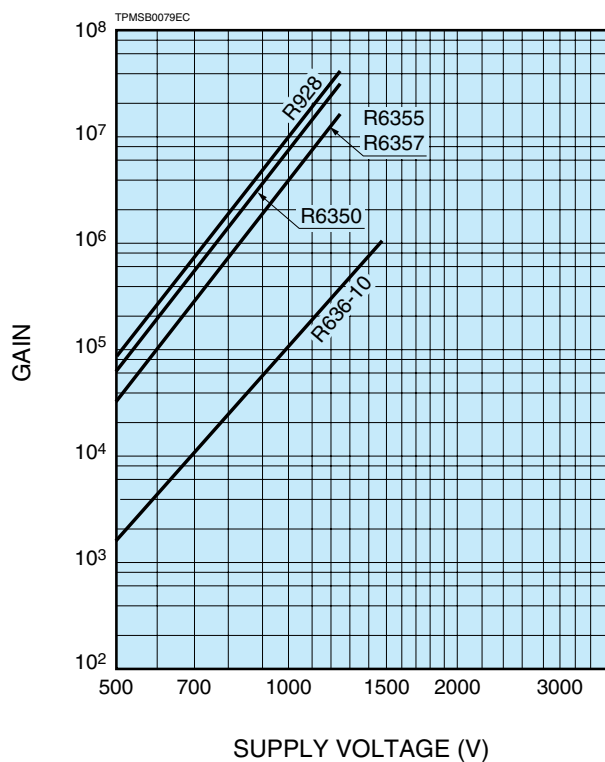
■ Gain



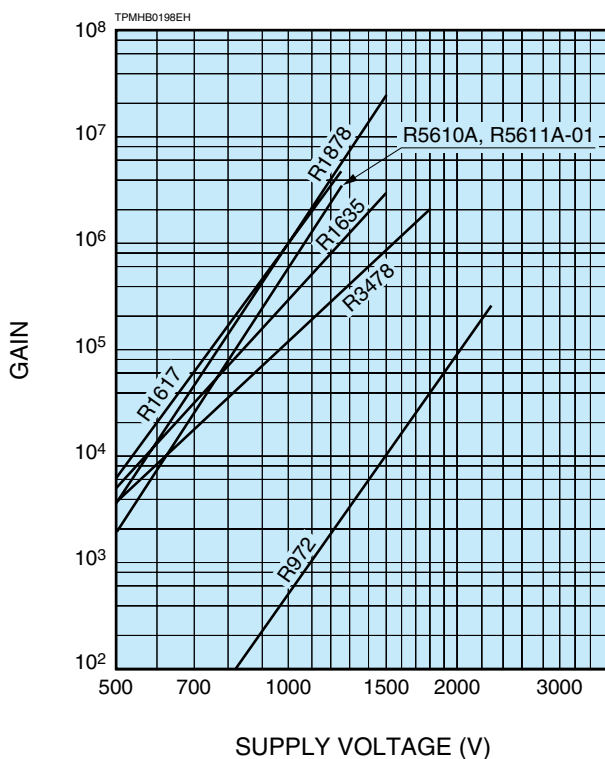
Gain Characteristics

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

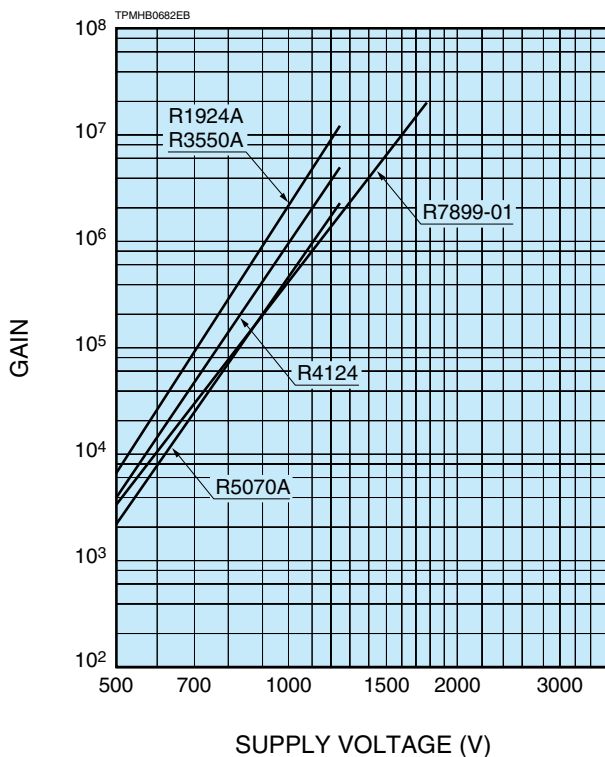
Side-on Types



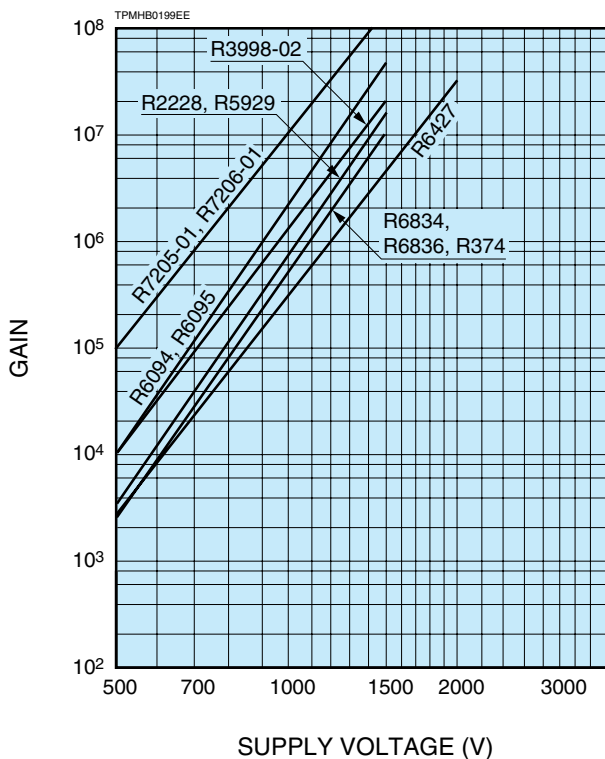
Head-on Types (10 mm and 19 mm Dia.)



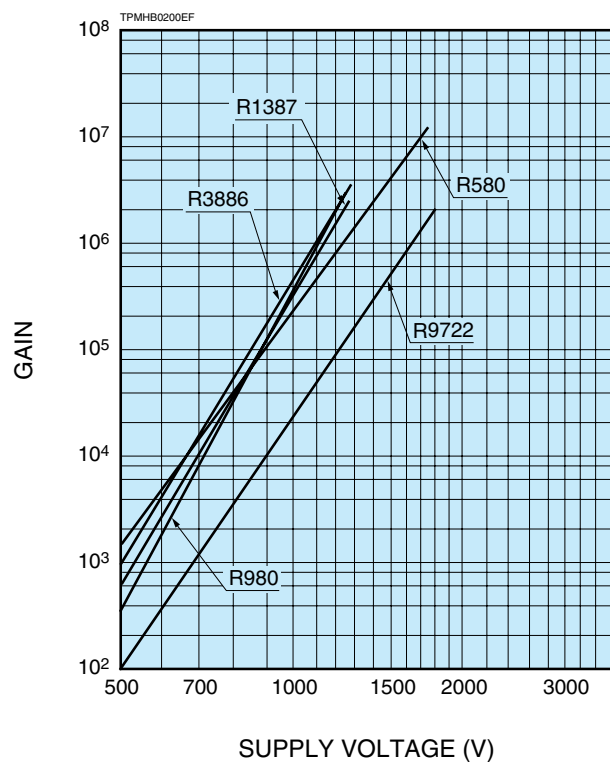
Head-on Types (13 mm and 25 mm Dia.)



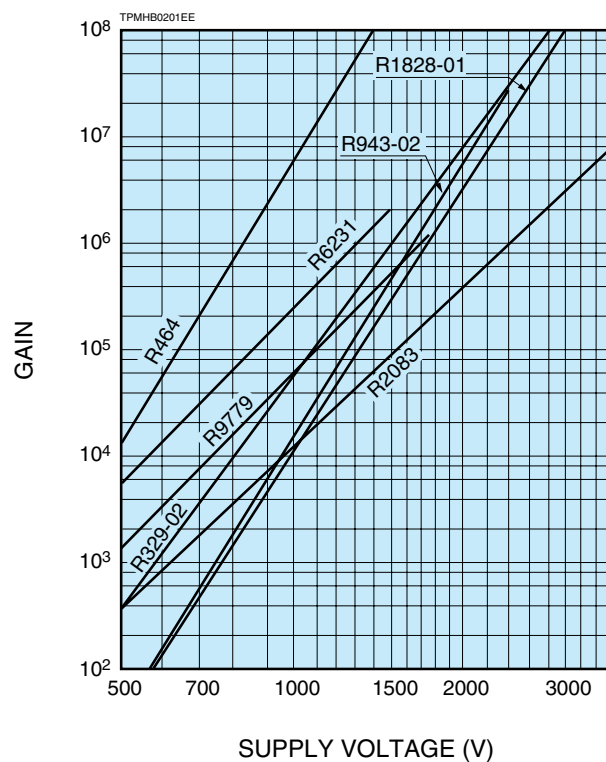
Head-on Types (28 mm Dia.)



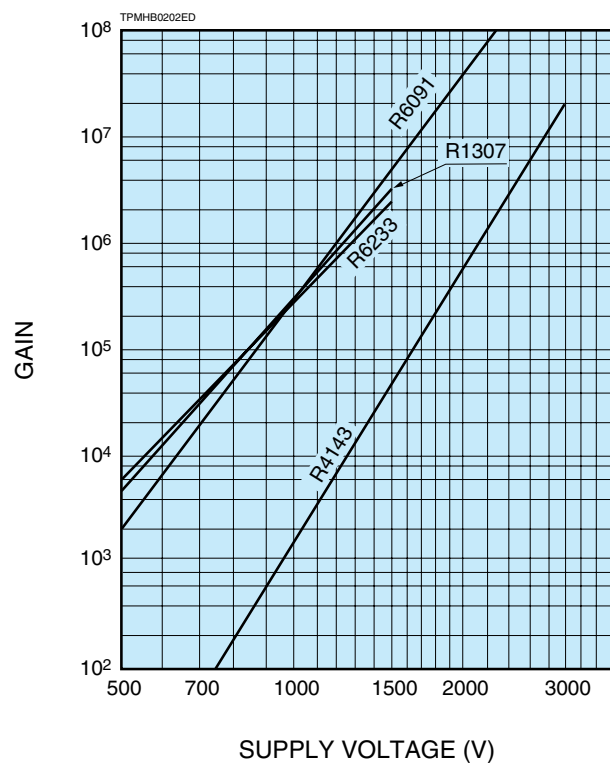
Head-on Types (38 mm Dia.)



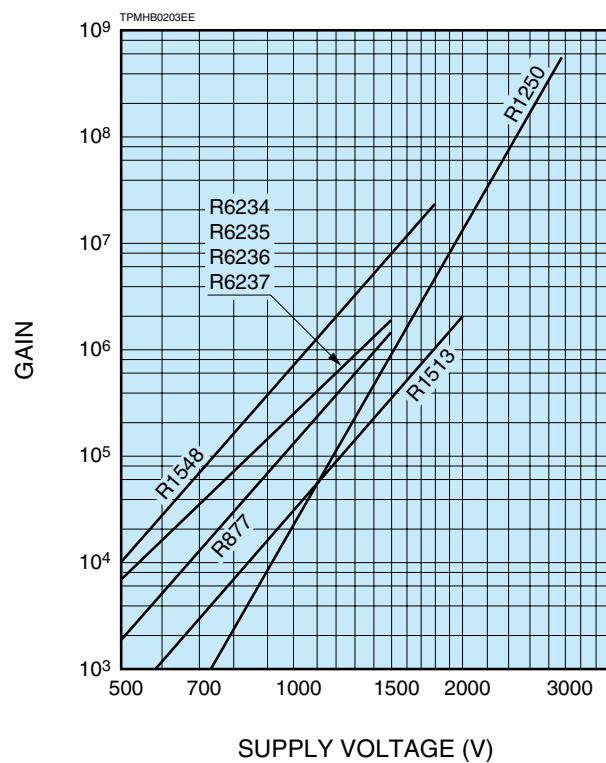
Head-on Types (51 mm Dia.)



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.

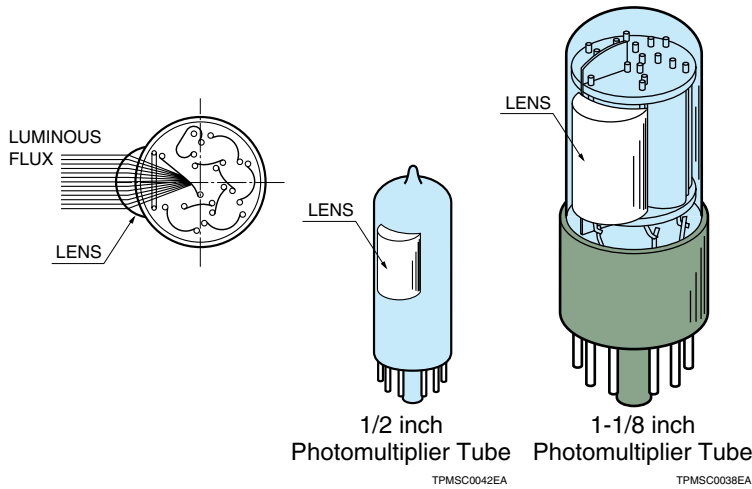
Distribution Ratio Codes	Number of Stage	Voltage Distribution Ratio																	
		K: Photocathode Dy: Dynode P: Anode G: Grid F: Focus																	
① ② ③ ④ ⑤ ⑥ ⑦ ⑧	8	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Acc	Dy7	Dy8	P						
		2	—	2	1	1	1	1	1	—	1	1							
		1	1	1	1	1	1	1	1	—	1	1							
		1.3	4.8	1.2	1.8	1	1	1	1	0.5	3	2.5							
		3	—	1.5	1.5	1	1	1	1	—	1	1							
		7	—	1	1.5	1	1	1	1	—	1	1							
		2	2	1	1	1	1	1	1	—	1	1							
		1	—	1	1	1	1	1	1	—	1	0.5							
		0.4	1.8	2	2	1	1	1	1	—	1	1							
⑨ ⑩	9	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	P						
		1	—	1	1	1	1	1	1	1	1	1							
		3	1	1	1	1	1	1.5	1	1	1	1							
⑪ ⑫ ⑬ ⑭ ⑮ ⑯ ⑰ ⑱ ⑲ ⑳ ㉑ ㉒ ㉓	10	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P					
		1	—	1	1	1	1	1	1	1	1	1	1	1					
		1	1	1	1	1	1	1	1	1	1	1	1	1					
		1.5	—	1	1	1	1	1	1	1	1	1	1	1					
		2	—	1	1	1	1	1	1	1	1	1	1	1					
		2	—	1	1.5	1	1	1	1	1	1	1	1	0.75					
		3	—	1	1	1	1	1	1	1	1	1	1	1					
		3	—	1	1.5	1	1	1	1	1	1	1	1	1					
		3	—	1.5	1	1	1	1	1	1	1	1	1	1					
		4	—	1	1.5	1	1	1	1	1	1	1	1	1					
		1.3	4.8	1.2	1.8	1	1	1	1	1	1	1.5	3	2.5 (Note 1)					
		1.5	—	1.5	1.5	1	1	1	1	1	1	1	1	0.5					
		1.5	—	1.5	1.5	1	1	1	1	1	1	1	1	1					
		0.5	1.5	2	1	1	1	1	1	1	1	1	1	0.5					
㉔ ㉕ ㉖	11	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	P				
		1	—	1	1	1	1	1	1	1	1	1	1	1	1				
		0.5	1.5	2	1	1	1	1	1	1	1	1	1	1	0.5				
		2	—	1	1	1	1	1	1	1	1	1	1	1	1				
㉗ ㉘ ㉙ ㉚ ㉛ ㉜ ㉝ ㉞	12	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	P			
		1.2	2.8	1.2	1.8	1	1	1	1	1	1	1	1.5	1.5	3	2.5			
		4	0	1	1.4	1	1	1	1	1	1	1	1	1	1	1 (Note 2)			
		4	0	2.5	1.5	1	1	1	1	1	1	1	1	1	1	1			
		1	3	1.2	1.8	1	1	1	1	1	1	1	1.5	1.5	3	2.5			
		4	0	1.2	1.8	1	1	1	1	1	1	1	1	1	1	1			
		1	—	1	1	1	1	1	1	1	1	1	1	1	1	1			
		0.6	1.8	2.4	1	1	1	1	1	1	1	1	1	1	1	1			
㉟	14	K	G1	G2	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	Dy13	Dy14	P
		2.5	7.5	0	1.2	1.8	1	1	1	1	1	1	1	1	1	1	1.5	1.5	3
㊱	15	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	Dy13	Dy14	Dy15	P	
		2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
㊲	19	K	Dy1	Dy2	Dy3	.	.	.	.	.	.	.	.	.	.	Dy17	Dy18	Dy19	P
		2	1	1	1	.	.	.	.	.	.	.	.	.	.	1	1	1	1

Note 1: Please connect ACC of R5496 to Dy7.

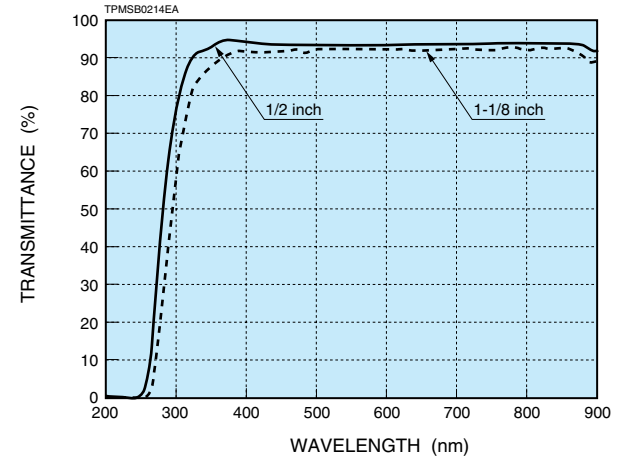
Note 2: The shield pin should be connected to Dy5.

Lens for Side-on Type Photomultiplier Tubes

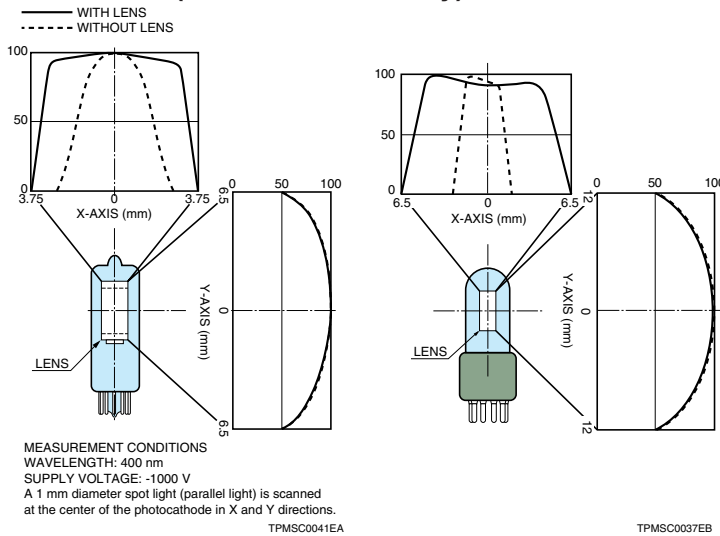
The optimized cylindrical lens which can be attached at the entrance window of 1-1/8 inch side-on photomultiplier tube. This lens helps the incident light reaches the photocathode efficiently.
With these lenses, the effective area widens by the factor of three in case of 1-1/8" PMT (13 mm width) or the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



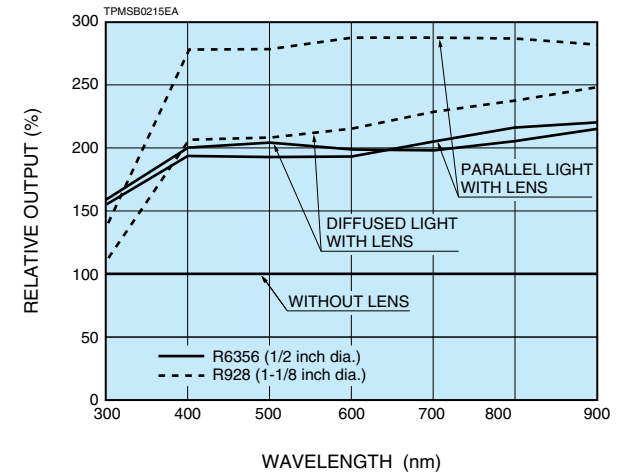
Transmittance of Lens



Lens Effect (at anode sensitivity)



Lens Effect



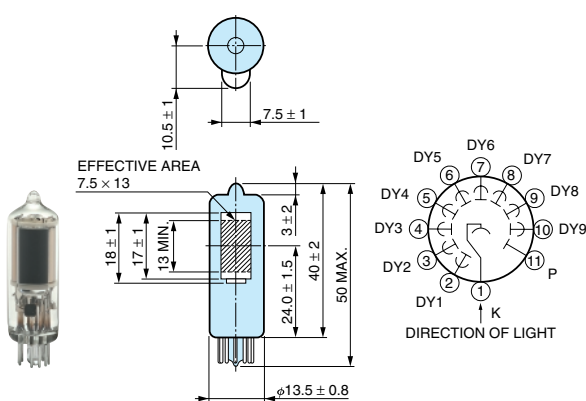
Parallel light:

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.

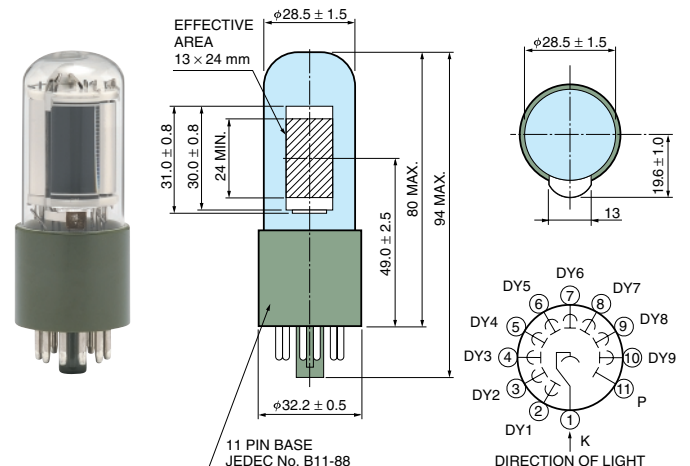
Diffused light:

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)



TPMSA0041EA

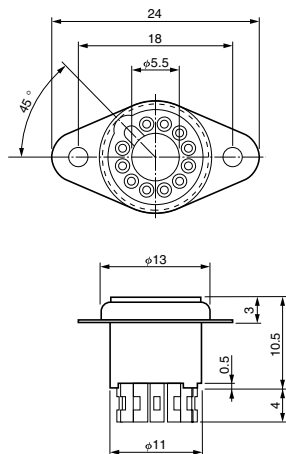


TPMSA0036EB

Photomultiplier Tube Socket

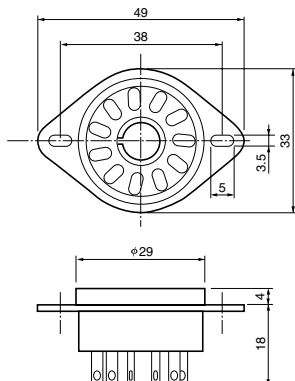
Dimensional Outline (Unit: mm)

E678-11U



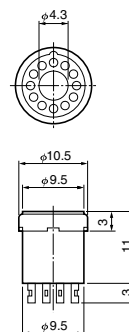
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E678-11A



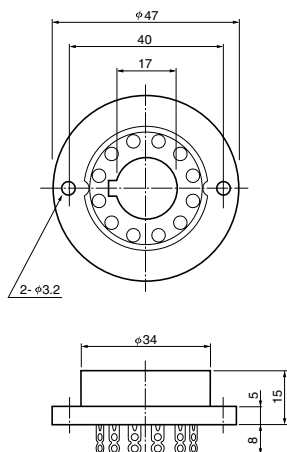
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E678-11N



TACCA0043EB

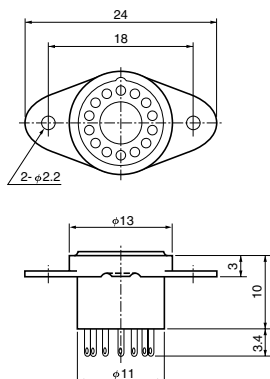
E678-12A, E678-12R*



* Gold Plating type

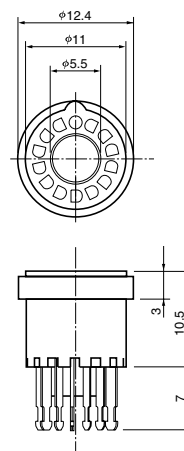
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E678-13F



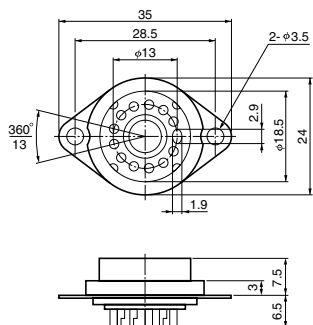
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E678-13E



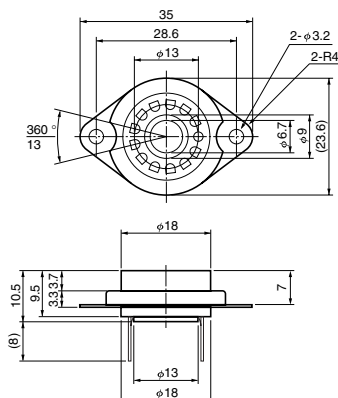
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E678-12T



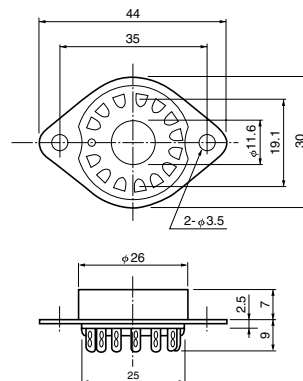
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E678-12L



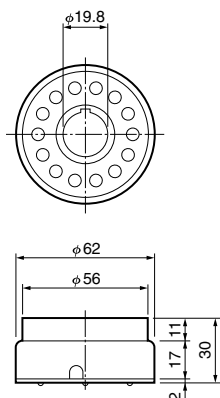
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E678-14C

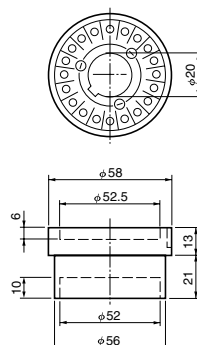


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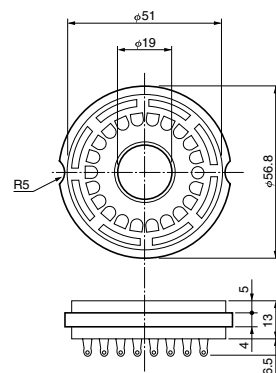
E678-14W



E678-20A

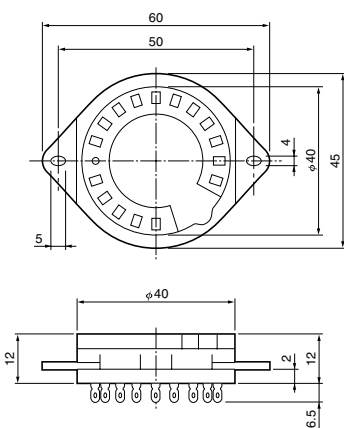


E678-21C



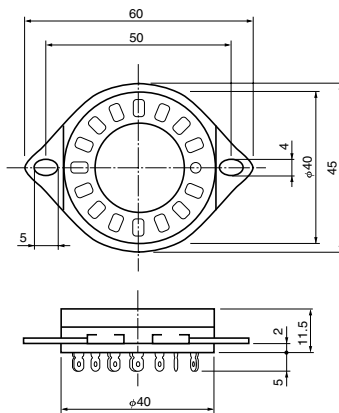
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E678-19J



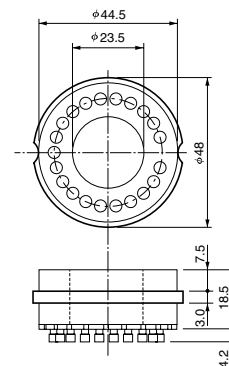
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E678-15C



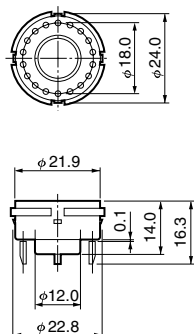
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E678-21D



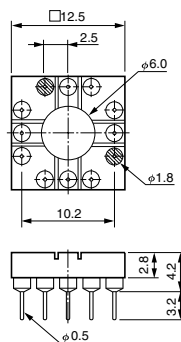
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E678-17A



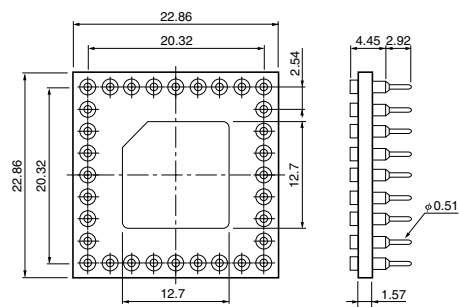
TACCA0201EA

E678-12V



TACCA0054EB

E678-32B



MATERIAL: Glass Epoxy

TACCA0046EB

TACCA0164EC

TACCA0094ED

Photomultiplier Tube Assemblies



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		Cathode Sensitivity		
								Anode to Cathode Voltage Max. (V)	Divider Current Max. (mA)	Anode to Cathode Supply Voltage (V)	Luminous Typ. ($\mu\text{A}/\text{lm}$)	Blue Sensitivity Index (CS 5-58) Typ.
H3164-10	ϕ 10.5	10 (3/8)	R1635	400K	300 to 650	①	L / 8	-1500	0.41	-1250	100	9.5
H3695-10	ϕ 11.3	10 (3/8)	R2496	400S	160 to 650	②	L / 8	-1500	0.37	-1250	100	9.5
H3165-10	ϕ 14.3	13 (1/2)	R647-01	400K	300 to 650	③	L / 10	-1250	0.34	-1000	110	10.0
H6520	ϕ 23.5	19 (3/4)	R1166	400K	300 to 650	④	L / 10	-1250	0.33	-1000	110	10.5
H6524	ϕ 23.5	19 (3/4)	R1450	400K	300 to 650	⑤	L / 10	-1800	0.43	-1500	115	11.0
H6612	ϕ 23.5	19 (3/4)	R3478	400K	300 to 650	⑥	L / 8	-1800	0.35	-1700	115	11.0
H6152-70	ϕ 31.0	25 (1)	R5505-70	—	300 to 650	⑦	FM / 15	+2300	0.41	+2000	80	9.5
H6533	ϕ 31.0	25 (1)	R4998	400K	300 to 650	⑧	L / 10	-2500	0.36	-2250	70	9.0
H7415	ϕ 33.0	28 (1-1/8)	R6427	400K	300 to 650	⑨	L / 10	-2000	0.41	-1500	95	11.0
H3178-51	ϕ 47.0	38 (1-1/2)	R580	400K	300 to 650	⑩	L / 10	-1750	0.63	-1500	95	11.0
H8409-70	ϕ 38.0	38 (1-1/2)	R7761-70	—	300 to 650	⑪	FM / 19	+2300	0.33	+2000	80	9.5
H1949-51	ϕ 60.0	51 (2)	R1828-01	400K	300 to 650	⑫	L / 12	-3000	0.70	-2500	90	10.5
H6410	ϕ 60.0	51 (2)	R329-02	400K	300 to 650	⑬	L / 12	-2700	0.67	-2000	90	10.5
H7195	ϕ 60.0	51 (2)	R329-02	400K	300 to 650	⑭	L / 12	-2700	1.23	-2000	90	10.5
H2431-50	ϕ 60.0	51 (2)	R2083	400K	300 to 650	⑮	L / 8	-3500	0.61	-3000	80	10.0
H6614-70	ϕ 60.0	51 (2)	R5924-70	—	300 to 650	⑯	FM / 19	+2300	0.33	+2000	70	9.0
H6559	ϕ 83.0	76 (3)	R6091	400K	300 to 650	⑰	L / 12	-2500	0.62	-2000	90	10.5
H6527	ϕ 142.0	127 (5)	R1250	400K	300 to 650	⑱	L / 14	-3000	1.02	-2000	70	9.0
H6528	ϕ 142.0	127 (5)	R1584	400U	185 to 650	⑲	L / 14	-3000	1.02	-2000	70	9.0
H9530-20	$\square$ 35 × 16	—	—	—	300 to 920	⑳	MC / 12	-1200	0.42	-1000	500	—
H8711	$\square$ 30	—	R7600-00-M16	—	300 to 650	㉑	MC / 12	-1000	0.35	-800	80	9.5
H8711-20	$\square$ 30	—	R5900-20-M16	—	300 to 920	㉒	MC / 12	-1000	0.014	-800	500	—
H7546B	$\square$ 30	—	R7600-00-M64	—	300 to 650	㉓	MC / 12	-1000	0.45	-800	80	9.5
H7546B-20	$\square$ 30	—	R5900-00-M64	—	300 to 920	㉔	MC / 12	-1000	0.023	-800	500	—
H7260-20	$\square$ 52 × 24	—	R7259-20	—	300 to 920	㉕	MC / 10	-900	0.37	-800	500	—
H8500C	$\square$ 52	—	R10551-00-M64	—	300 to 650	㉖	MC / 12	-1100	0.173	-1000	60	9.5
H9500	$\square$ 52	—	R8400-00-M256	—	300 to 650	㉗	MC / 12	-1100	0.18	-1000	60	9.5
H10515-20	$\square$ 30	—	R5900U-20-L16	—	300 to 920	㉘	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.

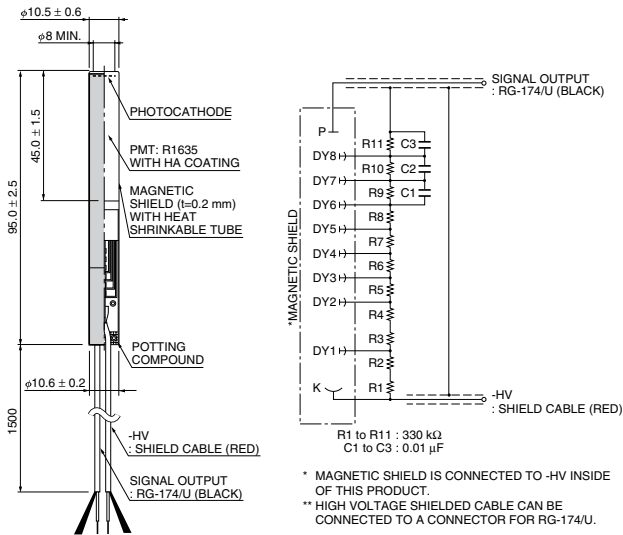
Anode Characteristics

Luminous Typ. (A/lm)	Gain Typ.	Dark Current		Time Response			Pulse Linearity		Notes	Type No.
		Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)	Transit Time Spread Typ. (ns)	2 % Typ. (mA)	5 % 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	2.5	24	1.6	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	2.0×10^7	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	2.3	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		H9530-20
280	3.5×10^6	0.8 / 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	—	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)	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
500	1.0×10^6	1 / ch	10 / ch	0.6	7.4	0.18	0.8 / ch	1 / ch	16 Linearanode	H10515-20

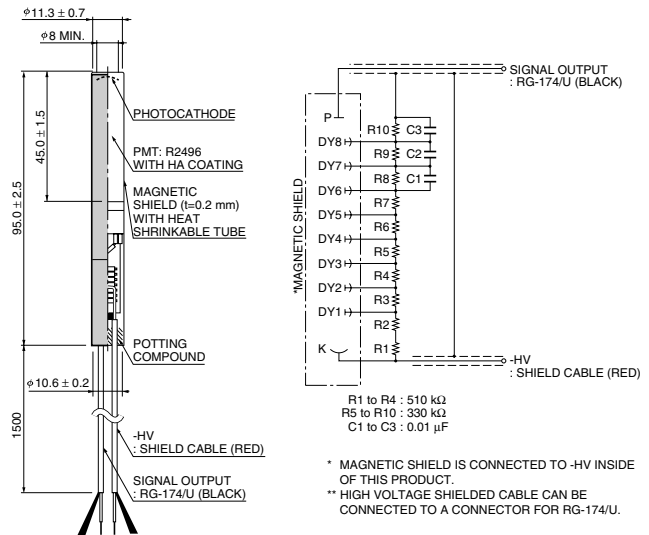
Note: * marks = 50 Ω is a terminal resistor at anode output.

Photomultiplier Tube Assemblies Dimensional Outlines and Diagrams (Unit: mm)

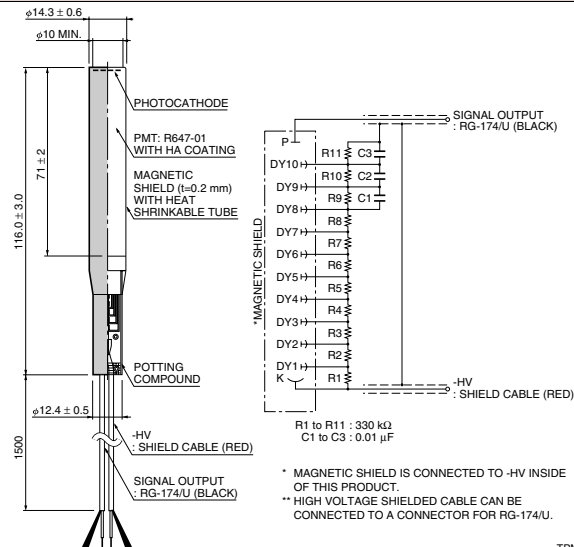
1 H3164-10



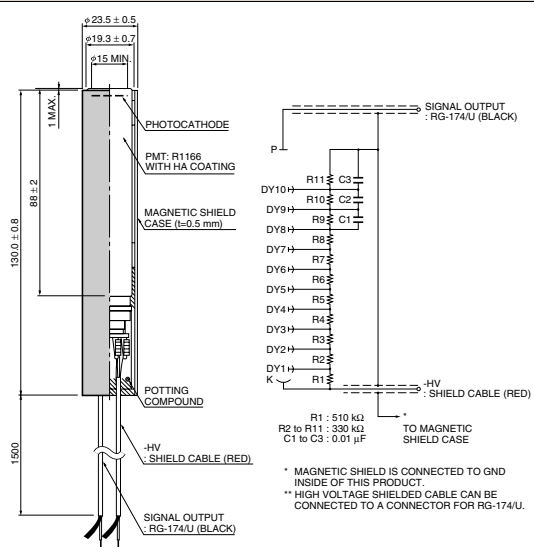
2 H3695-10



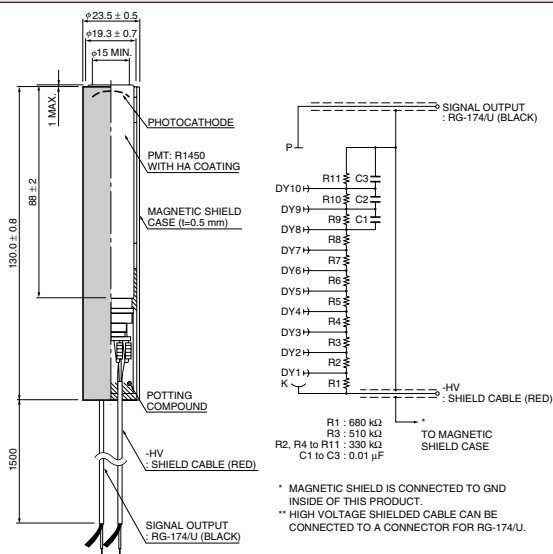
3 H3165-10



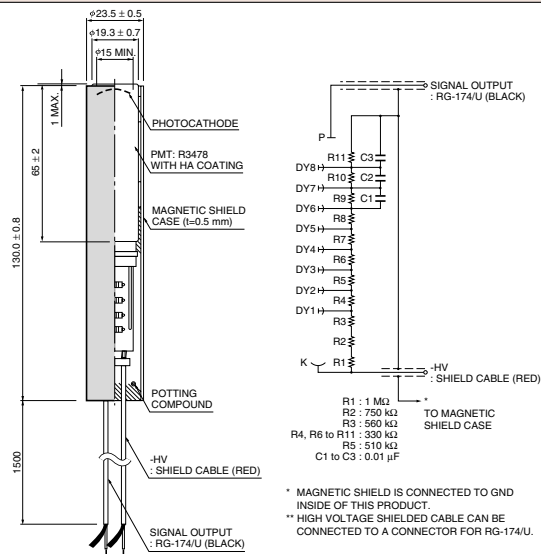
4 H6520



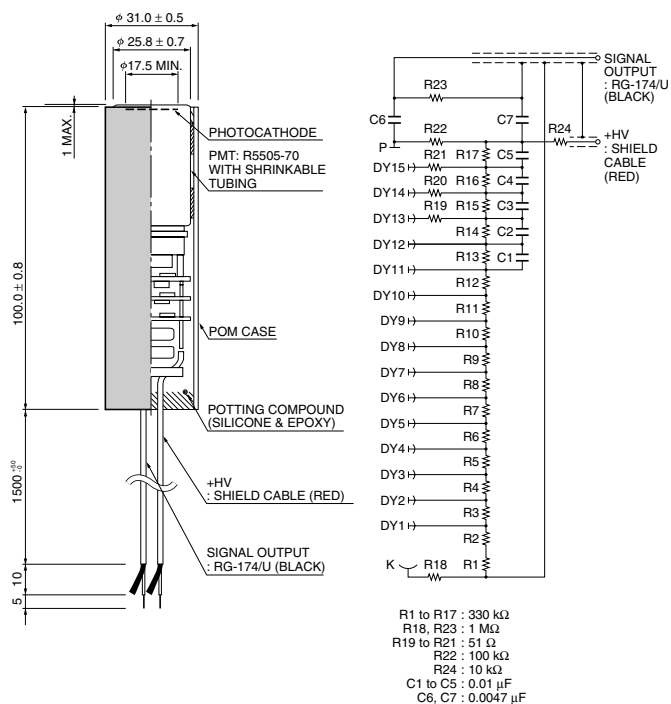
5 H6524



6 H6612



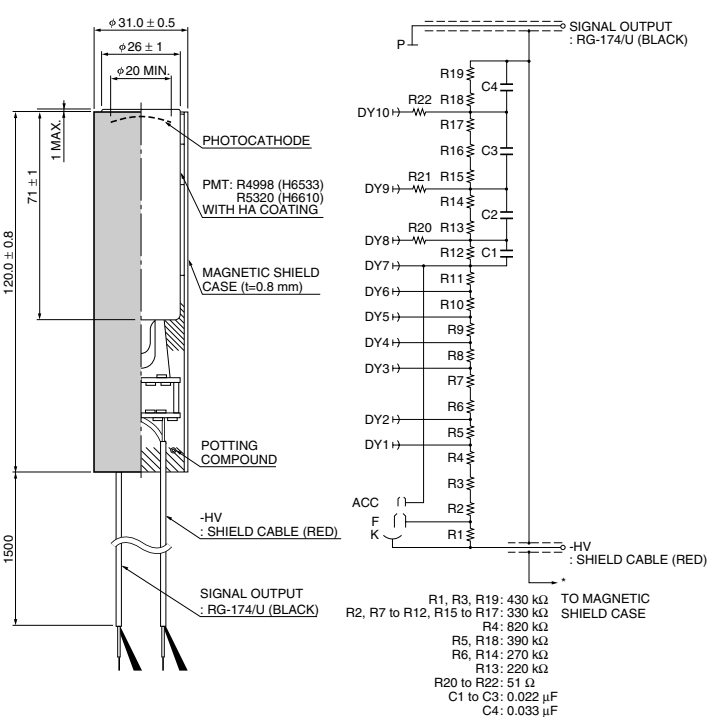
7 H6152-70



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

TPMHA0470EA

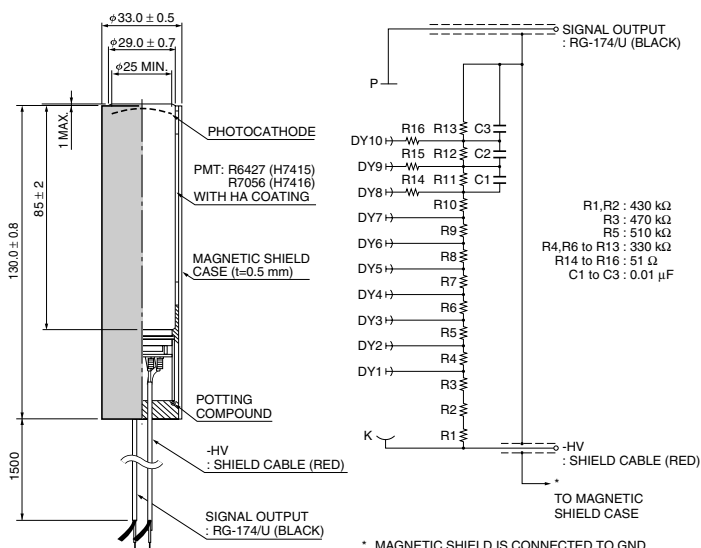
8 H6533



* 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

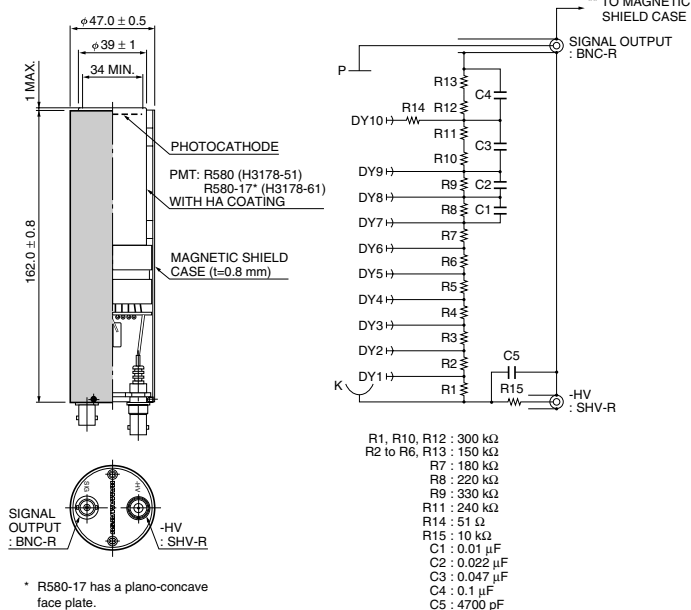
9 H7415



* 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



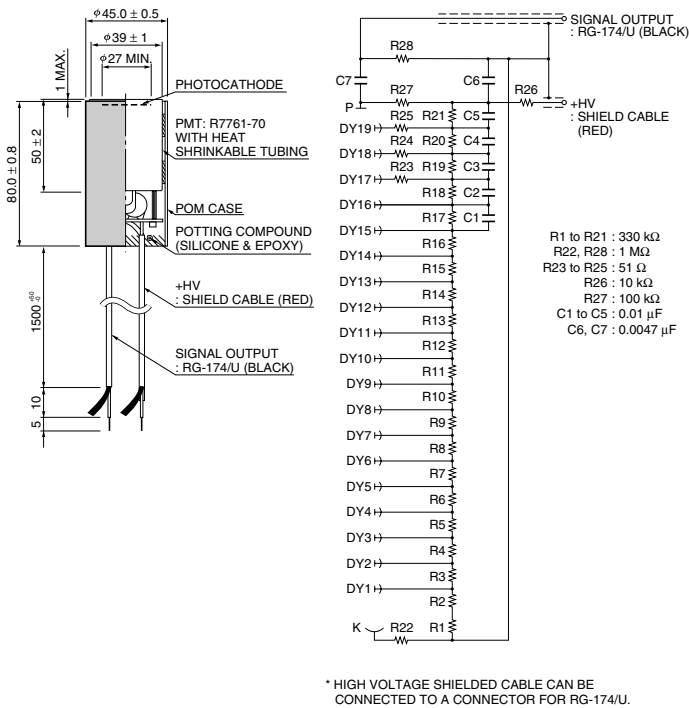
* R580-17 has a plano-concave
face plate.

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

TPMHA0320EB

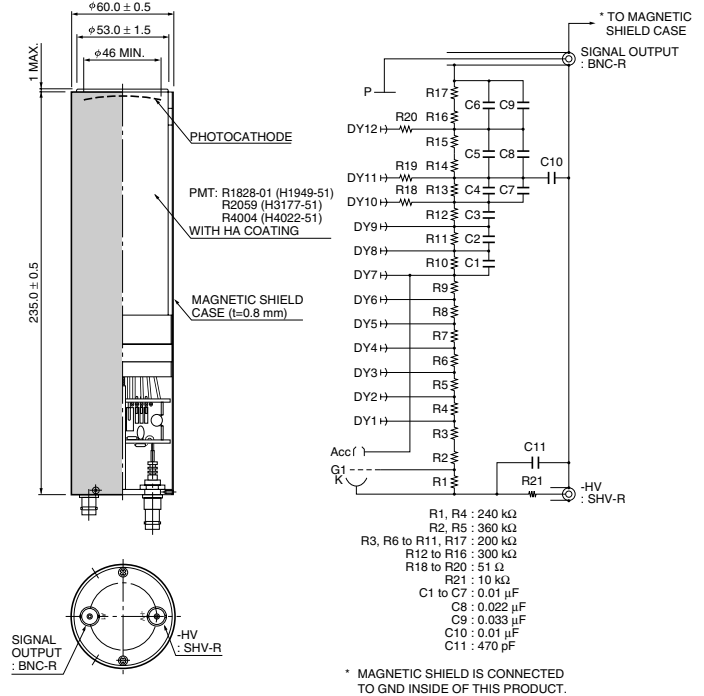
Photomultiplier Tube Assemblies Dimensional Outlines and Diagrams (Unit: mm)

11 H8409-70



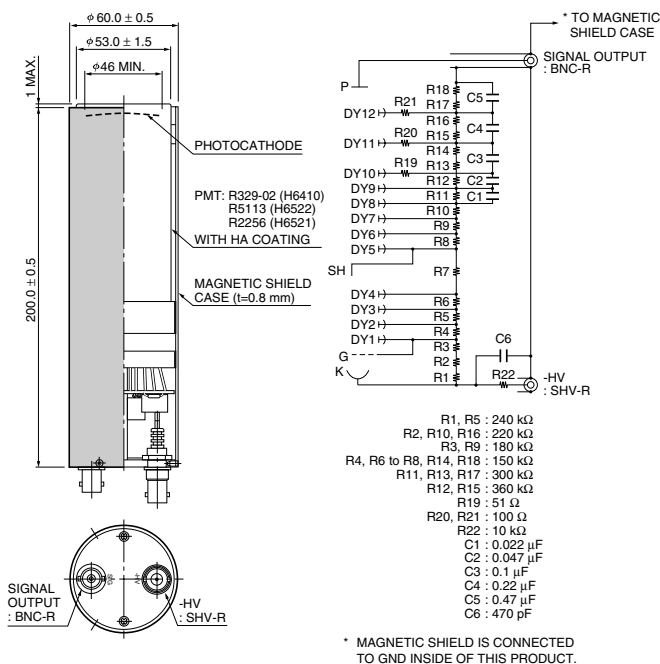
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12 H1949-51



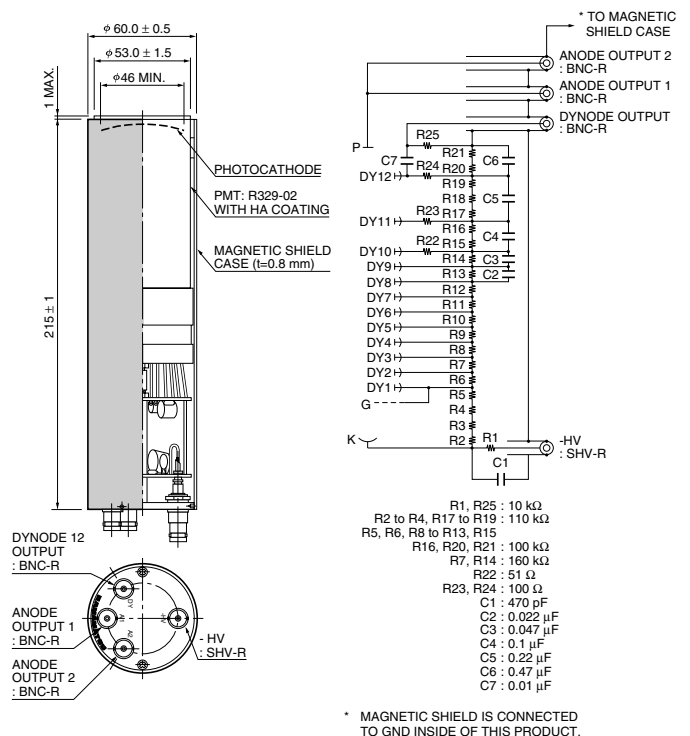
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13 H6410



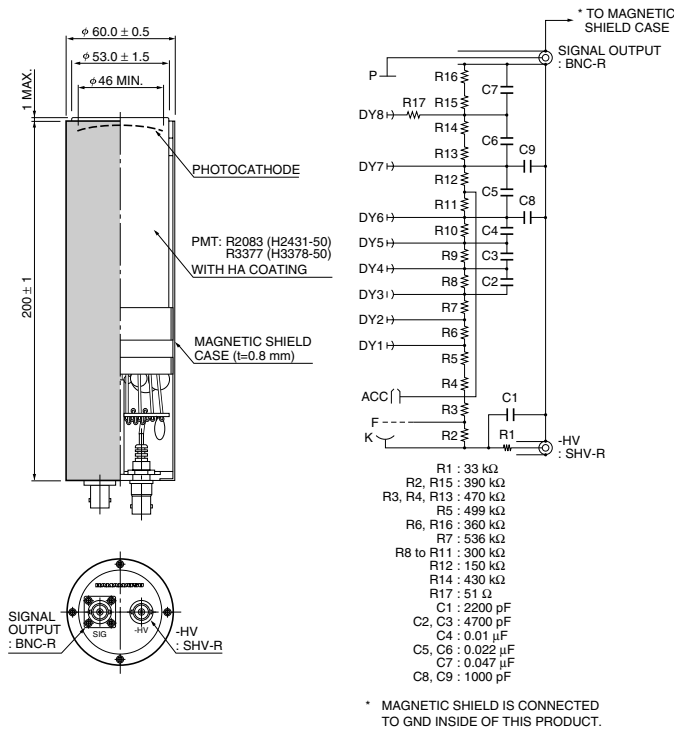
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14 H7195

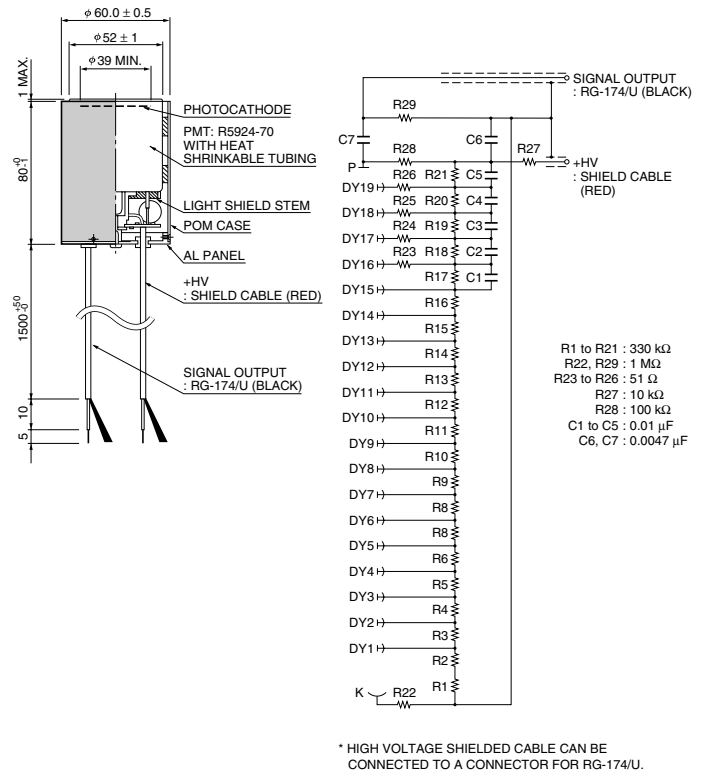


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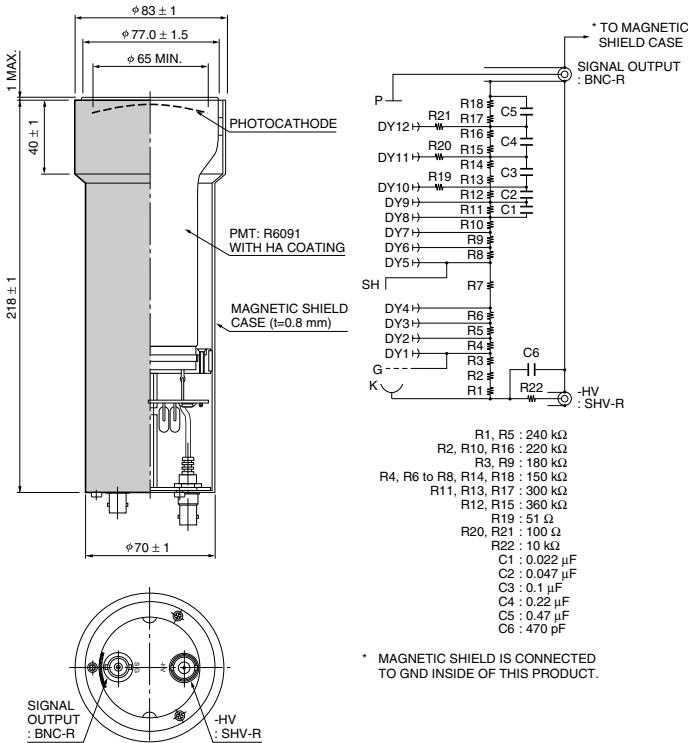
15 H2431-50



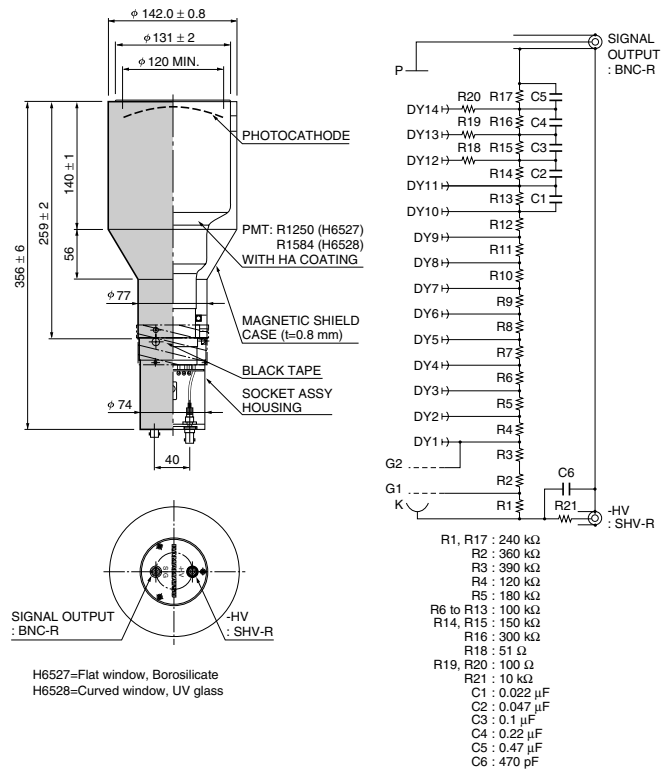
16 H6614-70



17 H6559

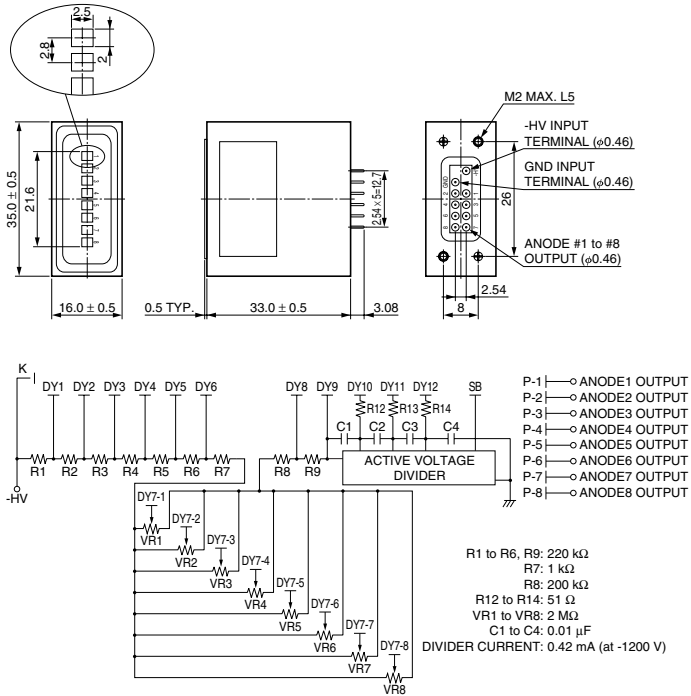


18 H6527, H6528



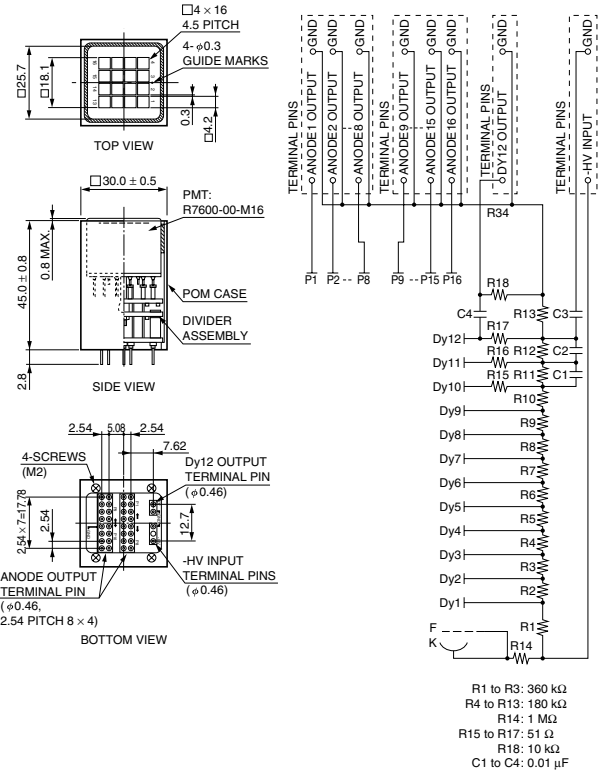
Photomultiplier Tube Assemblies Dimensional Outlines and Diagrams (Unit: mm)

19 H9530-20



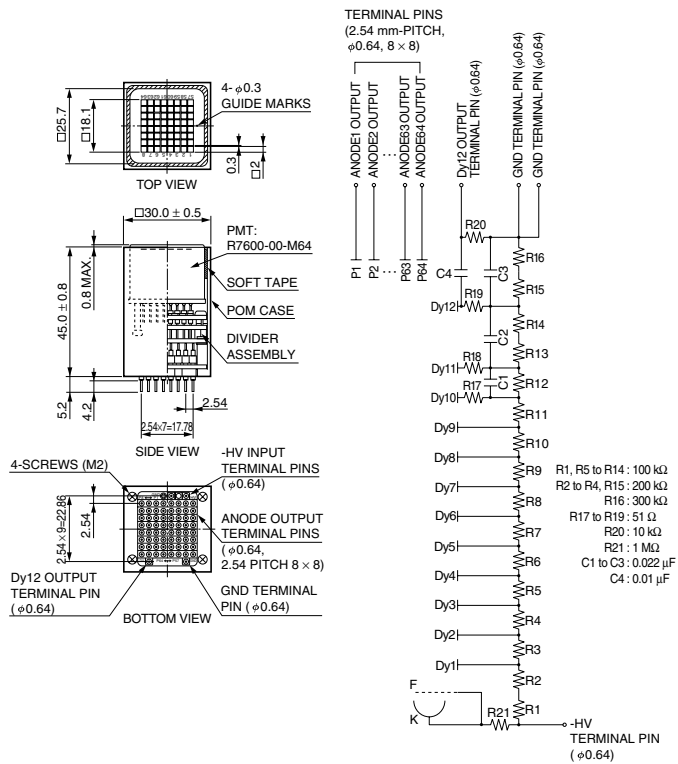
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20 H8711



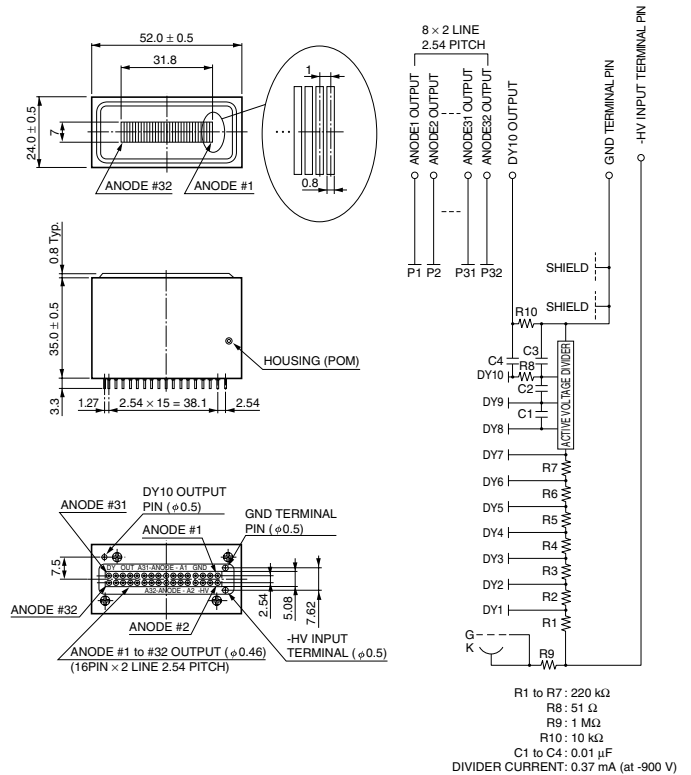
TPMHA0487EC

21 H7546B, H7546B-20



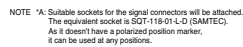
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22 H7260-20

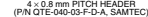


TPMHA0192EA

23 H8500C

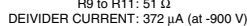


24 H9500



TPMHA0504EB

25 H10515-20



TPMHA0534JA

Photomultiplier Tube Socket Assemblies



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.

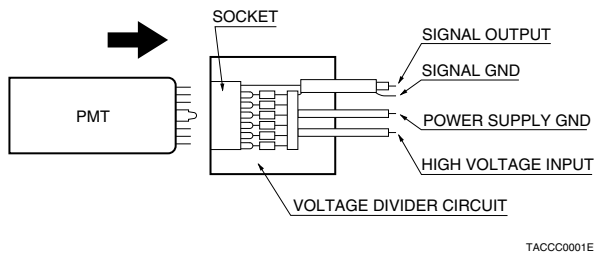
- D : Voltage Divider
- A : Amplifier
- P : High Voltage Power Supply

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 88 for the selection guide to D-type socket assemblies.

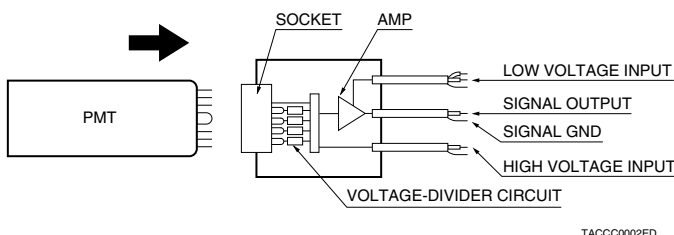
Figure 1: D-Type Socket Assembly



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.

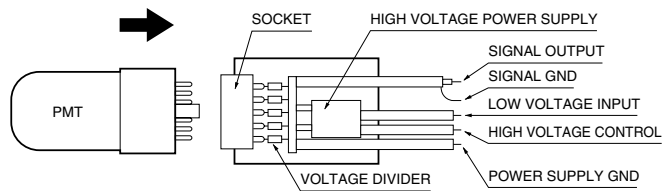
Figure 2: DA-Type Socket Assembly



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.

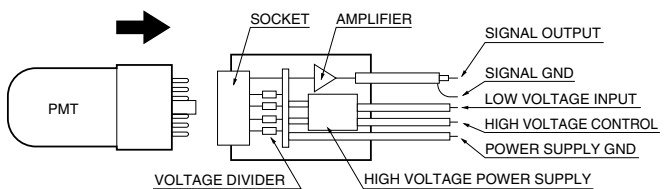
Figure 3: DP-Type Socket Assembly



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 4: DAP-Type Socket Assembly



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 5 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 5: Schematic Representation of Photomultiplier Tube Operation

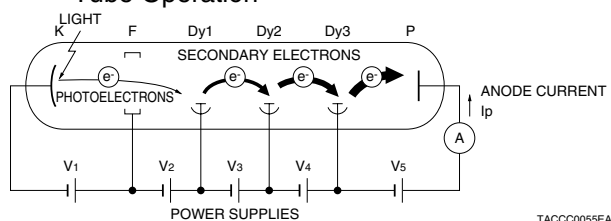
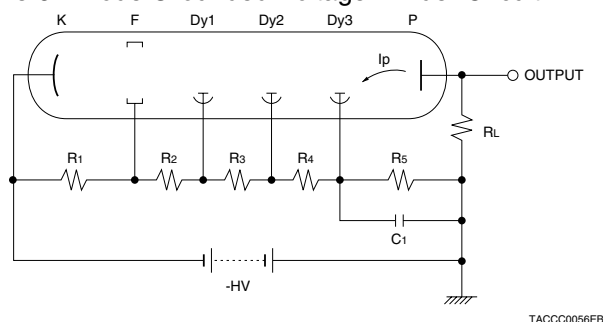


Figure 6 shows a typical voltage divider circuit using resistors, with the anode side grounded. The capacitor C_1 connected in parallel to the resistor R_5 in the circuit is called a storage capacitor and improves the output linearity when the photomultiplier tube is used in pulse operation, and not necessarily used in providing DC output. In some applications, transistors or Zener diodes may be used in place of these resistors.

Figure 6: Anode Grounded Voltage Divider Circuit

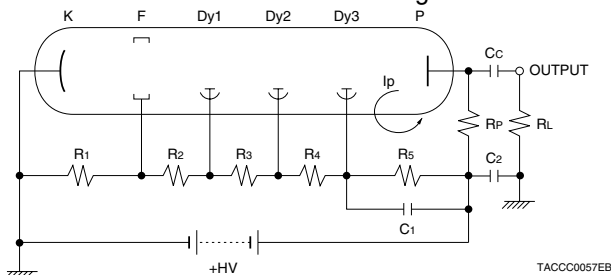


Anode Grounding and Photocathode Grounding

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 6. 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 7, 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 .

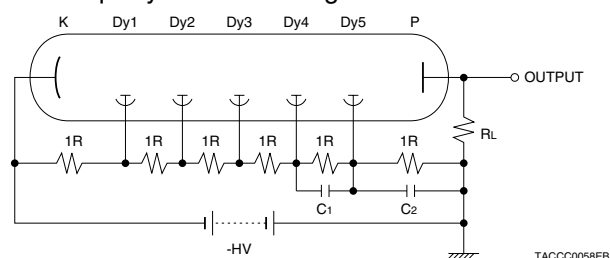
Figure 7: Photocathode Grounded Voltage Divider Circuit



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 8: 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 9. 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.

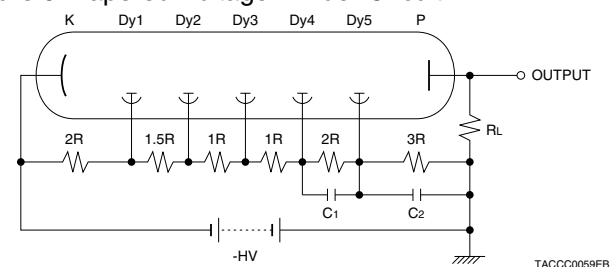
Tapered circuit at the first few stages (resistance: large $\rightarrow$ small)

- 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 $\rightarrow$ 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 9: Tapered Voltage Divider Circuit

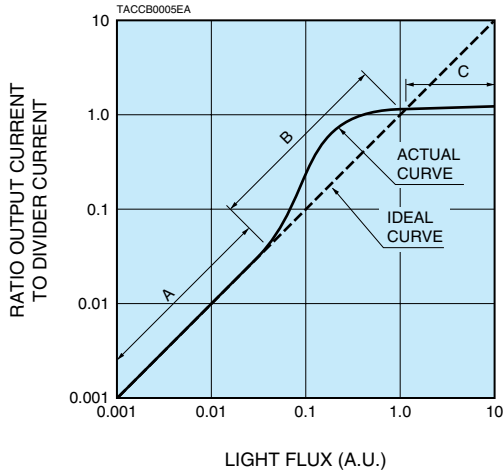


Voltage Divider Circuit and Photomultiplier Tube Output Linearity

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 10, 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.

Photomultiplier Tube Socket Assemblies

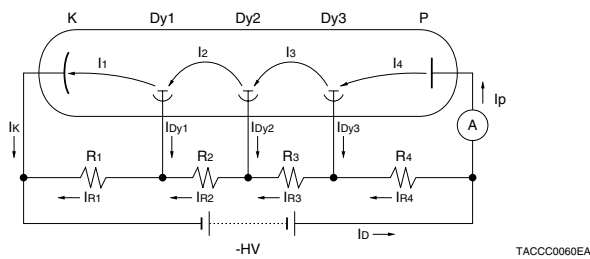
Figure 10: Output Linearity of Photomultiplier Tube



Output Linearity in DC Mode

Figure 11 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 11: 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 12 (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

$$I_1 = I_2 = I_3 = I_4 (= 0 \text{ A})$$

Electrode current of photomultiplier tube

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

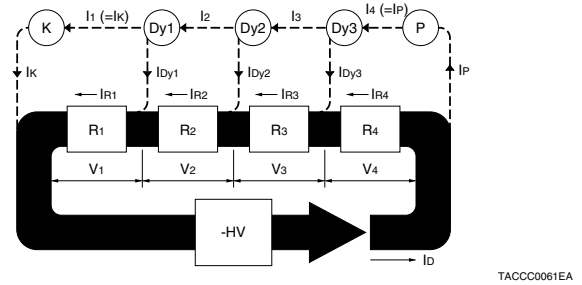
Voltage divider circuit current

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

Voltage divider circuit voltage

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

Figure 12: 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 12, the resulting currents can be considered to flow through the photomultiplier tube and the voltage divider circuit as schematically illustrated in Figure 13. 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 R_n becomes as follows:

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

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

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

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

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

Figure 13: Operation with Light Input

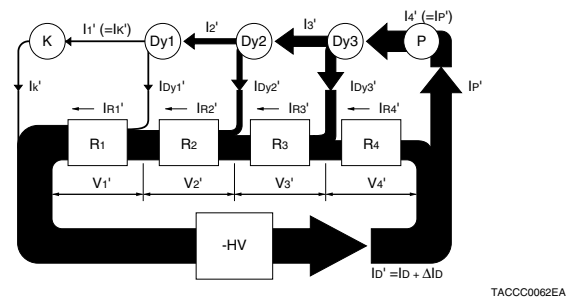
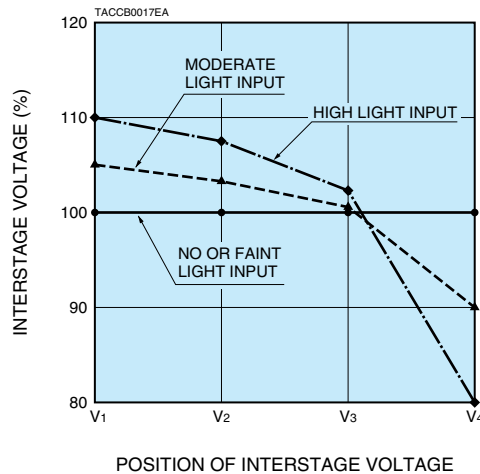


Figure 14 shows changes in the interstage voltages as the incident light level varies. The interstage voltage V_4' with light input drops significantly compared to V_4 in dark state operation. This voltage loss is redistributed to the other stages, resulting in increases in V_1' , V_2' and V_3' which 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 ($= \delta_1 \cdot \delta_2 \cdot \delta_3$). This is the cause of overlinearity in region B in Figure 10. As the incident light level further increases so that V_4' approaches 0 volts, output saturation occurs in region C.

Figure 14: Changes in Interstage Voltages at Different Incident Light Levels



Linearity Improvement in DC Output Mode

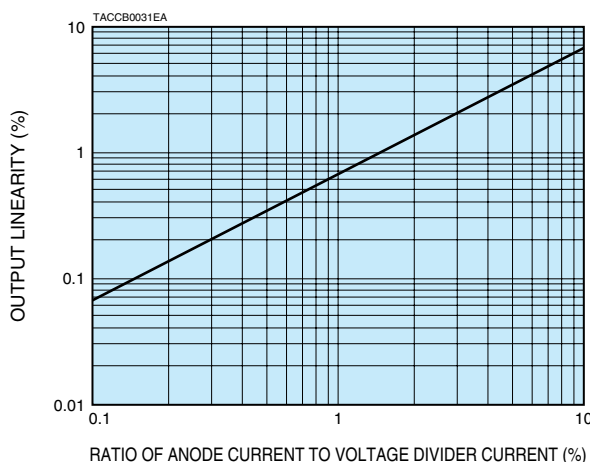
To improve the linearity in DC output mode, it is important to minimize the changes in the interstage voltage when photocurrent flows through the photomultiplier tube. There are several specific methods for improving the linearity, as discussed below.

① Increasing the voltage divider current

Figure 15 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 15: Output Linearity vs. Anode Current to Voltage Divider Current Ratio

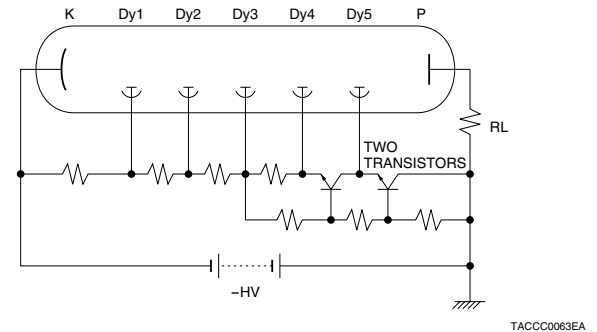


As stated above, good output linearity can be obtained simply by increasing the voltage divider current. However, this is accompanied by heat emanating from the voltage divider. If this heat is conducted to the photomultiplier tube, it may cause problems such as an increase in the dark current, and variation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

② Using 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 E6270 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 16.

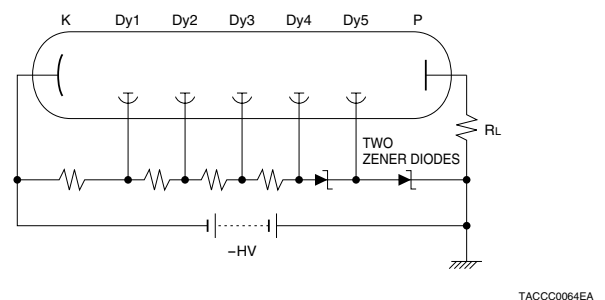
Figure 16: Active Voltage Divider Circuit



③ Using 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 17 shows a typical voltage divider circuit using Zener diodes.

Figure 17: Voltage Divider Circuit Using Zener Diodes



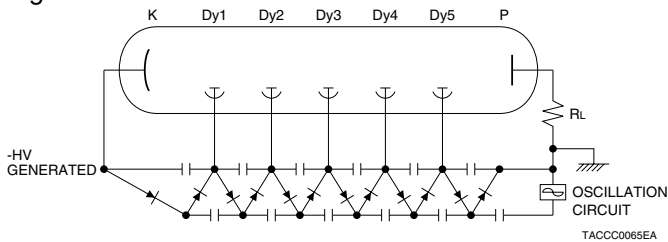
Photomultiplier Tube Socket Assemblies

④ Using Cockcroft-Walton Circuit

When a Cockcroft-Walton circuit as shown in Figure 18 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 μ A 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.

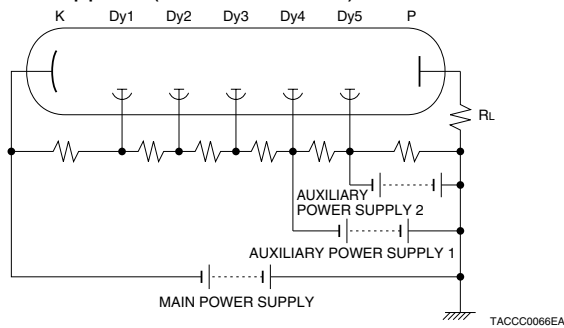
Figure 18: Cockcroft-Walton Circuit



⑤ Using multiple high voltage power supplies

As shown in Figure 19, 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 19: 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

① Using 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 20. There are two methods for connecting these storage capacitors: the serial method and the parallel method. As Figures 20 and 21 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:

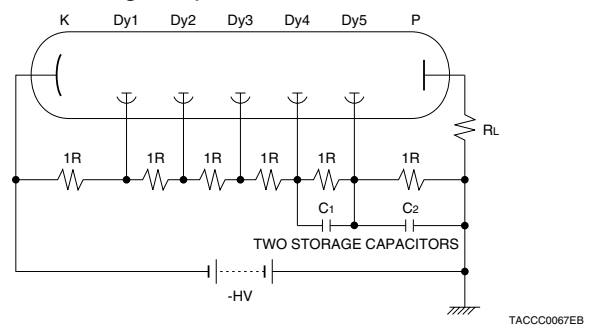
$$C > 100 \cdot Q/V$$

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 20: Equally Divided Voltage Divider Circuit and Storage Capacitors

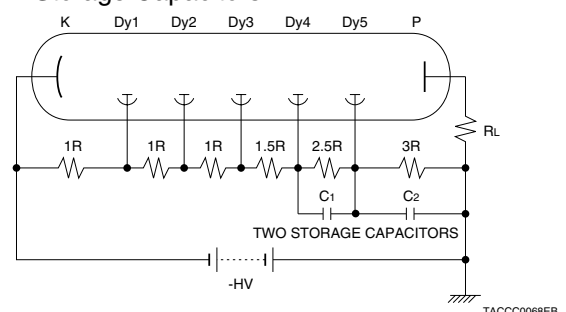


② Using tapered voltage divider circuit with storage capacitors

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 21. 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 21: 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

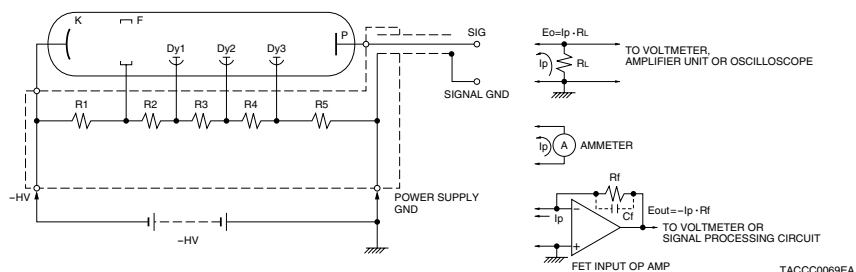
- (d) For DC or pulsed output (-HV supply), or pulsed output (+HV supply)
ex. E717-74

Connection of D-Type Socket Assemblies to External Circuits

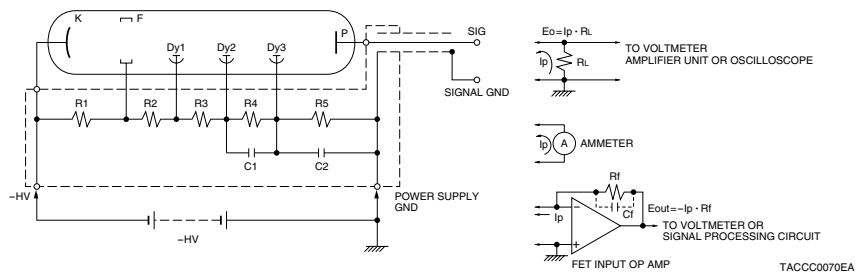
Figure 22 shows typical examples of connecting various D-type socket assemblies to external circuits.

Figure 22: Connection of D-Type Socket Assemblies to External Circuits

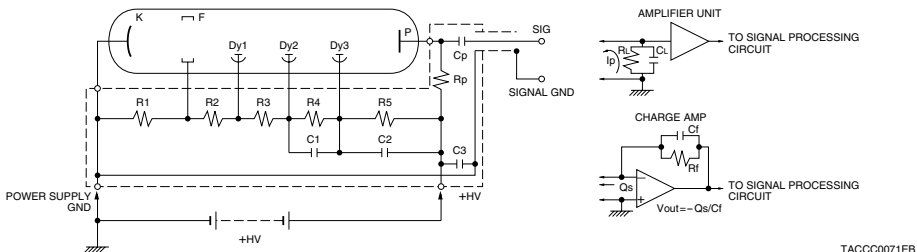
- (a) For DC output (-HV supply)



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

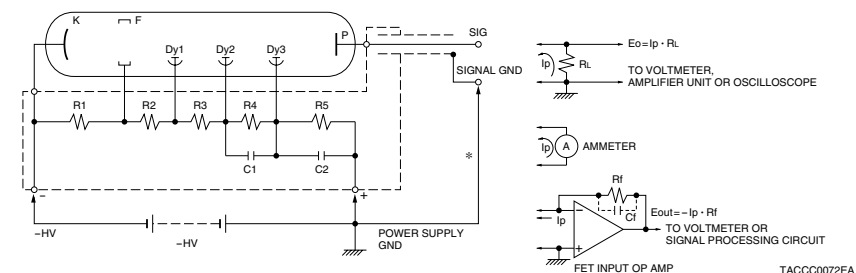


- (c) For pulsed output (+HV supply)



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

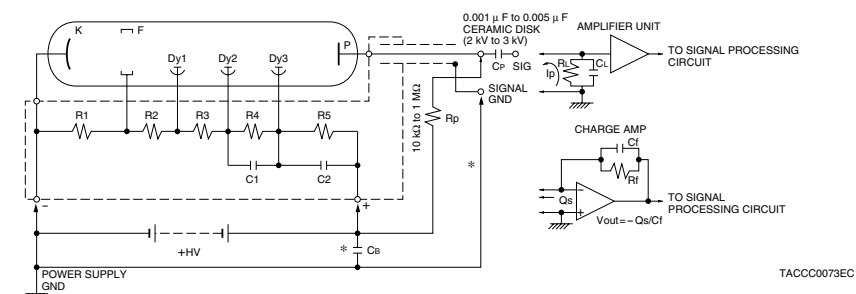
* GND should be connected externally.



- d-2. For pulsed output/+HV supply

For general scintillation counting and photon counting applications, recommended values for C_P and R_P are $0.001 \mu F$ to $0.005 \mu F$ and $10 k\Omega$ to $1 M\Omega$. 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	Out-line and Diagram	Grounded Electrode / Supply Voltage Polarity	Maximum Ratings			Leakage Current in Signal Max.	Total Voltage Divider Resistance	Maximum Linear Output in DC Mode	Signal Output	Note
				Insulation Voltage between Case and Pins (V)	Supply Voltage (V)	Voltage Divider Current (mA)					
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		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		④	Anode-Cathode / +--	1500	1500	0.45	1 × 10 ⁻¹⁰	3.30	22 (at 1500 V)	DC / Pulse	Pin output
E717-500		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		⑦	Anode / -	1500	1500	0.37	1 × 10 ⁻¹⁰	4.02	19 (at 1500 V)	DC / Pulse	For R2496, with connector
E1761-05		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		⑩	Anode / -	1500	1250	0.34	1 × 10 ⁻¹⁰	3.63	17 (at 1250 V)	DC / Pulse	E849-35, with connector
E849-68		⑪	Anode / -	1500	1250	0.27	1 × 10 ⁻¹⁰	4.48	13 (at 1250 V)	DC / Pulse	For R4124
E849-52		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		⑭	Cathode / +	1800	1800	0.47	—	3.81	—	Pulse	For Scintillation Counting
E974-17		⑮	Anode / -	1800	1800	0.47	1 × 10 ⁻¹⁰	3.81	23 (at 1800 V)	DC / Pulse	E974-13, with connector
E974-22		⑯	Anode / -	1800	1800	0.43	1 × 10 ⁻¹⁰	4.16	21 (at 1800 V)	DC / Pulse	For R1450, with connector
E2253-05		⑰	Anode / -	1800	1800	0.35	1 × 10 ⁻¹⁰	5.13	17 (at 1800 V)	DC / Pulse	For R3478, with connector
E2253-08		⑱	Cathode / +	1800	1800	0.35	—	5.13	—	Pulse	For R3478, for Scintillation Counting
E974-18		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
E2924	㉑		Anode / -	1500	1250	0.29	1 × 10 ⁻¹⁰	4.29	14 (at 1250 V)	DC / Pulse	
E2924-500	㉒		Anode / -	1500	1250	0.29	1 × 10 ⁻¹⁰	4.29	14	DC / Pulse	E2924, with connector
E2924-05	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		㉕	Cathode / +	1500	1500	0.38	—	3.96	—	Pulse	For Scintillation Counting
E990-501		㉖	Anode / -	1500	1500	0.38	1 × 10 ⁻¹⁰	3.96	18 (at 1500 V)	DC / Pulse	E990-07, with connector
E2624		㉗	Anode / -	2500	2500	0.52	1 × 10 ⁻¹⁰	4.80	26 (at 2500 V)	DC / Pulse	For R6427,
E2624-05		㉘	Cathode / +	2500	2500	0.52	—	4.80	—	Pulse	For R6427, for Scintillation Counting
E2624-14		㉙	Anode / -	2500	2500	0.52	1 × 10 ⁻¹⁰	4.80	26 (at 2500 V)	DC / Pulse	E2624, with connector

NOTE: ① Measured with the maximum supply voltage

② Measured with a supply voltage of 1000 V

③ The current at which the output linearity is kept within $\pm 5\%$

Temperature ranges of D-type socket assemblies.

Operating: 0 °C to +50 °C

Storage : -15 °C to +60 °C

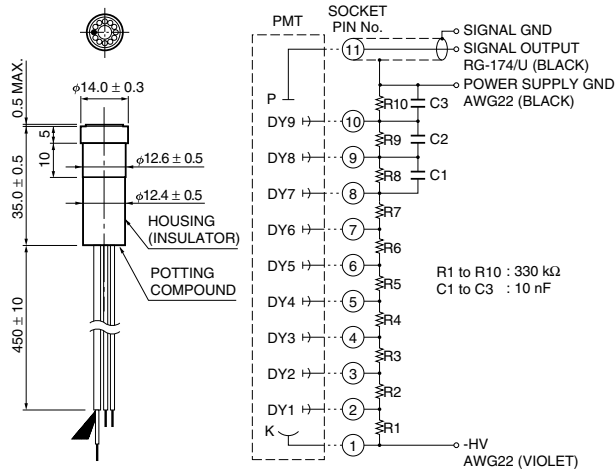
Socket Assembly Type No.	Applicable PMT Diameter	Out-line and Diagram	Grounded Electrode / Supply Voltage Polarity	Maximum Ratings			Leakage Current in Signal Max.	Total Voltage Divider Resistance	Maximum Linear Output in DC Mode	Signal Output	Note
				Insulation Voltage between Case and Pins (V)	Supply Voltage (V)	Voltage Divider Current (mA)					
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	
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
E2979-501		40	Anode / -	2500	2500	0.67	1 × 10 ⁻¹⁰	3.75	33 (at 2500 V)	DC / Pulse	For R3234-01, with rear panel connector, with magnetic shield
E1198-23	51 mm (2") 76 mm (3") 127 mm (5")	41	Cathode / +	2200	2000	0.50	—	3.97	—	Pulse	For scintillation counting
E1198-22		42	Anode / -	2200	2000	0.50	1 × 10 ⁻¹⁰	3.97	25 (at 2000 V)	DC / Pulse	
E6316		43	Cathode / +	2200	2000	0.50	—	3.97	—	Pulse	E1198-23, with rear panel connector, for scintillation counting
E6316-01		44	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")	45	Anode / -	1500	1500	0.38	1 × 10 ⁻¹⁰	3.98	18 (at 1500 V)	DC / Pulse	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
E5780	Metal Package PMT R7400U Series	51	Anode / -	1000	1000	0.36	1 × 10 ⁻¹⁰	2.8	17 (at 1000 V)	DC / Pulse	Board mounting type E5770
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) ^D	DC / Pulse	
E6736	Metal Package PMT R5900U-L16	54	Anode / -	900	900	0.38	1 × 10 ⁻¹⁰	2.42	1.16 (at 900 V) ^D	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) ^D	DC / Pulse	
E6133-04	For High Magnetic Environments 25 mm (1")	57	Cathode / +	2500	2500	0.45	—	5.62	—	Pulse	For R5505, with connector

NOTE: ① Current of one anode

CAUTION: Socket assemblies are not designed to operate in a vacuum.

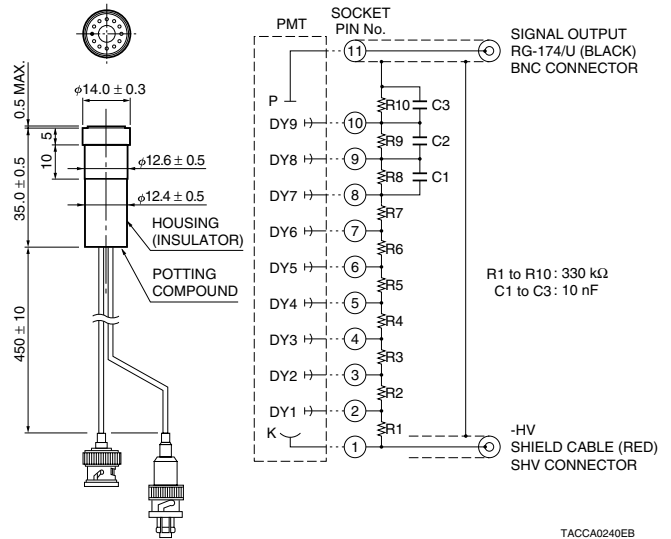
D-Type Socket Assemblies Dimensional Outlines and Diagrams (Unit: mm)

1 E850-13



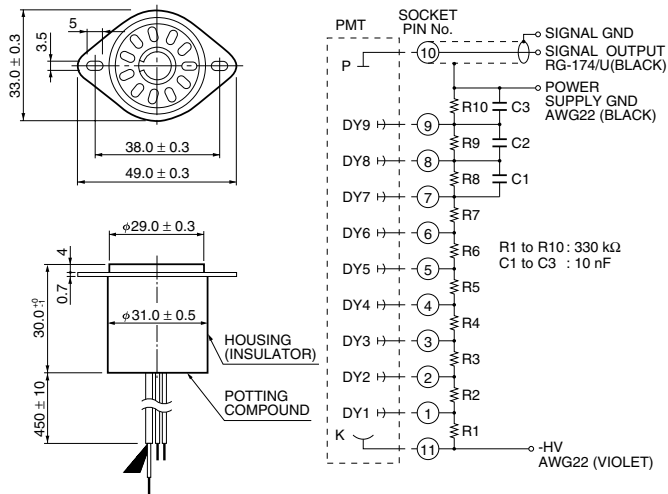
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2 E850-22



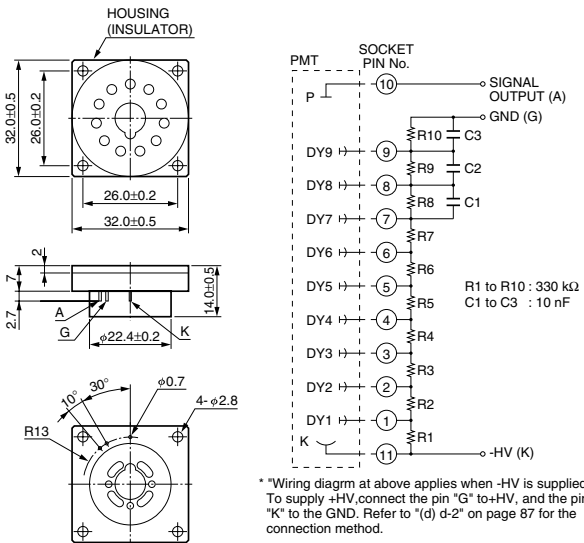
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3 E717-63



TACCA0002EH

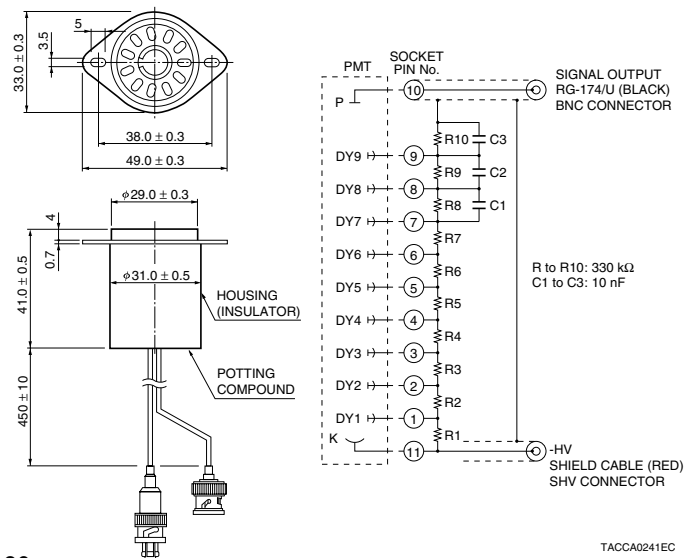
4 E717-74



* 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 87 for the connection method.

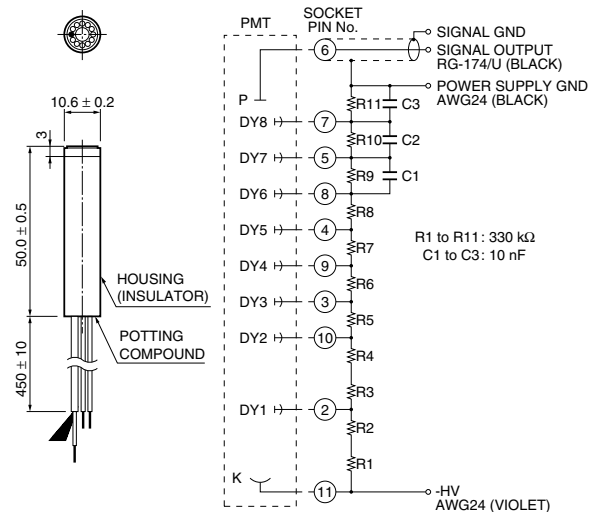
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5 E717-500



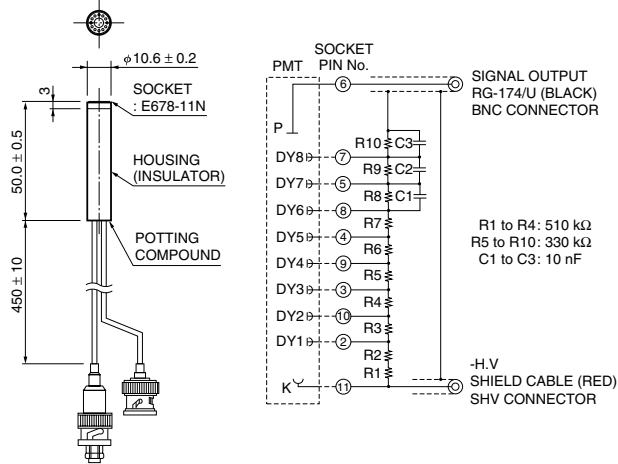
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6 E1761-04



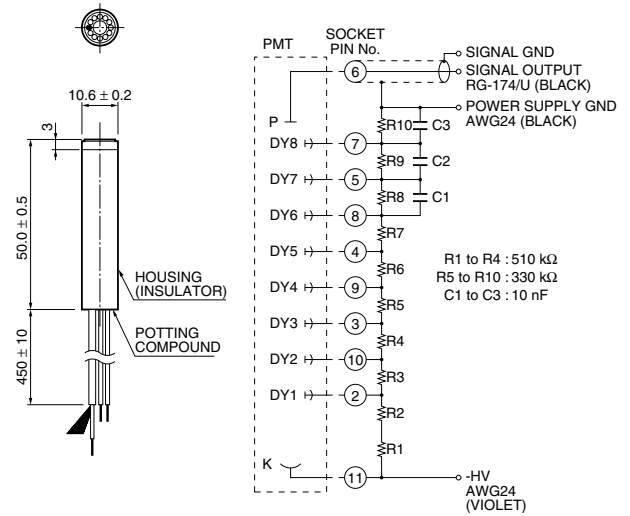
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7 E1761-22



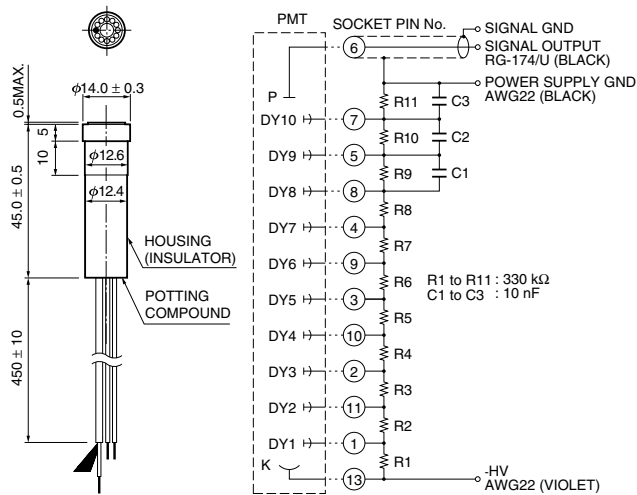
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8 E1761-05



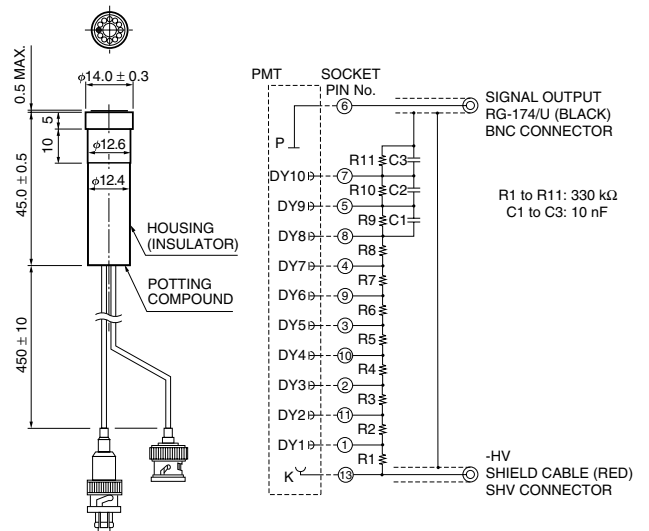
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9 E849-35



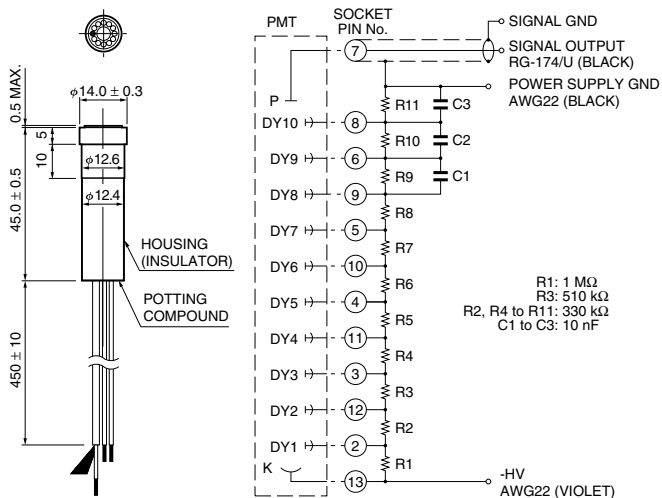
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10 E849-90



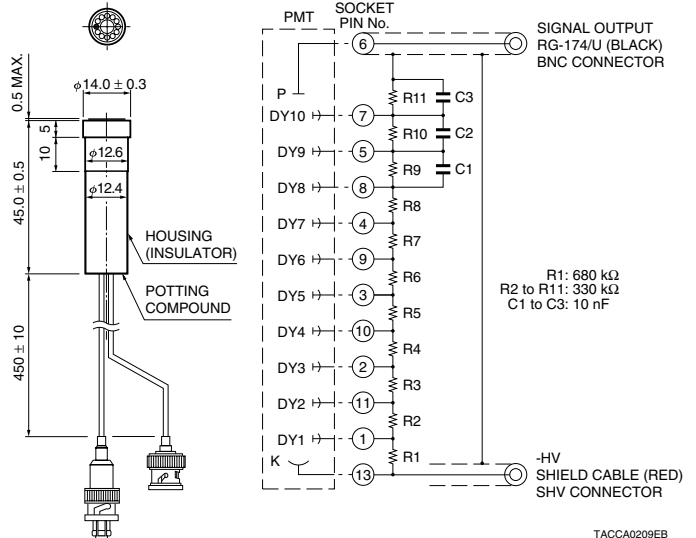
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11 E849-68



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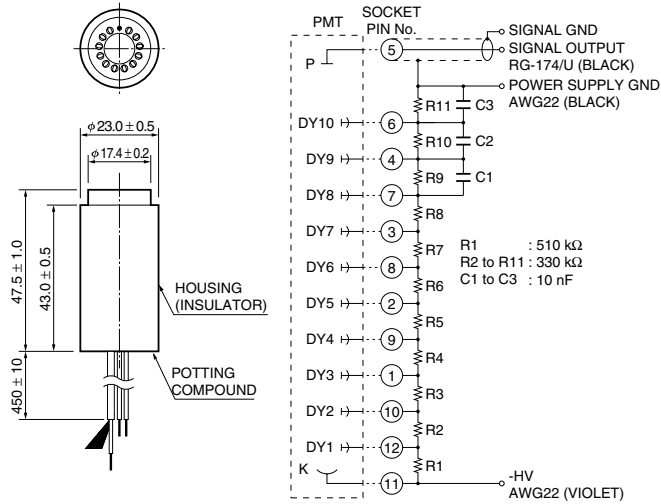
12 E849-52



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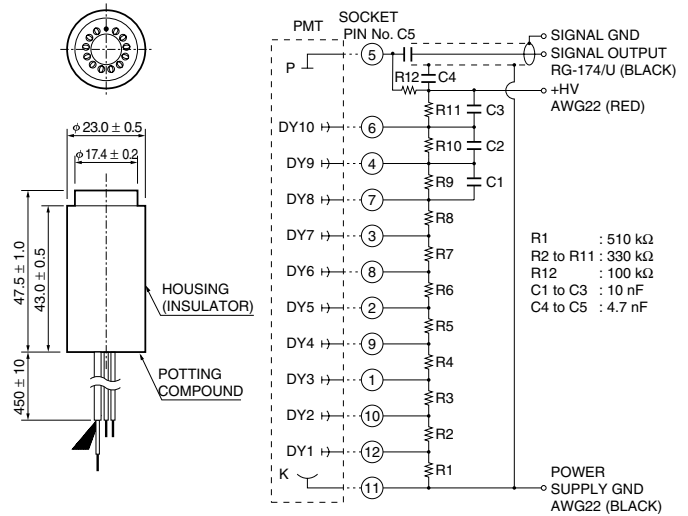
D-Type Socket Assemblies Dimensional Outlines and Diagrams (Unit: mm)

13 E974-13



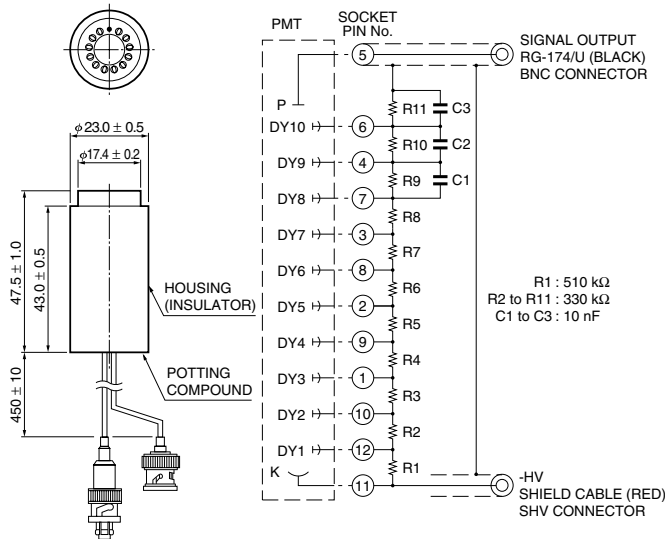
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14 E974-14



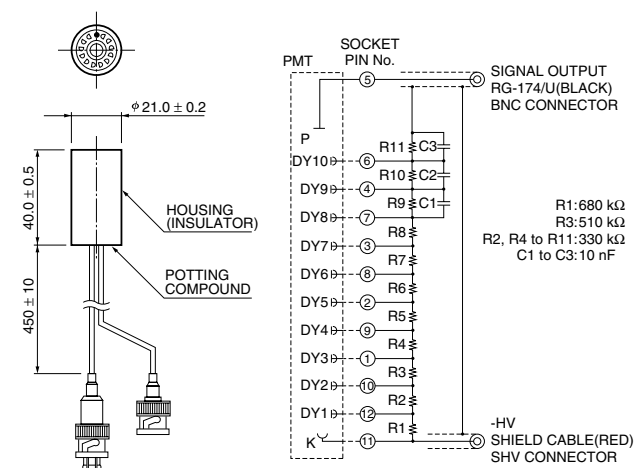
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15 E974-17



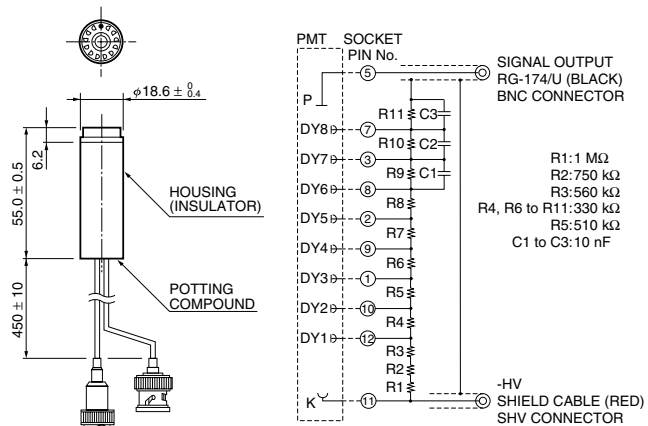
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16 E974-22



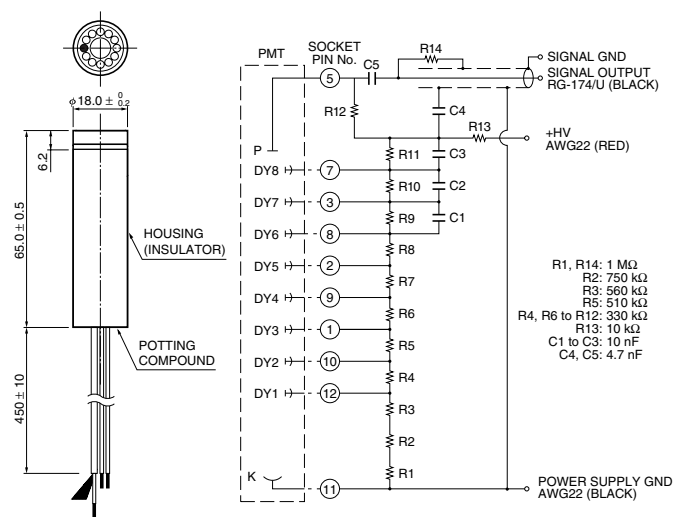
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17 E2253-05



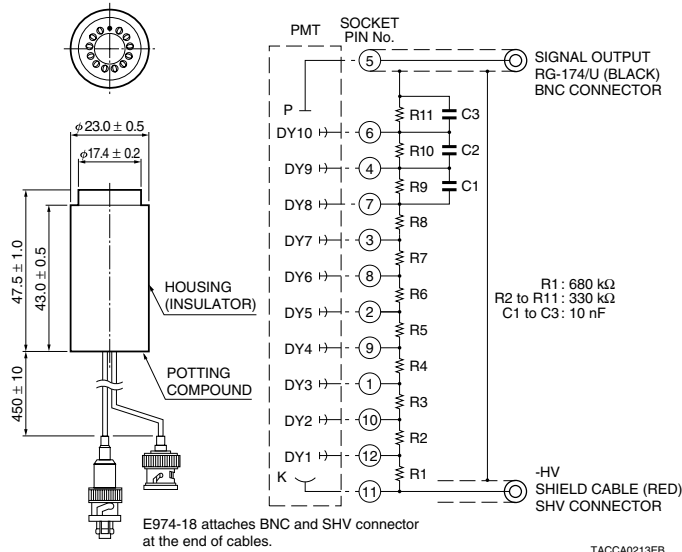
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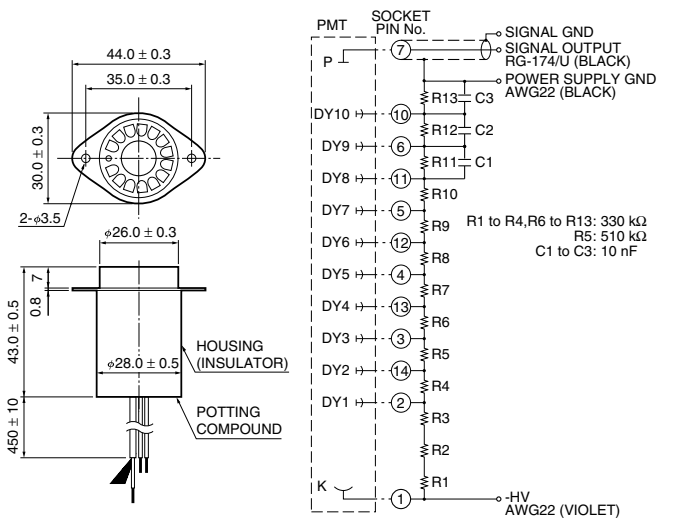
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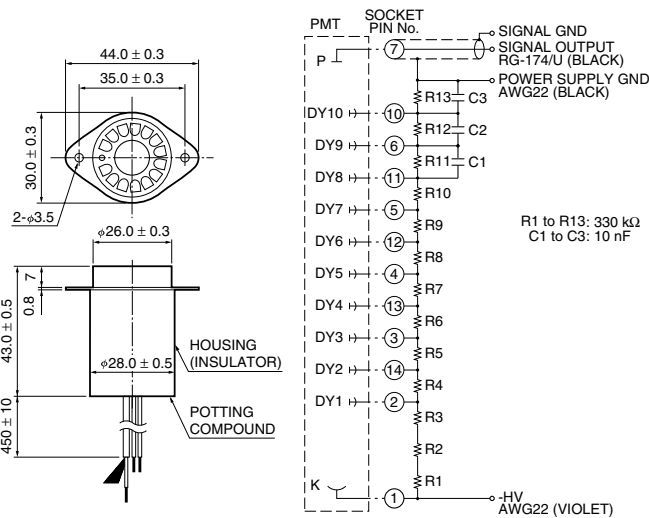
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20 E2924-11



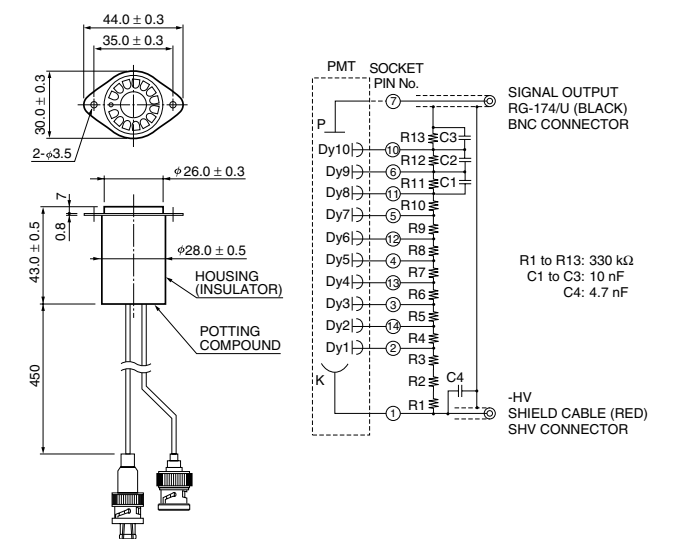
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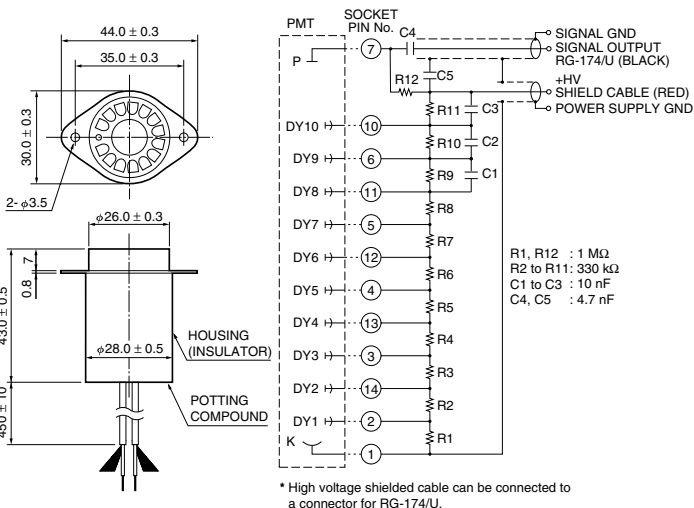
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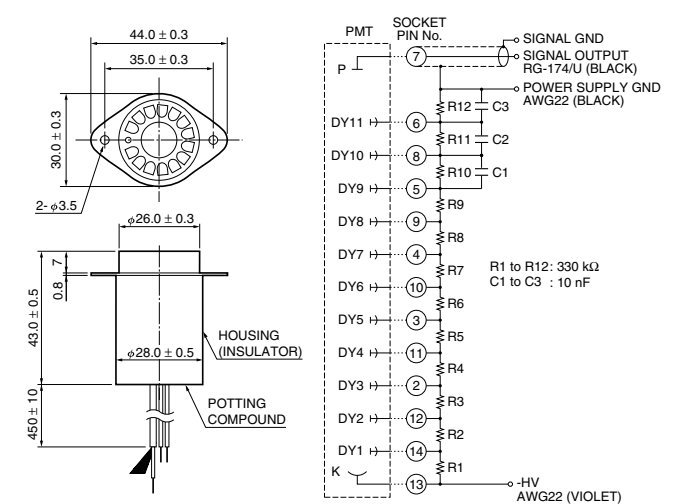
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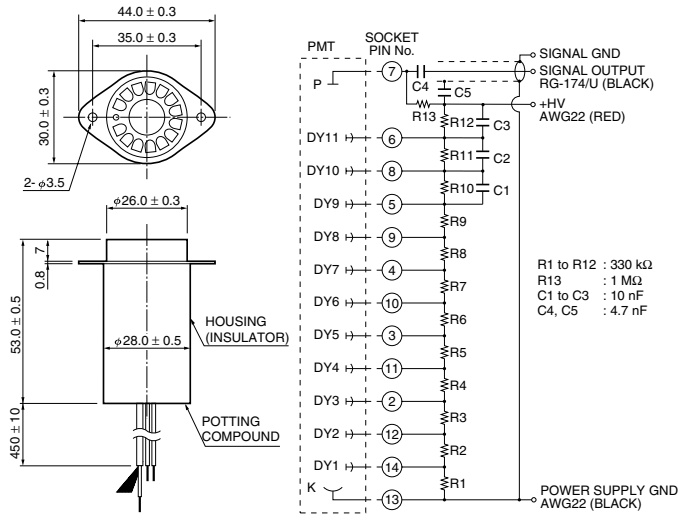
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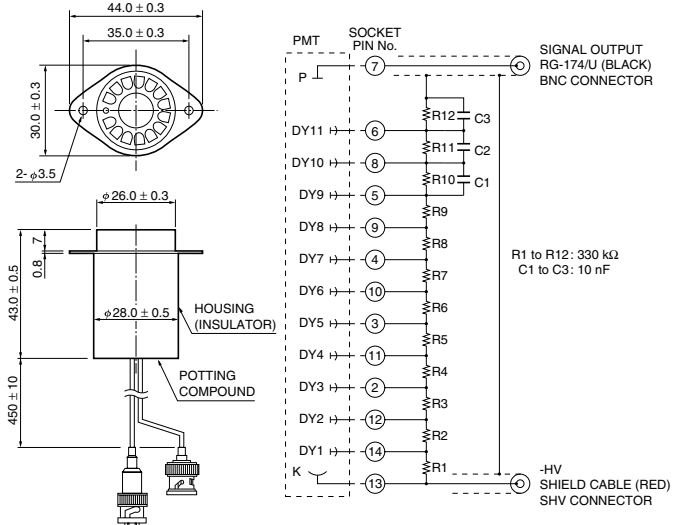
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D-Type Socket Assemblies Dimensional Outlines and Diagrams (Unit: mm)

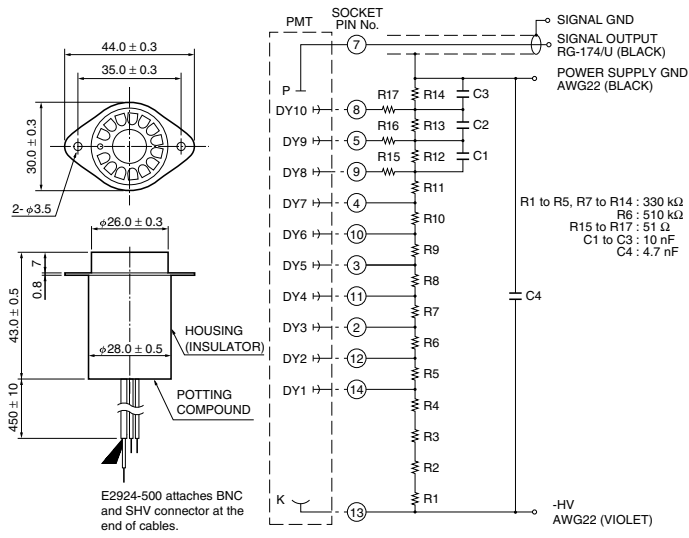
25 E990-08



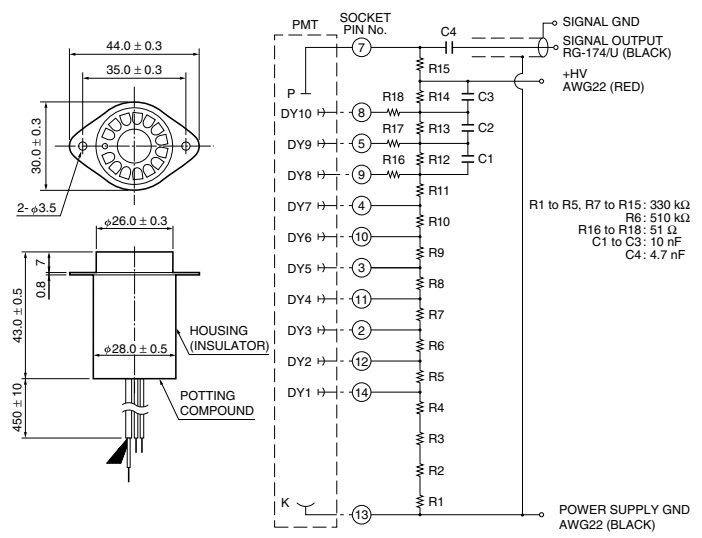
26 E990-501



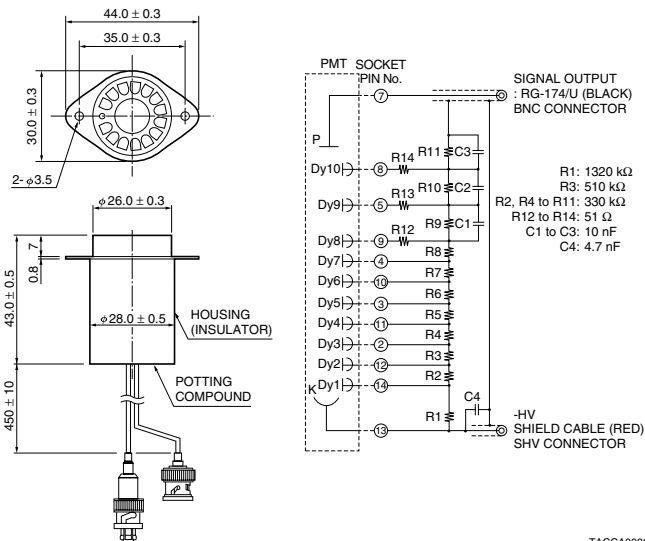
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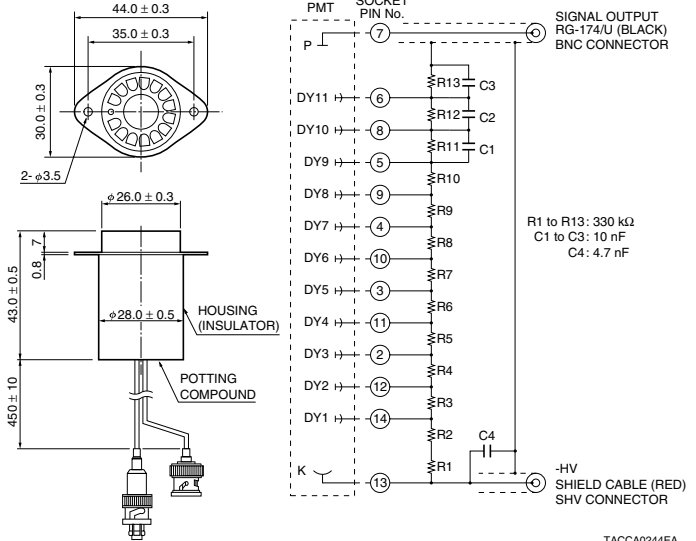
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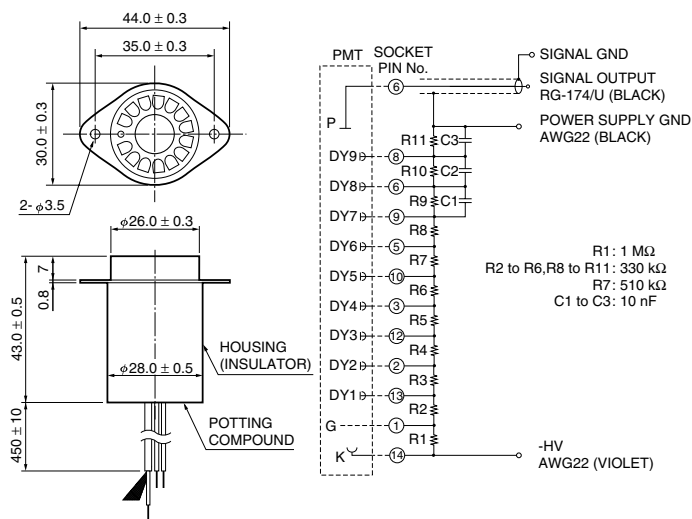
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30 E990-500

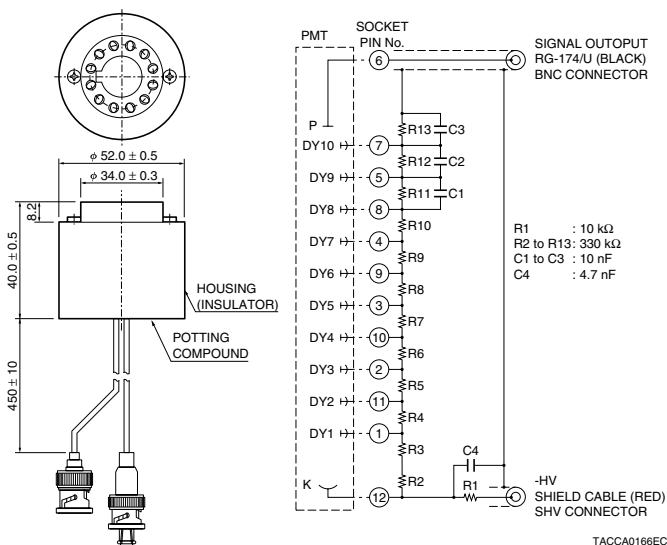


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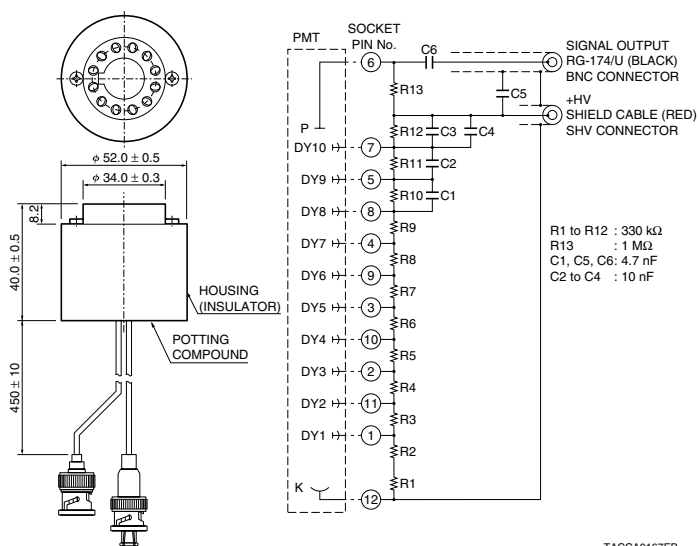
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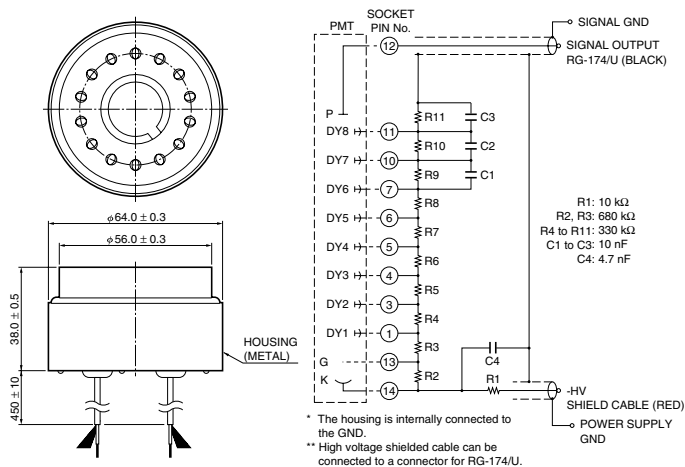
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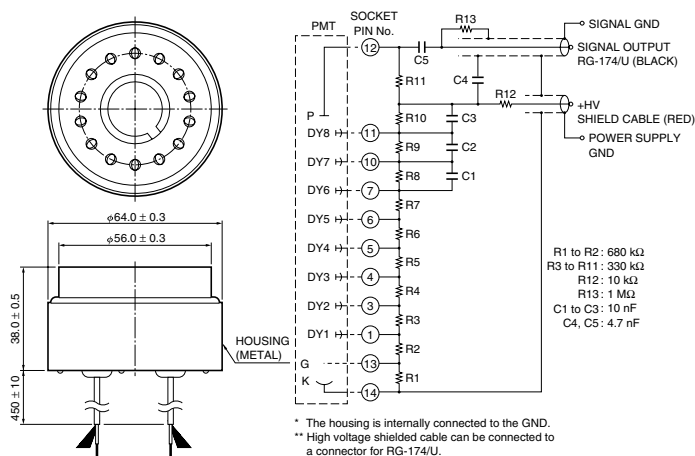
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34 E1198-26



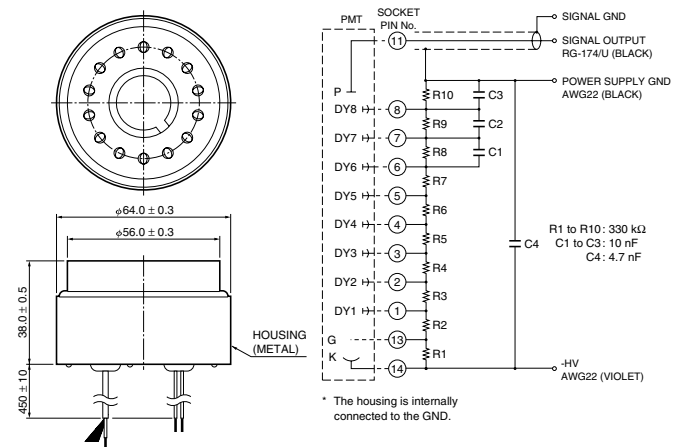
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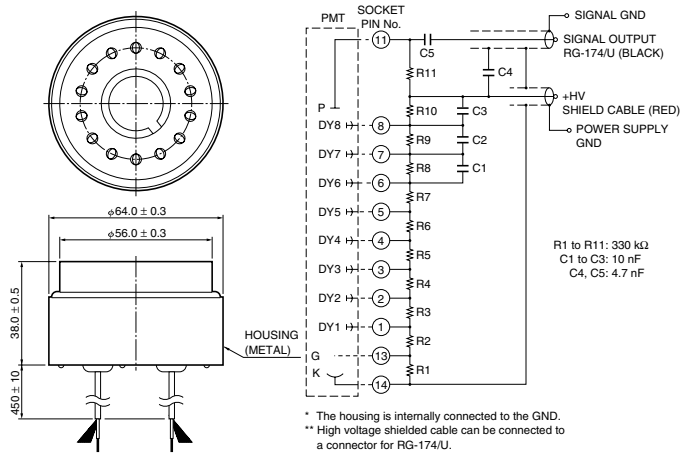
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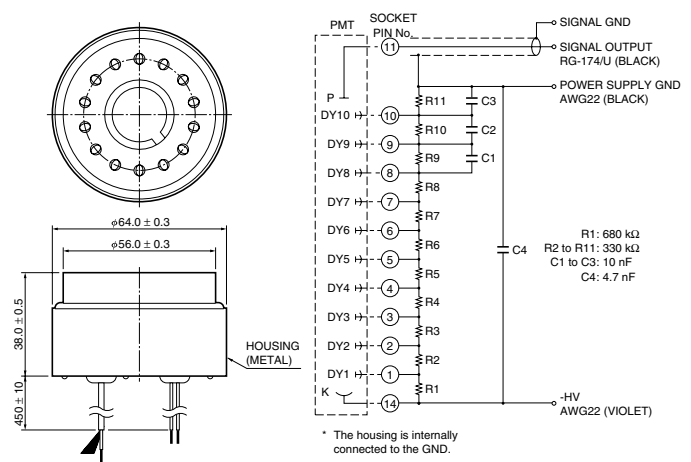
D-Type Socket Assemblies Dimensional Outlines and Diagrams (Unit: mm)

37 E1198-20



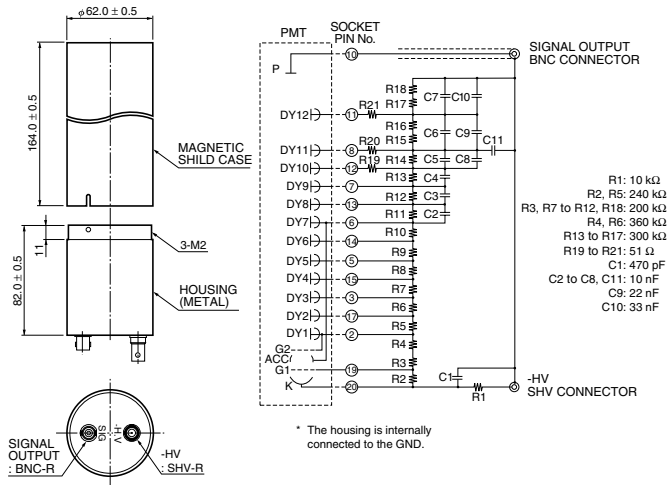
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38 E1198-07



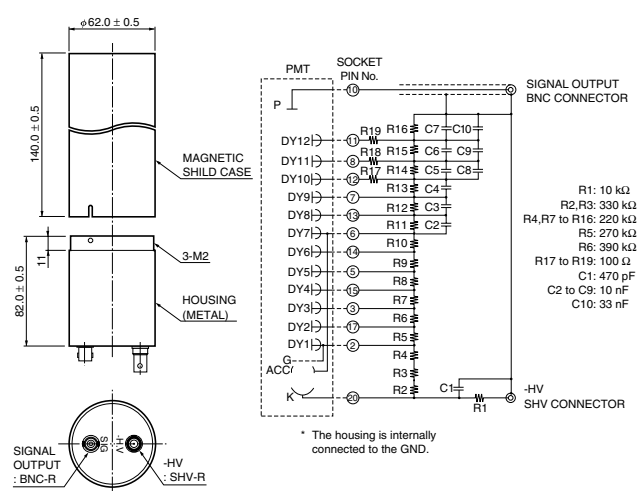
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39 E2979-500



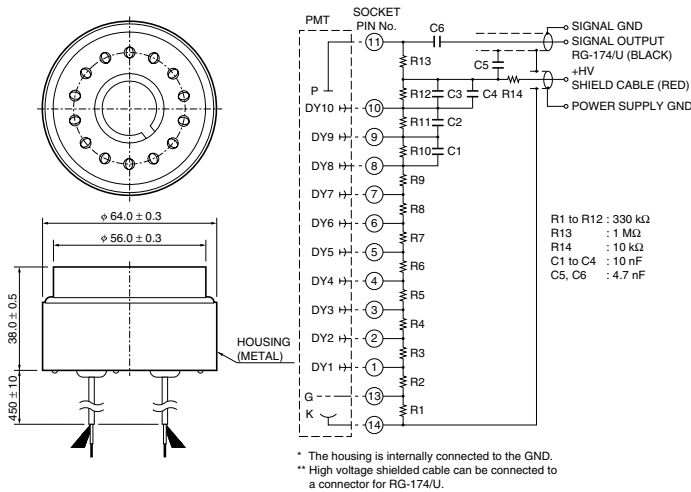
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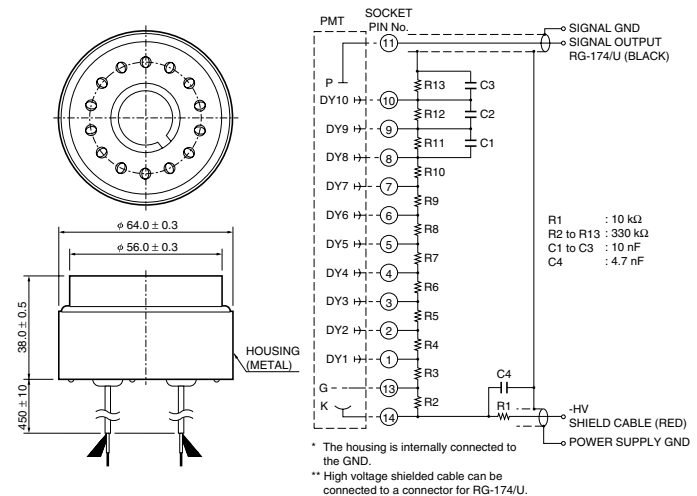
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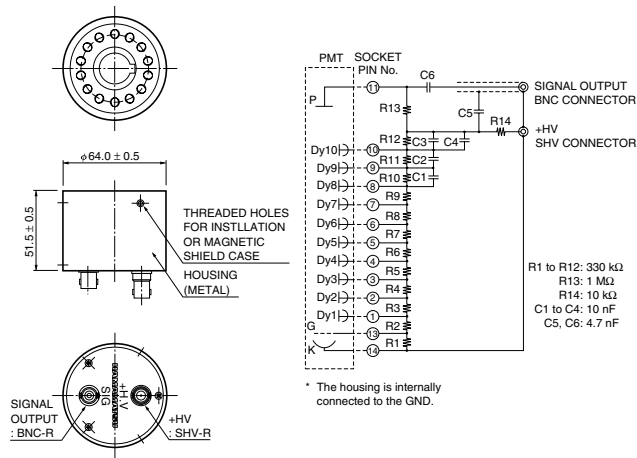
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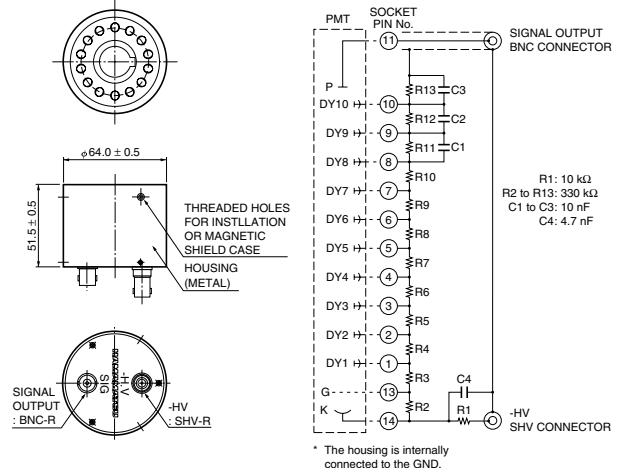
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43 E6316



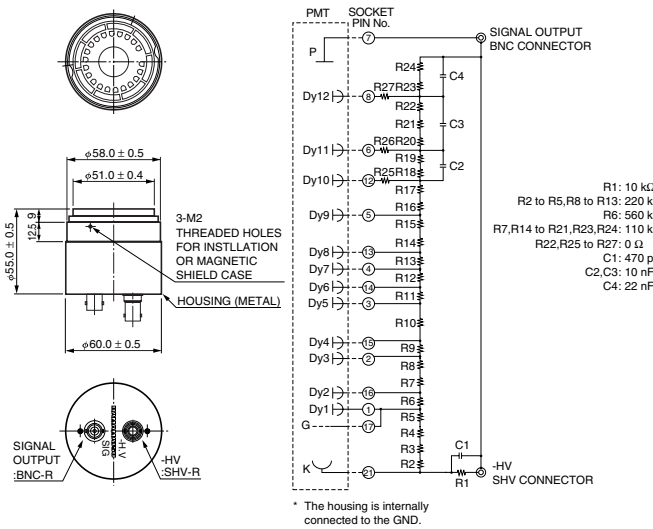
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44 E6316-01



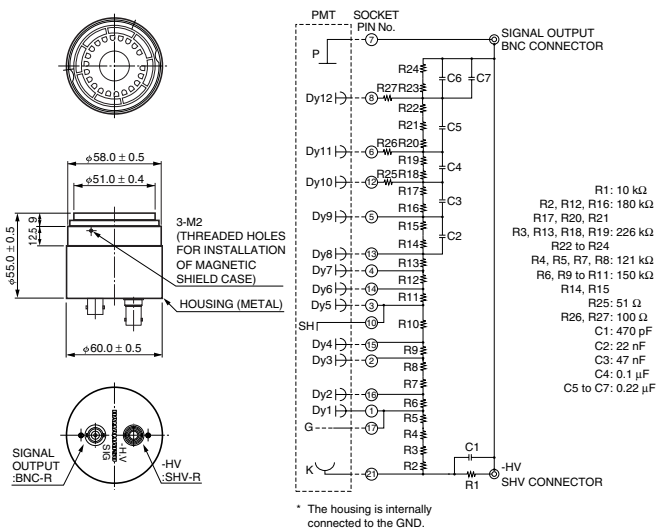
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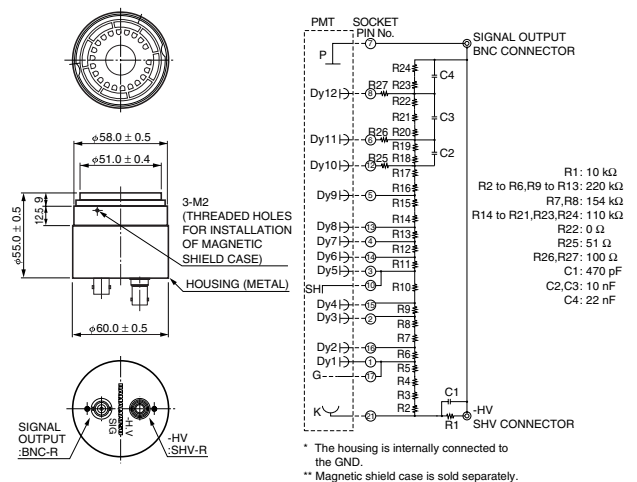
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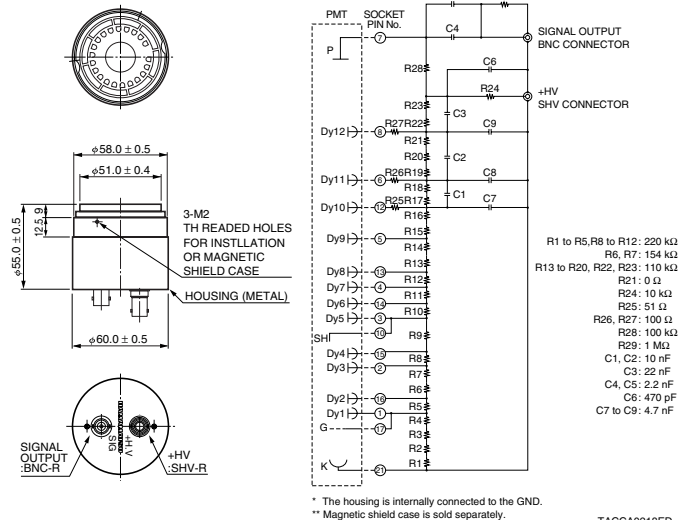
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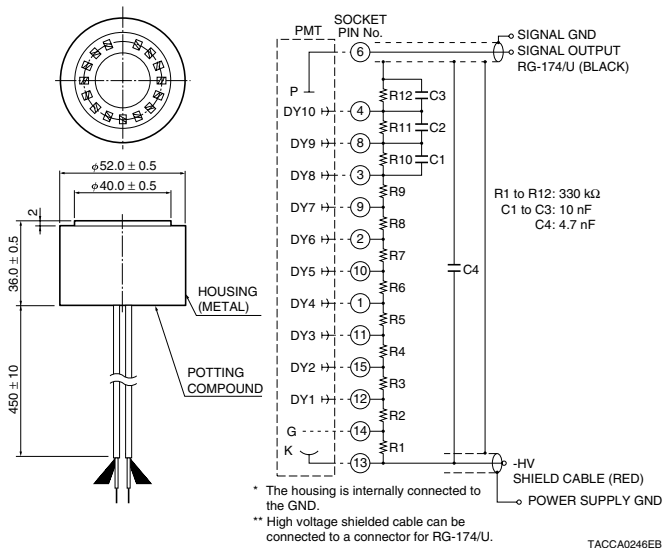
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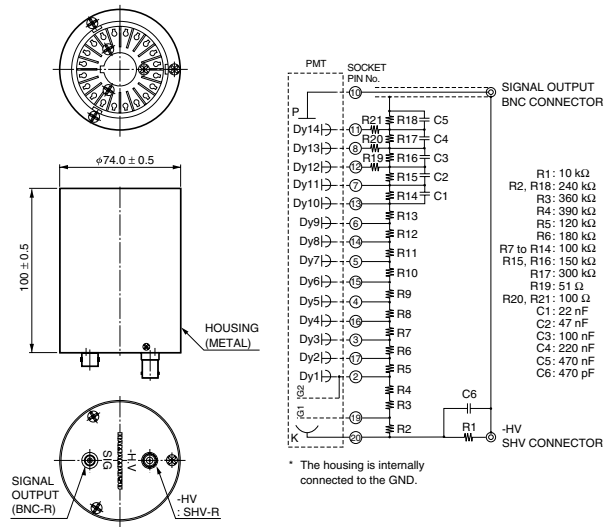
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D-Type Socket Assemblies Dimensional Outlines and Diagrams (Unit: mm)

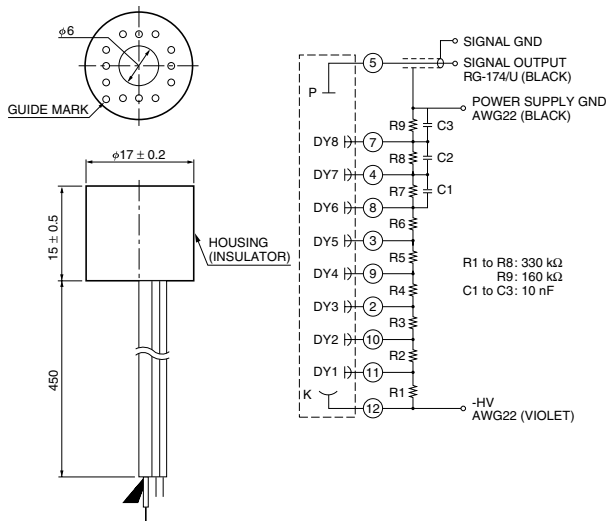
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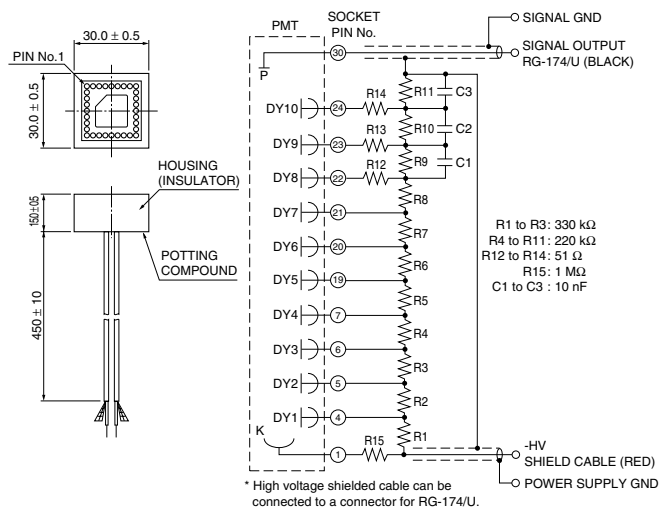
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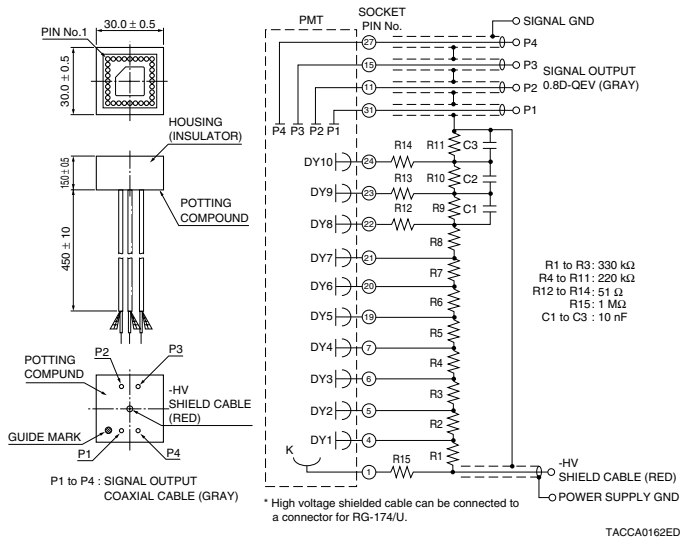
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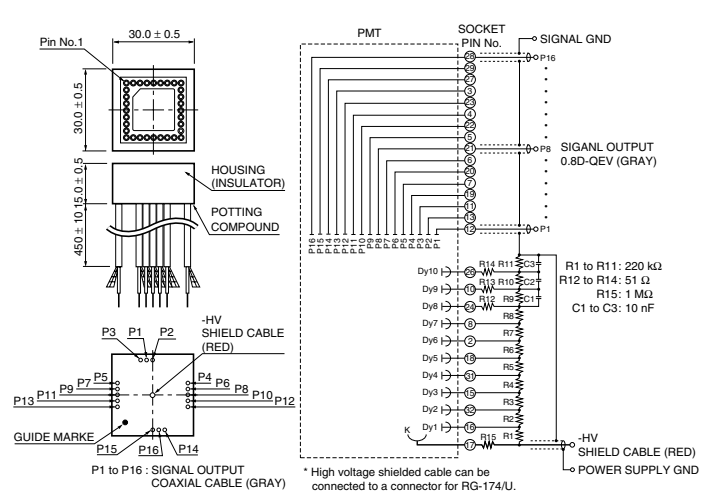
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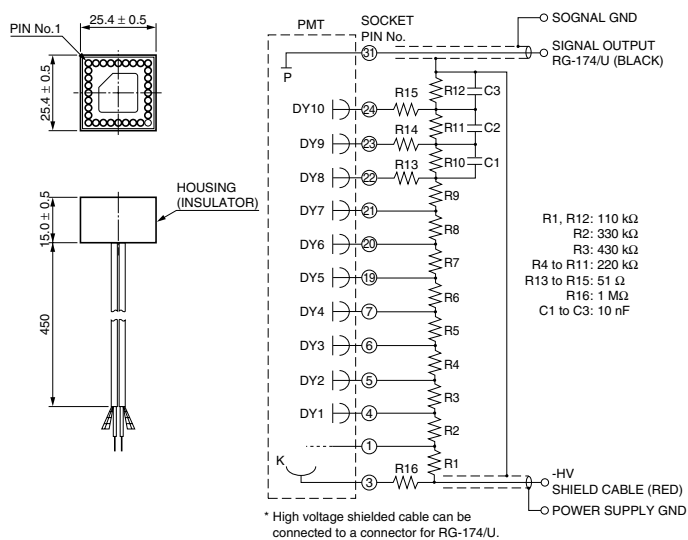
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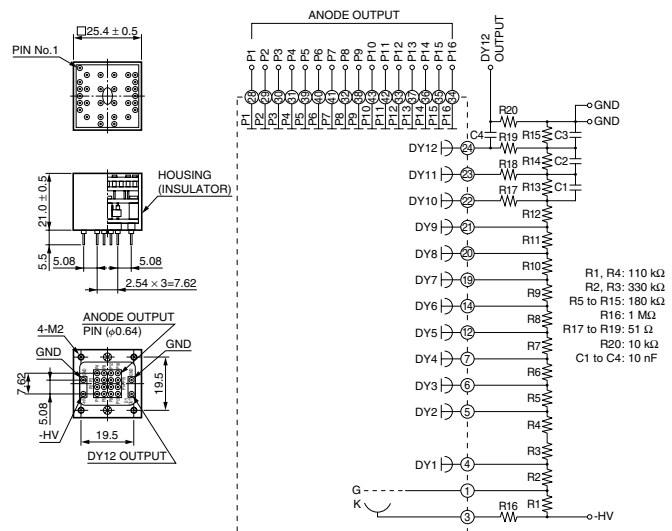


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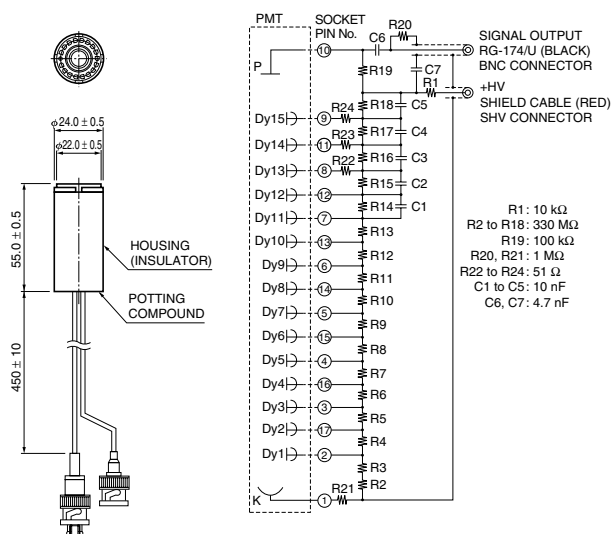
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56 E9349



TACCA0248EA

57 E6133-04



TACCA0248EA

DA-Type Socket Assemblies

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
Input Voltage for Amplifier	± 18				V
Supply Voltage for Divider	-1500				V
Operating Ambient Temperature	0 to +40				°C
Storage Temperature	-15 to +60				°C

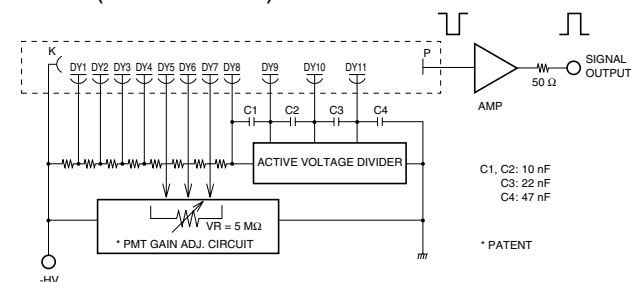
GENERAL

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 k Ω)		0.15 (at load resistance 50 Ω)		V/ μ A
Maximum Output Signal Voltage	10 (at load resistance 10 k Ω)		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 k Ω)	4.5 (at load resistance 50 Ω)		mV
PMT Gain Adjustable Range	Min.	10	30	—	dB
Input Voltage for Amplifier	± 12 to ± 15		± 12 to ± 15		V
Input 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)	166 (at HV = -600 V)	μ A
Weight	Typ.	55 / 170	50 / 170	55 / 170	g

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

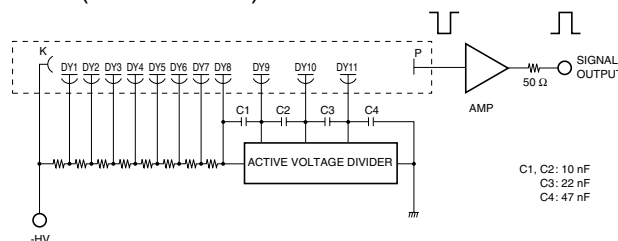
Circuit Diagrams

C7246 (-01[Ⓑ]/-22/-23[Ⓑ])



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

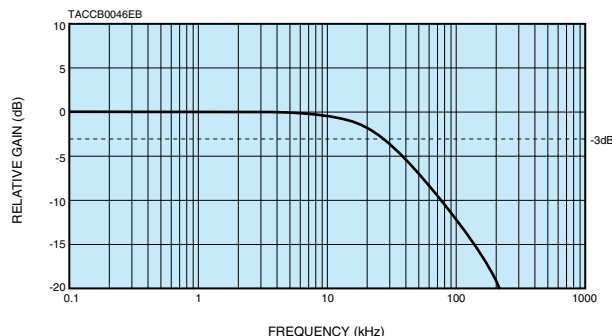
C7247 (-01[Ⓑ]/-22/-23[Ⓑ])



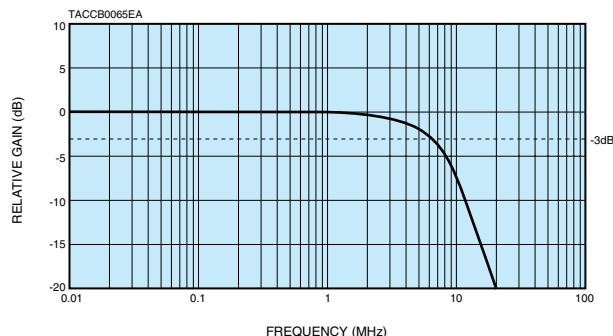
NOTE: [Ⓑ] C7247-01/-23 are for 28 mm side-on PMT so that the last dynode number is "DY9"

Frequency Response of Built-in Amplifier

C7246/-01/-22/-23

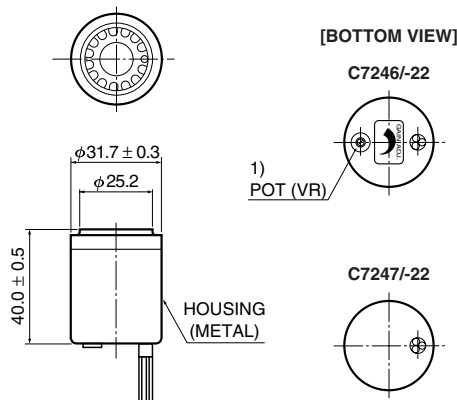


C7247/-01/-22/-23



Dimensional Outlines (Unit : mm)

C7246/-22, C7247/-22

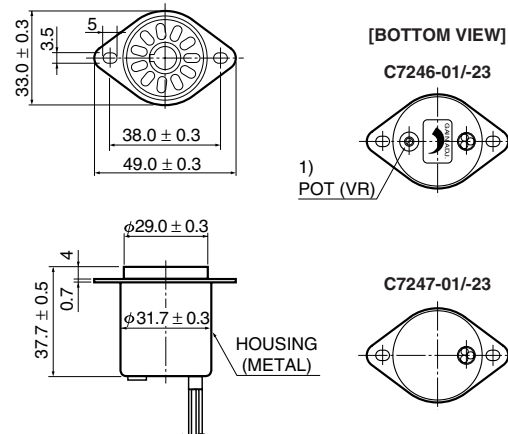


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Type No.	Input/output	Cable Type	Cable Length	Connector
C7246/-01	-HV	COAXIAL CABLE ²⁾ (RED)	—	—
C7247/-01	Signal Output	COAXIAL CABLE: RG-174/U (BLACK)	450 ± 10	—
	±15 V	TWISTED PAIR CABLE WITH SHIELD ³⁾ (GRAY)	—	—
C7246-22/-23	-HV	COAXIAL CABLE (RED)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

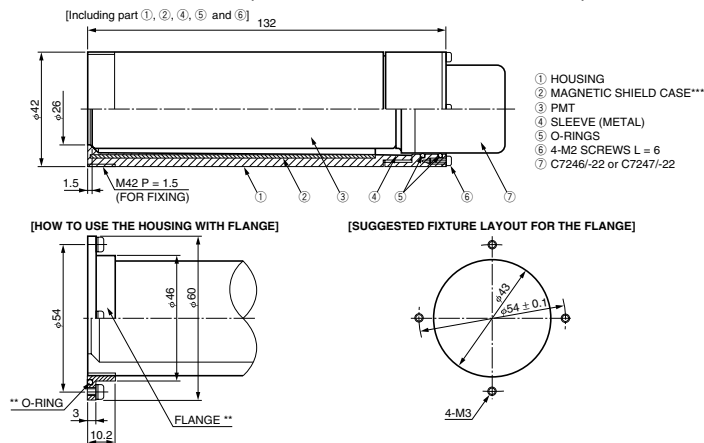
C7246-01/-23, C7247-01/-23



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Sold Separately

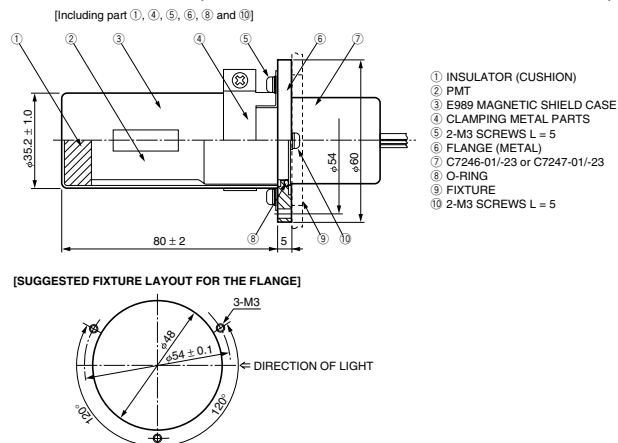
HOUSING E7718* (for C7246/-22 or C7247/-22)



* Can also be attached to C9028-01, C7950-01 and C10344-03.
 ** Flange and O-ring are sold separately. (Type No.: A7719)
 *** Magnetic shield case is electrically floating.

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FLANGE A7709* (for C7246-01/-23 or C7247-01/-23)



* Can also be attached to E717-63/500, C8991 and C7950.
 A7708 dedicated flange is provided for C6270 and C6271.

TACCA0199EB

DP-Type Socket Assemblies

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		φ 28 mm side-on type	φ 28 mm head-on type R374, R2228 R5929, R6094 R6095, etc.	φ 25 mm head-on type R1924A, R1925A R3550A, R5070A	φ 28 mm side-on type	φ 28 mm head-on type R374, R2228 R5929, R6094 R6095, etc.	—
Input Voltage		+15 ± 1			+11.5 to +15.5		V
Input Current		45	60	50	8		mA
Linear DC Output Current of PMT ^(A)	at -1000 V	Typ. 100 ^(A)			Typ. 100 ^(B)		μA
	at -500 V	Typ. 50 ^(A)			Typ. 50 ^(B)		μA
Operating Ambient Temperature		0 to +40			0 to +50		°C
Storage Temperature		-15 to +60			-15 to +60		°C
Weight		Typ. 50	60		57		g

NOTE: (A) Within: ±2 % linearity (B) Within: ±0.5 % linearity

HIGH VOLTAGE POWER SUPPLY

Parameter		C6270	C9028-01	C9773	C8991	C10344-03	Unit
Output Voltage Range		0 to -1250			-200 to -1200 ^(F)	-200 to -1500	V
Line Regulation Against ±1 V Input Change		Typ. ±0.01					%
Ripple / Noise (p-p) in High Voltage Output		0.008			—		%
Anode Ripple Noise ^(C) (p-p)		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 ^(D)		Typ. 80			—		ms
Settling Time ^(E)		—			10		s
Temperature Coefficient		Typ. ±0.01			±0.005		%/°C

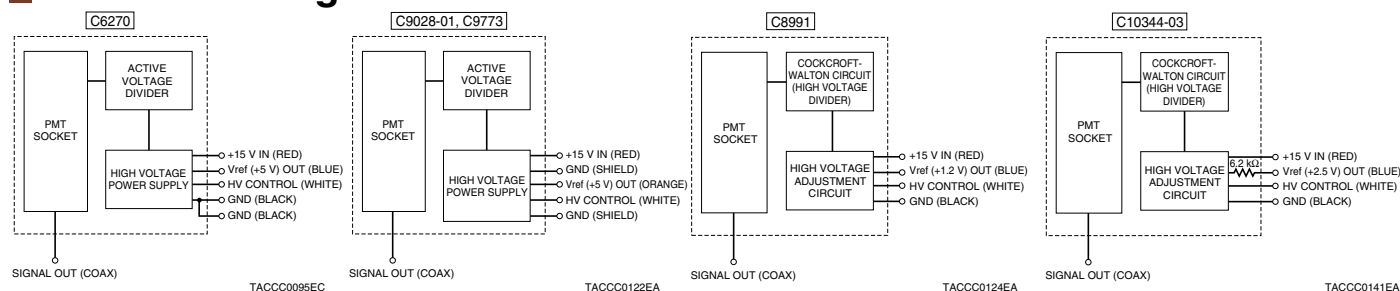
NOTE: (C) Load resistance = 1 MΩ, Load capacitance = 22 pF

(D) for 0 %→99 % HV change

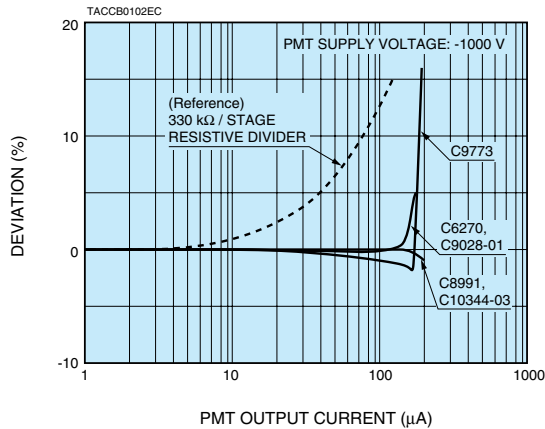
(E) The time required for the output to reach a stable level following a change in the control voltage from +1.0 V to +0.5 V.

(F) C8991-01 with an output voltage range of -200 V to -1500 V is also provided.

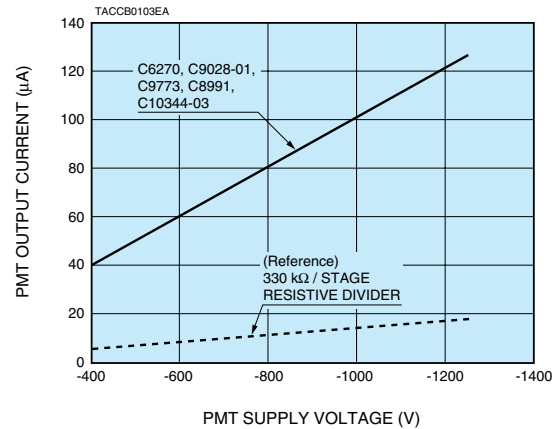
Schematic Diagrams



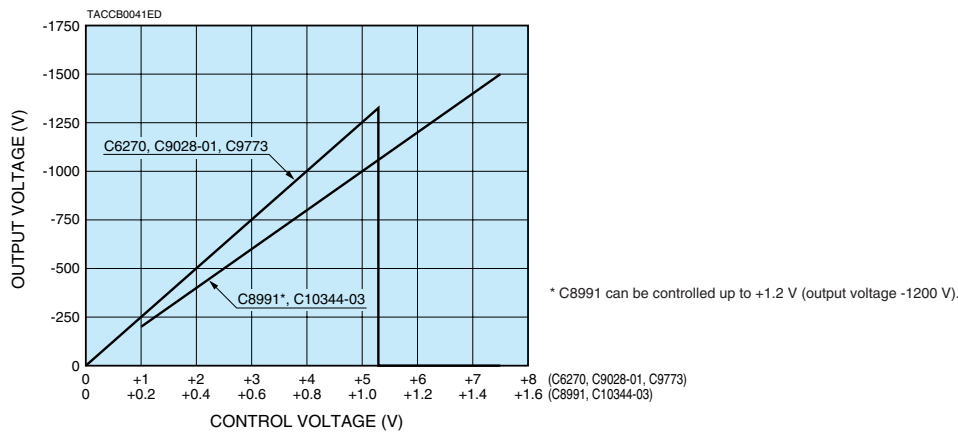
DC Linearity Characteristics



Practical PMT DC Output Limits

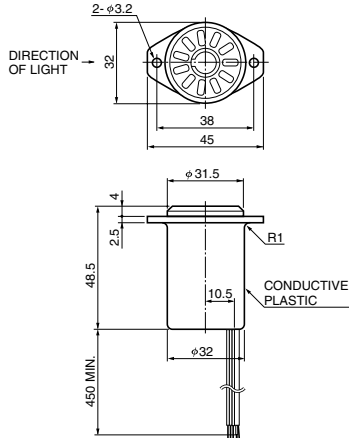


High Voltage Controlling Characteristics



Dimensional Outlines (Unit: mm)

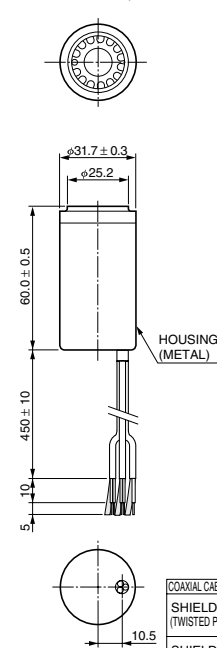
C6270



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

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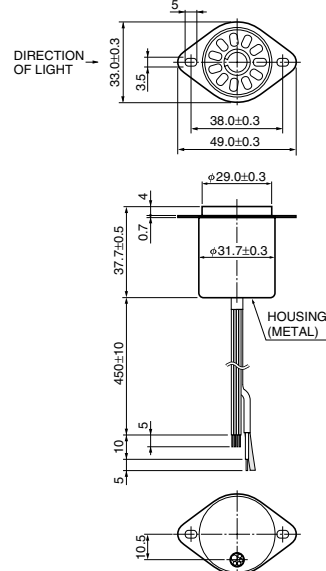
C9028-01, C9773



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

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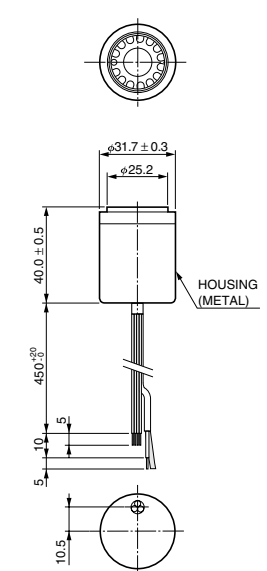
C8991



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 101 for details on flanges and housings.
(C9773 has no suitable flange and housing.)

DAP-Type Socket Assemblies

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

Common Specifications

GENERAL

Parameter			C6271	C7950	C7950-01	Unit
Applicable PMTs			ϕ 28 mm (1-1/8") side-on type		ϕ 28 mm (1-1/8") head-on type	—
					R374, R2228, R5929	
					R6094, R6095, etc.	
Input Voltage			+15 $\pm$ 1	$\pm$ 15 $\pm$ 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			μ A
	at -500 V	Typ.	43			μ A
Operating Ambient Temperature			0 to +40			°C
Storage Temperature			-15 to +60			°C
Weight	Typ.		55	65	70	g

NOTE: (A) Within: ± 2 % linearity

HIGH VOLTAGE POWER SUPPLY

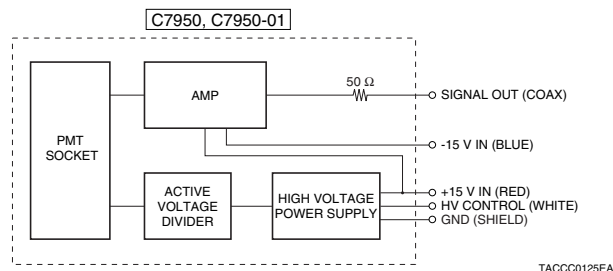
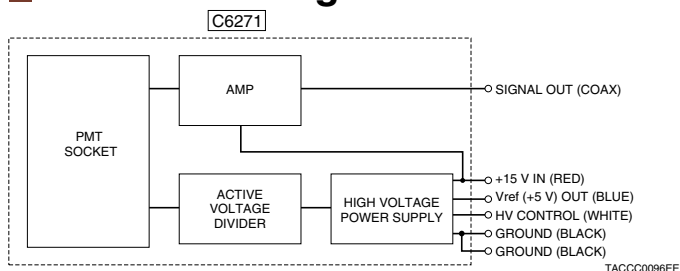
Parameter		C6271	C7950	C7950-01	Unit
Output Voltage Range		0 to -1250	0 to -900		V
Line Regulation Against ±1 V Input Change	Typ.	±0.01	±0.03		%
Ripple / Noise (p-p) in High Voltage Output	Typ.	0.008	0.03		%
Output Voltage Control		0 V to +5 V or external 50 kΩ potentiometer	0 V to +3.6 V		—
Output Voltage Programming Response [®]	Typ.	80			ms
Temperature Coefficient	Typ.	±0.01	±0.03		%/°C

NOTE: (B) for 0 % $\rightarrow$ 99 % HV change

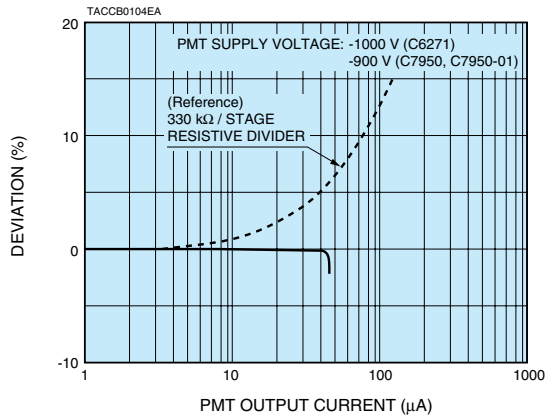
TRANSIMPEDANCE AMPLIFIER SECTION

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 k Ω)	0.15 (at load resistance 50 Ω)		V/ μ A
Maximum Output Voltage			13 (at load resistance 10 k Ω)	2 (at load resistance 50 Ω)		V
Signal Output Offset Voltage	Typ.		-0.3 to +0.3	± 10		mV
Induced Ripple (p-p) on Signal Output	Typ.		2	10		mV

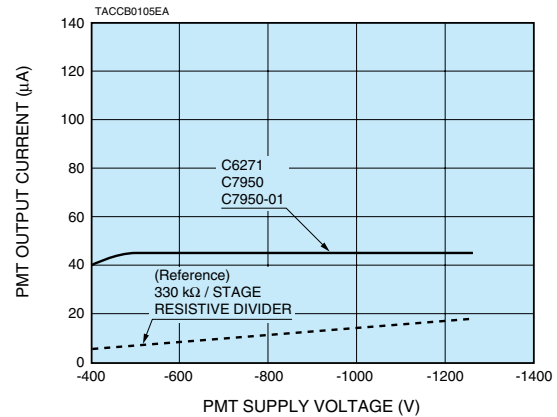
Schematic Diagrams



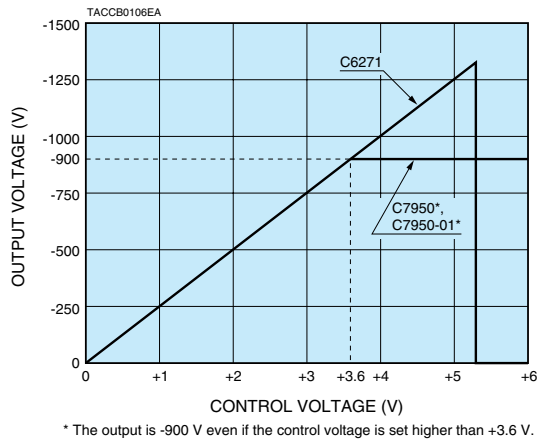
DC Linearity Characteristics



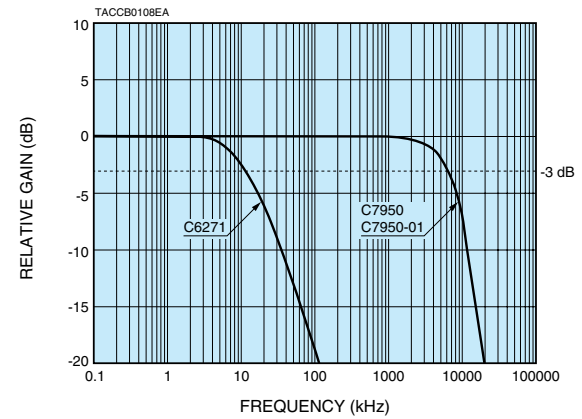
Practical PMT DC Output Limits



High Voltage Controlling Characteristics

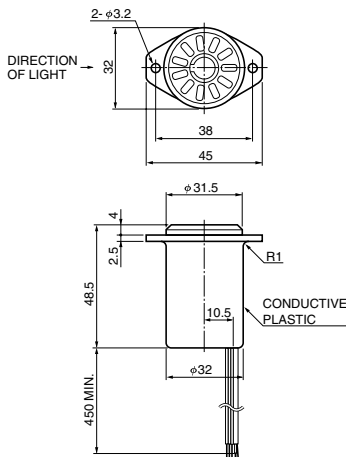


Frequency Bandwidth



Dimensional Outlines (Unit: mm)

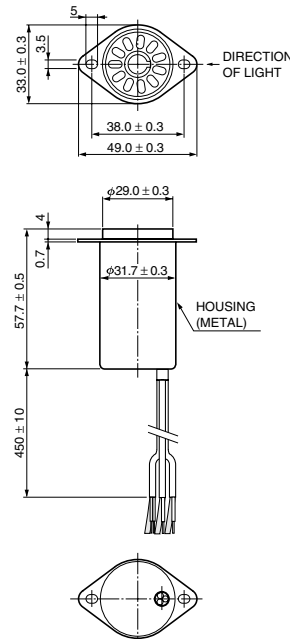
C6271



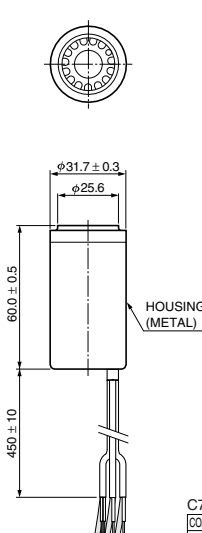
SIGNAL OUTPUT	COAXIAL CABLE RG-174/U
+15 V INPUT	AWG 24, RED
V _{ref} OUTPUT	AWG 24, BLUE
HV CONTROL INPUT	AWG 24, WHITE
GND	AWG 24, BLACK
GND	AWG 24, BLACK

TACCA0156JD

C7950



C7950-01



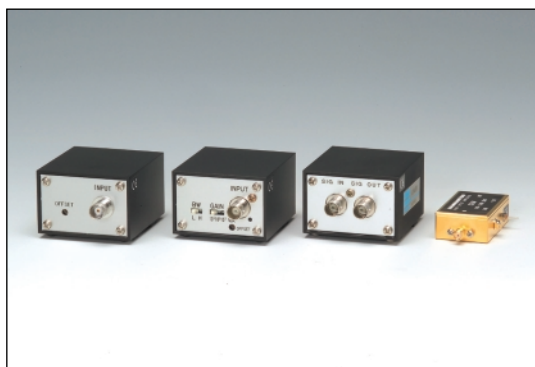
C7950, C7950-01	
COAXIAL CABLE RG-174/U	BLACK
SHIELDED CABLE (TWISTED PAIR CABLE)	GRAY
SIGNAL OUTPUT	—
HV CONTROL INPUT	WHITE
GND	ORANGE
+15 V INPUT	RED
-15 V INPUT	BLUE
GND	SHIELD

TACCA0261EA

* See page 101 for details on flanges and housings.

Amplifier Units

Amplifier Units C7319, C6438, C9663, C5594



From left: C9663, C7319, C6438, C5594

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

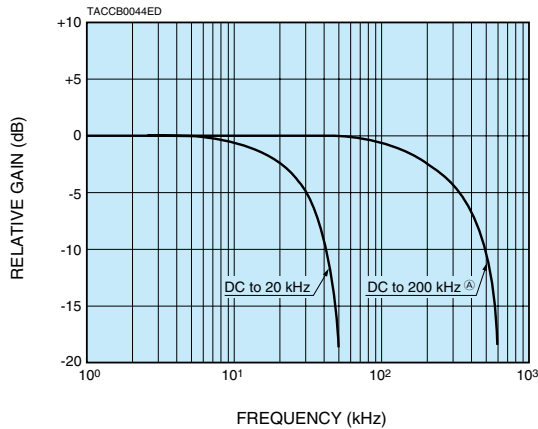
[Ⓔ]Value after current-to-voltage conversion by input impedance.

C5594 Input connector 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

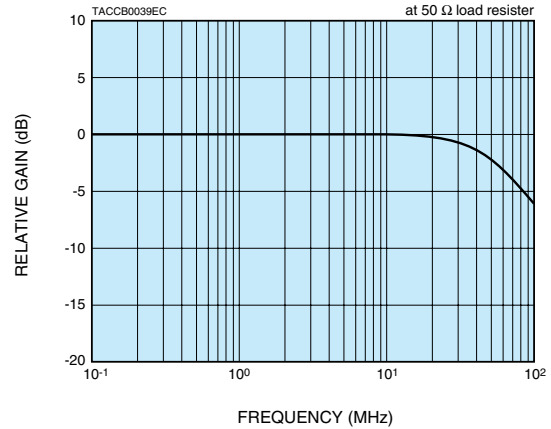
Frequency Response

C7319

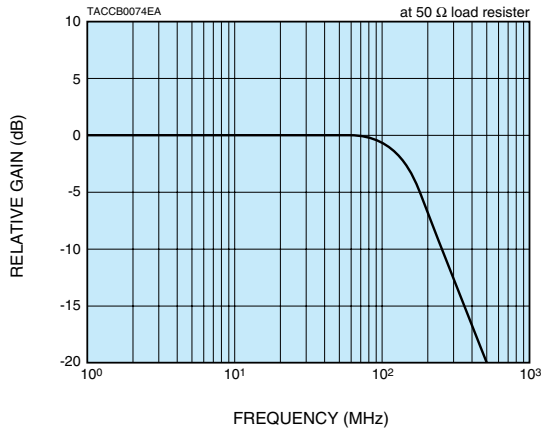


(A) To be limited to DC to 100 kHz at 10 V/μA
(Current to voltage conversion factor)

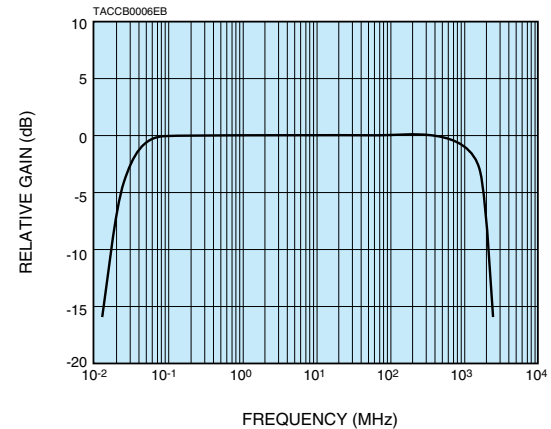
C6438



C9663

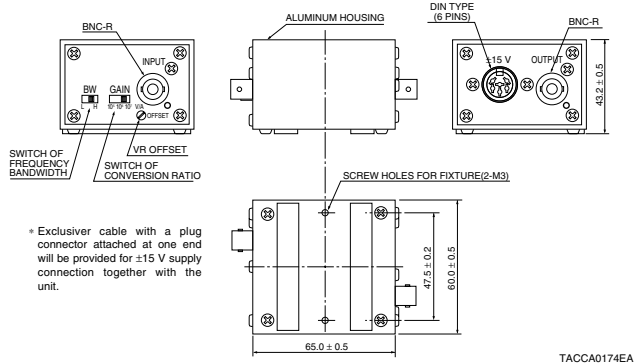


C5594

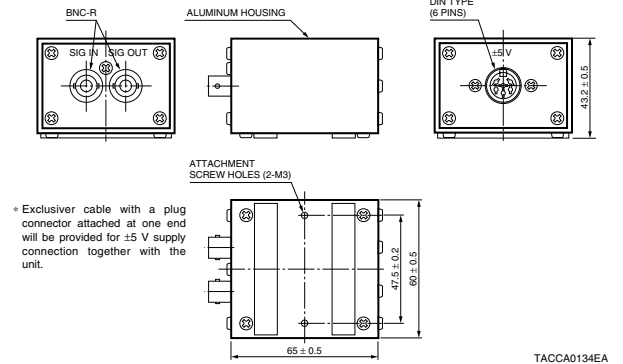


Dimensional Outlines (Unit: mm)

C7319

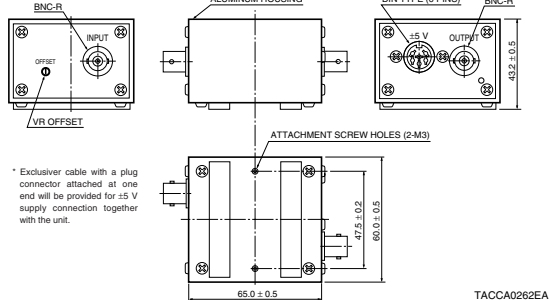


C6438



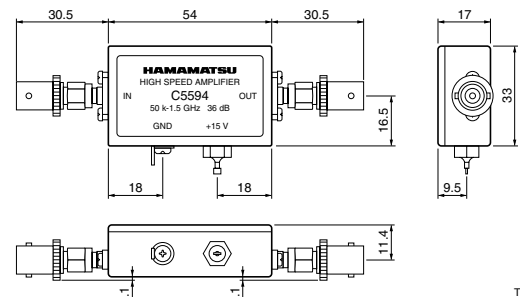
* Exclusion cable with a plug connector attached at one end will be provided for ±15 V supply connection together with the unit.

C9663



* Exclusion cable with a plug connector attached at one end will be provided for ±15 V supply connection together with the unit.

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:

$$\delta = A \cdot E^\alpha$$

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

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

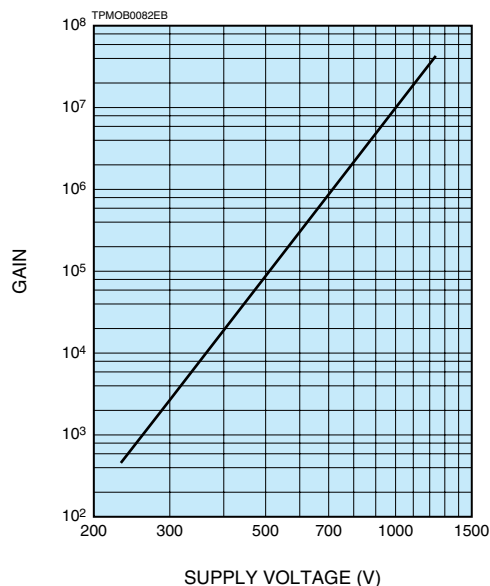
Here, if $\{A^n / (n+1)^{\alpha n}\}$ is substituted for K, μ becomes

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

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

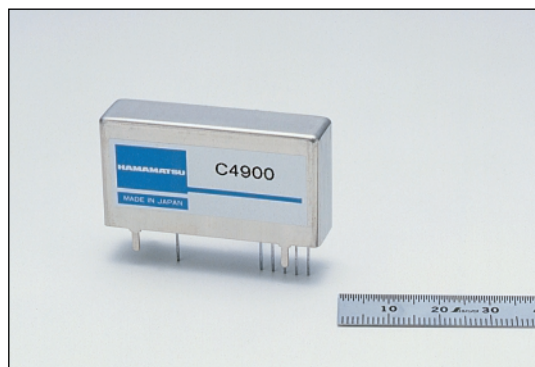


Selection Guide to High Voltage Power Supplies

Type	Type No.	Max. Output Voltage (V)	Output Current (mA)	Input Voltage	Dimensions* (W × H × D) (mm)	Weight
Unit Type	C4900	—	—	—	46 × 24 × 12	31 g
			0.6	+15 V		
		-01	0.5	+12 V		
		-50	0.6	+15 V		
	C9619	+1250	0.5	+12 V	65 × 15 × 45	100 g
			2	+15 V		
		-2000	2	+12 V		
		+2000	2	+15 V		
Bench-top Type	C9525	—	—	—	246 × 70 × 312	3.0 kg
			2	AC 100 V/120 V		
		-01	2	AC 230 V		
		-50	2	AC 100 V/120 V		
	C4840	+2000	10	AC 230 V	245 × 135 × 385	10 kg
			10	AC 120 V		
		-3000	10	AC 230 V		
		±3000	10	AC 120 V		

* Excluding projecting parts

Compact High Voltage Power Supply Units C4900 Series



CE EN61010-1: 2001

TACCF0154

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

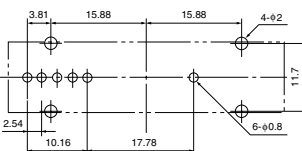
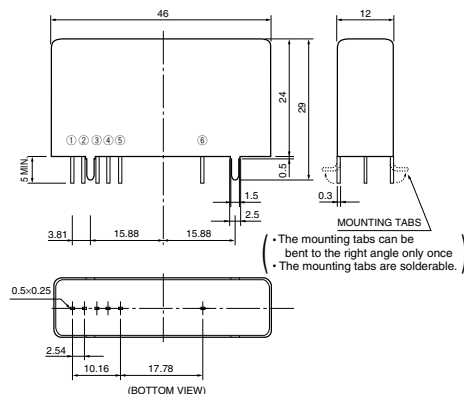
Parameter			C4900	C4900-01	C4900-50	C4900-51	Unit
Input Voltage Range			+15 ± 1	+12 ± 0.5	+15 ± 1	+12 ± 0.5	V
Input Current [Ⓐ]	with no load	Typ.	14	15	14	15	mA
	with full load	Typ.	90	95	90	95	
Variable Output Range			0 to -1250		0 to +1250		V
Specification Guaranteed Output Voltage Range			-200 to -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 %				V
Output Voltage Rise Time (0 % → 99 %) ^{ⒶⒷ}		Typ.	50				ms
Temperature Coefficient ^{ⒶⒷ}		Typ.	±0.01				%/°C
Operating Ambient Temperature ^{ⒶⒷ} / Humidity ^{ⒶⒷⒸ}			0 °C to +50 °C / Below 80 %				—
Storage Temperature / Humidity [Ⓒ]			-20 °C to +70 °C / 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: (A) At maximum output voltage.

(B) At maximum output current.

(C) No condensation.

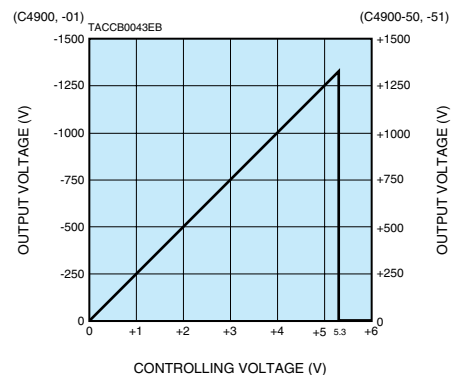
Dimensional Outlines (Unit: mm)



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

TACCA0157EC

Output Voltage Controlling Characteristic



TACCA0159EB

High Voltage Power Supplies

High Voltage Power Supply Units C9619 Series



The C9619 series are 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

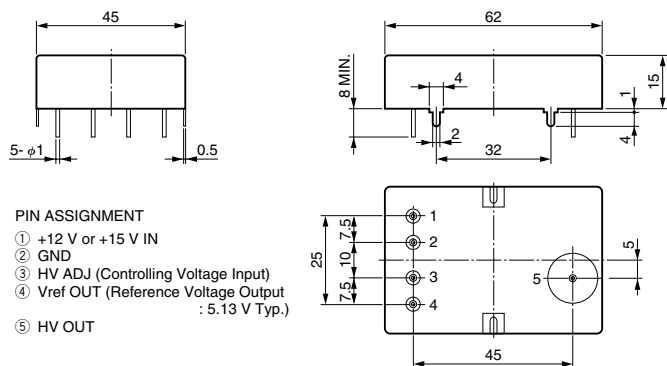
- Compact and Lightweight
- High Stability
- High Output Power (2 kV / 2 mA)
- Completed Fail-safe Functions

Specifications

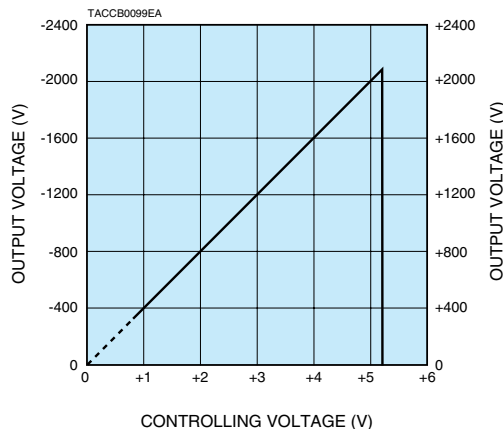
Parameter			C9619	C9619-01	C9619-50	C9619-51	Unit
Input Voltage			+15 ± 1	+12 ± 1	+15 ± 1	+12 ± 1	V
Input Current [Ⓐ]	with no load	Typ.	120	100	120	100	mA
	with full load	Typ.	380	460	380	460	
Variable Output Voltage Range			0 to -2000		0 to +2000		V
Specification Guaranteed Output Voltage Range			-320 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			(Controlling voltage × (-400)) ± 1 %		(Controlling voltage × (+400)) ± 1 %		V
Output Voltage Rise Time (0 % → 99 %) ^{ⒶⒷ}		Typ.	100				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: (A)At maximum output voltage. (B)At maximum output current. (C)No condensation

Dimensional Outline (Unit: mm)



Output Voltage Controlling Characteristic



Compact Bench-Top Type Regulated DC Power Supply C9525 Series



The C9525 series are 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

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	C9525/C9525-01	-320 V to -2000 V (variable)		
Output Voltage	C9525-50/C9525-51	+320 V to +2000 V (variable)		
Maximum Output Current		2 mA	500 mA	200 mA
Input Regulation ^{(A)(B)(C)}	Max.	±0.005 %	±0.1 %	±0.1 %
Load regulation ^{(A)(D)}	Max.	±0.03 %	±1 %	±0.5 %
Ripple / noise (p-p) ^{(A)(B)}	Max.	0.003 %	0.06 %	0.02 %
Drift ^{(A)(B)(E)}	Max.	±0.05 %/h	±0.05 %/h	±0.05 %/h
Temperature Coefficient ^{(A)(B)}	Max.	±0.01 %/°C	±0.01 %/°C	±0.005 %/°C
High Voltage Output Monitoring Accuracy ^(A)	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 ^{(A)(B)}		Approx. 40 V·A		
Operating Ambient Temperature ^{(A)(B)} / Humidity ^{(A)(B)(F)}		0 °C to +40 °C / 85 % RH Max.		
Storage Temperature / Humidity ^(F)		-20 °C to +50 °C / 90 % RH Max.		
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: (A)At maximum outut voltage (B)At maximum output current (C)For 10 % change in line voltage (D)For 0 % to 100 % change in load
(E)After 30 minute warm-up (F)No condensation

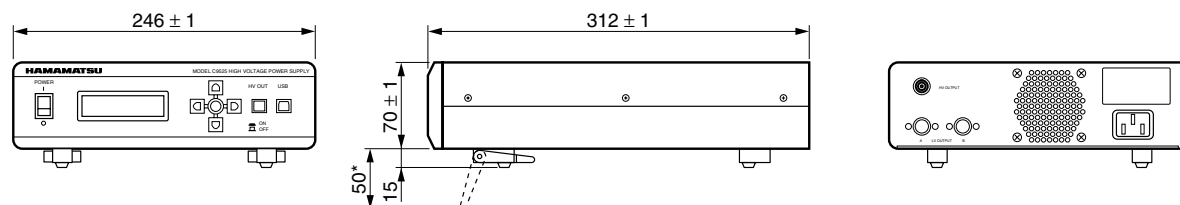
Accessories

- ① High voltage output cable (1.5 m long) terminated with SHV-P plugs E1168-17 1
- ② AC line cable (2 m long) 1
- ③ 3P/2P connector AC adapter (C9525/C9525-50 only) 1
- ④ USB cable (1.5 m long) with filter 1
- ⑤ Low voltage power supply section DIN connector plugs 2
- ⑥ CD-R (Containing instruction manual, sample software) 1

Sold Separately

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

Dimensional Outline (unit: mm)



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

High Voltage Power Supplies

Bench-Top High Voltage Power Supply C4840 (± 3 kV Output)



TACCF0188

The C4840 series are highly regulated, bench-top power supplies that provide high output voltage up to ± 3 kV/10 mA. The LED panel meter on the front panel allows easy and precise voltage monitoring. The C4840 is ideally suited for operating photomultiplier tubes or proportional counter tubes.

Specifications

Parameter		Value / Description
Output Voltage		0 V to ± 3000 V
Specification Guaranteed Output Voltage		± 250 V to ± 3000 V
Maximum Output Current		10 mA
Line Regulation Against ± 10 % Line Voltage Change ^{(A)(B)}	Max.	$\pm(0.005 \% + 10 \text{ mV})$
Load Regulation Against 0 % to 100 % Load Change ^(A)	Max.	$\pm(0.01 \% + 50 \text{ mV})$
Ripple / Noise (p-p) ^{(A)(B)}	Max.	0.0007 %
Drift (after 1 h Warm-up) ^{(A)(B)}	Max.	$\pm(0.02 \% + 10 \text{ mV}) / 8 \text{ h}$
Temperature Coefficient ^{(A)(B)}	Max.	$\pm 0.01 \% / ^\circ\text{C}$
Output Voltage Monitor		4-digit digital meter
Output Voltage Monitoring Accuracy ^(A)	Max.	$\pm(0.1 \% \pm 3 \text{ V})$
Protection Circuit		For short circuit and excess output current
Output Receptacles		Two SHV receptacles ^(D)
AC Input Voltage	C4840-01	120 V (± 10 %) (50/60 Hz)
	C4840-02	230 V (± 10 %) (50/60 Hz)
Power Consumption ^{(A)(B)}		Approx. 100 V·A
Operating Ambient Temperature ^{(A)(B)} / Humidity ^{(A)(B)(C)}		0 $^\circ\text{C}$ to +40 $^\circ\text{C}$ / 80 % RH Max.
Specification Guaranteed Temperature ^{(A)(B)} / Humidity ^{(A)(B)(C)}		+5 $^\circ\text{C}$ to +35 $^\circ\text{C}$ / 80 % RH Max.
Storage Temperature / Humidity ^(C)		-20 $^\circ\text{C}$ to +50 $^\circ\text{C}$ / 85 % RH Max.
Weight		10 kg
CE Marking		Conforms to EMC directive (89/336/EEC) / EN61326: 1997 + A1: 1998 + A2: 2001 Class B Conforms to low voltage directive (73/223/EEC) / EN61010-1: 2001

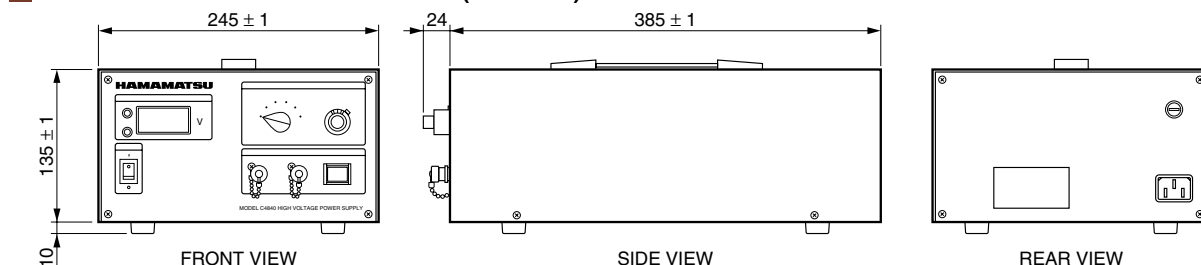
NOTE: ^(A)At maximum output voltage. ^(B)At maximum output current. ^(C)No condensation

^(D)The same polarity voltage is output from two SHV receptacles.

Accessories

- ① AC line cable (2.4 m long).....1
- ② High voltage output cable (1.5 m long) terminated with SHV-P plugs E1168-191
- ③ Spare fuse1
- ④ 3P / 2P connector AC adapter (C4840-01 only)1

Dimensional Outlines (Unit: mm)



TACCA0256EB

Thermoelectric Coolers

Photomultiplier Tube Dark Current and Cooling Effect

Causes of Dark Current

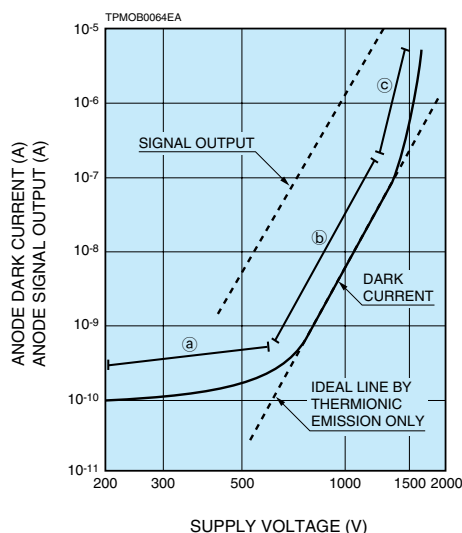
A small amount of current flows in a photomultiplier tube operated at a high voltage even when no light enters it. This output current is called the dark current. Since the dark current degrades the S/N ratio, it is the factor that determines the lower limit of detection when the output current is extremely 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 23 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 (a), the major cause of dark current is the leakage current (②) and in the high-voltage region (c), (③), (④), and (⑦) become the governing factors that determine the dark current. In contrast, in region (b) 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 23: Dark Current vs. Supply Voltage

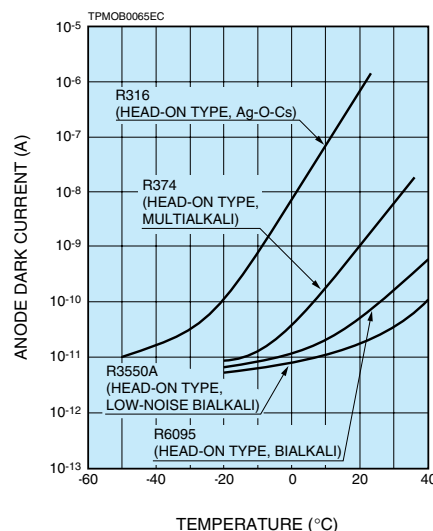


Thermal electron Emission and Cooling Effect

Figure 24 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 $-20\text{ }^{\circ}\text{C}$ to $-30\text{ }^{\circ}\text{C}$, 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 24: Dark Current vs. Temperature for Various photocathodes



Selection Guide

Type No.	Applicable PMTs
C10372 Series	$\phi 28\text{ mm}$ (1-1/8"), $\phi 38\text{ mm}$ (1-1/2") and $\phi 51\text{ mm}$ (2") Head-on
C10373 Series	MCP-PMT (R3809U-50 series, R3809U-61/-63/-64)
C9143 Series	$\phi 28\text{ mm}$ (1-1/8") Side-on
C9144 Series	$\phi 28\text{ mm}$ (1-1/8") Side-on

Thermoelectric Coolers

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 ^(A)	C10373/-01/-02 ^(A)	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 ^(B)	E3059-500 (R3809U-50 Series, R3809U-61/-63/-64)	—
Operating Ambient Temperature / Humidity ^(C)	+5 °C to +40 °C / 75 % RH Max.		—
Storage Temperature / Humidity ^(C)	-15 °C to +50 °C / 80 % RH Max.		—
Weight	Approx. 5.8	Approx. 5.5	kg

NOTE: ^(A)C10372 / C10373: For AC 100 V operation. C10372-01 / C10373-01: For AC 120V operation. C10372-02 / C10373-02: For AC 230 V operation.

^(B)See P.115 ^(C)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 / Humidity ^(C)	+5 °C to +40 °C / 75 % RH Max.	—
Storage Temperature / Humidity ^(C)	-15 °C to +50 °C / 80 % RH Max.	—
Weight	Approx. 2.1	kg

NOTE: ^(C)No condensation

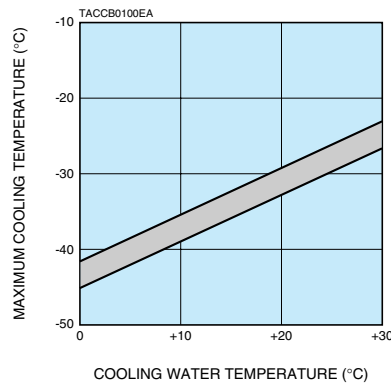
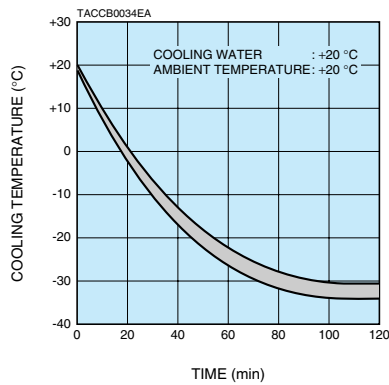
[Components and Accessories]

- 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)

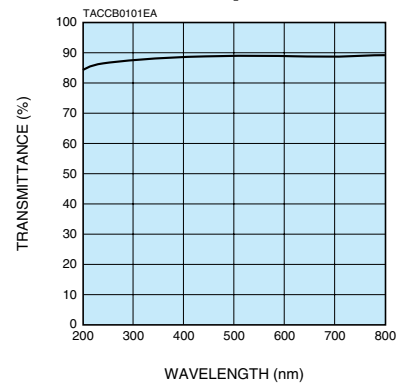
* To use these coolers, water hoses with an inner diameter of 15 mm and a water supply line with the matching round faucet are required. Prepare those hoses of the desired length. In addition, prepare a filter for removing impurities such as chlorine ions.

** **CE** C10372 series and C10373 series conform to the EMC directive and the LVD of the European Union.

Cooling Characteristics

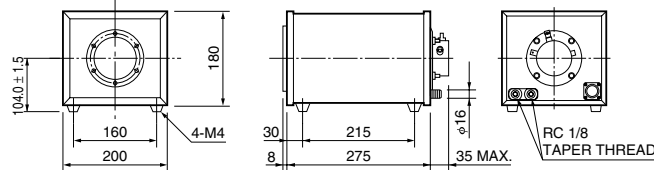


Spectral Transmission Characteristics of Optical Window

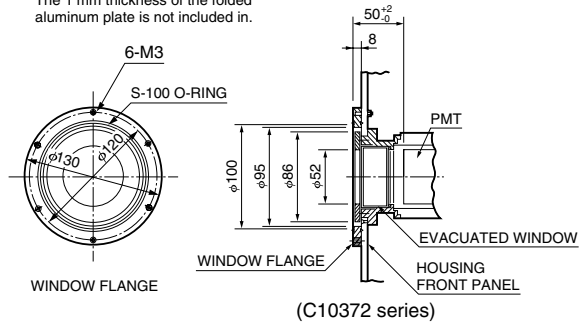


Dimensional Outlines (Unit: mm)

HOUSING

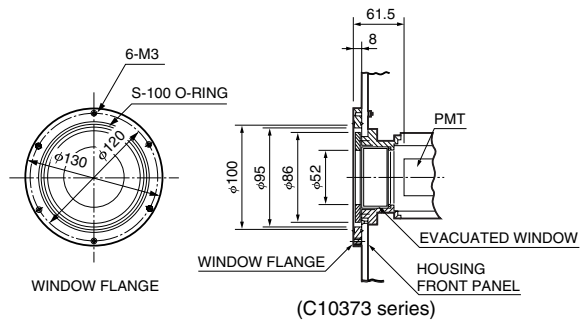
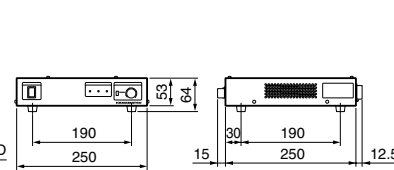


* The 1 mm thickness of the folded aluminum plate is not included in.



TACCA0292EA

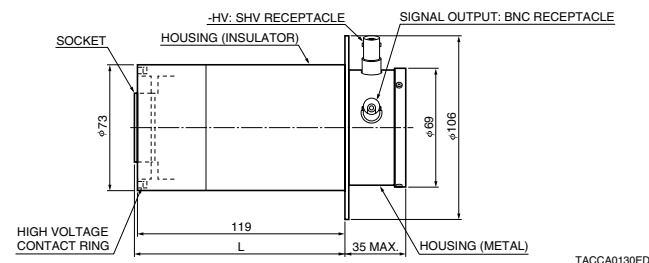
POWER SUPPLY



TACCA0293EA

Sold Separately (Unit: mm)

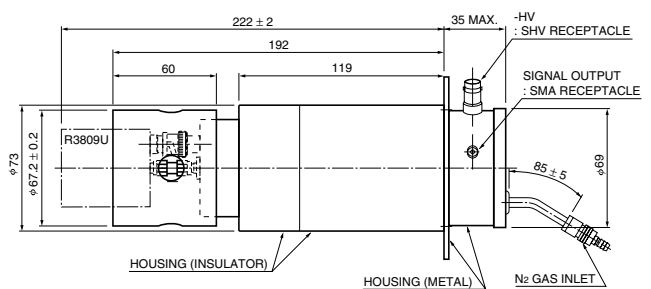
Socket Assemblies for C10372 Series E2762 Series



TACCA0130ED

L: E2762-502...133.5 E2762-510...106.5 * The high voltage contact ring is used for internal electrical connection to the magnetic shield case in the cooler.
E2762-506...144.5 E2762-511...120.5
E2762-509...106.5 E2762-513...120.5

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



TACCA0133EC

NOTE: (A)

E2762 Series	PMT
E2762-502	R980, R1387, R2066, etc.
E2762-506	R943-02, R3310-02
E2762-509	R464, R649, etc.
E2762-510	R329-02, R331-05, R2257, etc.
E2762-511	R374, R2228, R5929, etc.
E2762-513	R375, R669

Thermoelectric Coolers

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 Cockcroft-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 / 75 % RH Max.	+5 °C to +35 °C / 75 % RH Max.	—
Storage Temperature / Humidity [Ⓓ]	-20 °C to +50 °C / 85 % RH Max.		—
Weight	Approx. 1	Approx. 1.7	kg
Feature	Law infufluence 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)
	Output Current	0.5
	Connector	DIN (6 PIN)
Control Interface	DI (Input)	4 bit (TTL input)
	DO (Output)	4 bit (TTL open collector output)
Serial Interface	RS-232C, 9600 bps	—
Operating Temperature / Humidity [Ⓓ]	+5 °C to +40 °C / 75 % RH Max.	—
Storage Temperature / Humidity [Ⓓ]	-20 °C to +50 °C / 85 % RH Max.	—
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.

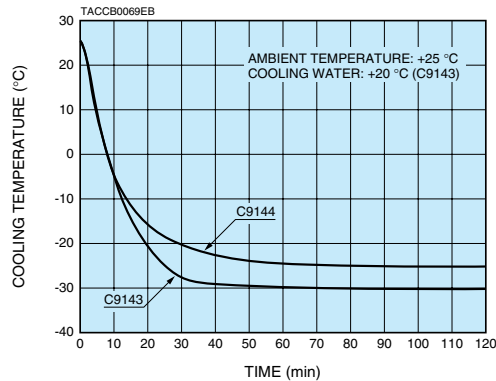
[Components and Accessories]

●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 1.5 m) ●D-Sub 15 pin connector 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)

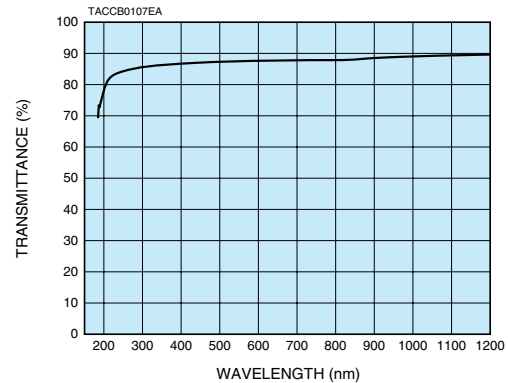
* To use C9143 series, water hoses with an outer diameter of 6 mm and an inner diameter of 4 mm and a water supply line with the matching round faucet are required. Prepare those hoses of the desired length. In addition, prepare a filter for removing impurities such as chlorine ions.

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

Cooling Characteristics

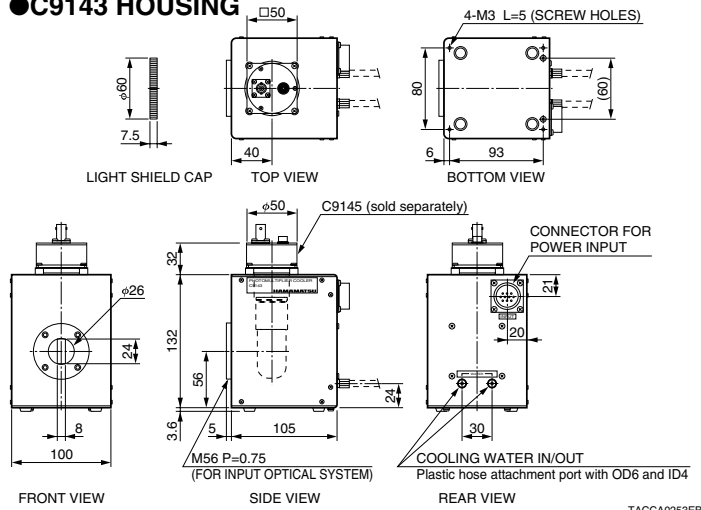


Spectral Transmission Characteristics of Optical Window

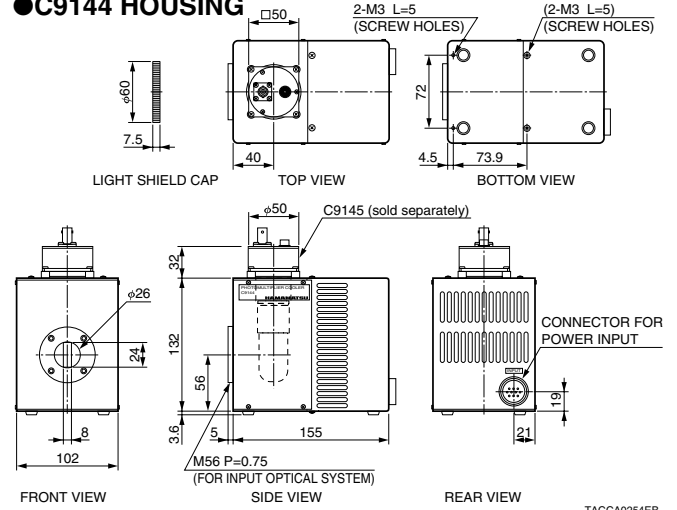


Dimensional Outlines (Unit: mm)

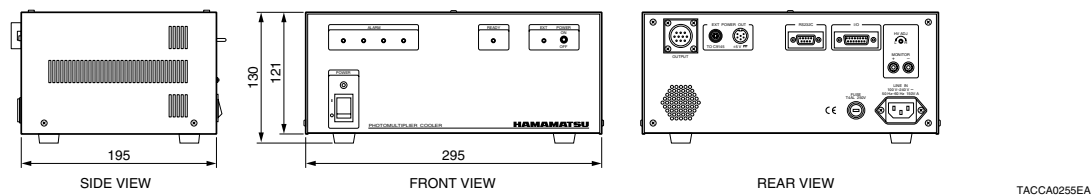
●C9143 HOUSING



●C9144 HOUSING

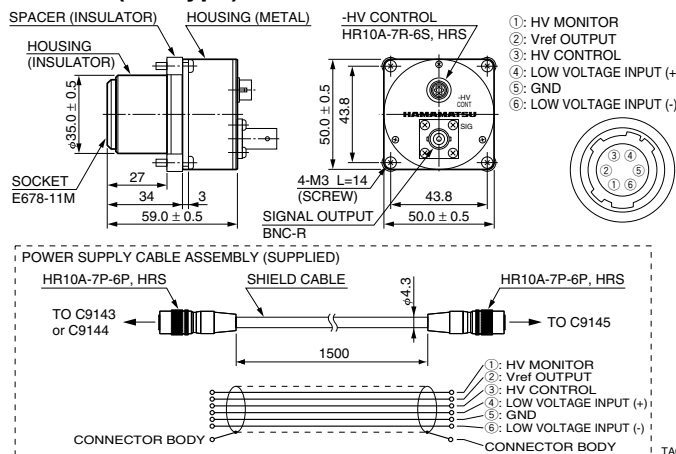


●CONTROLLER

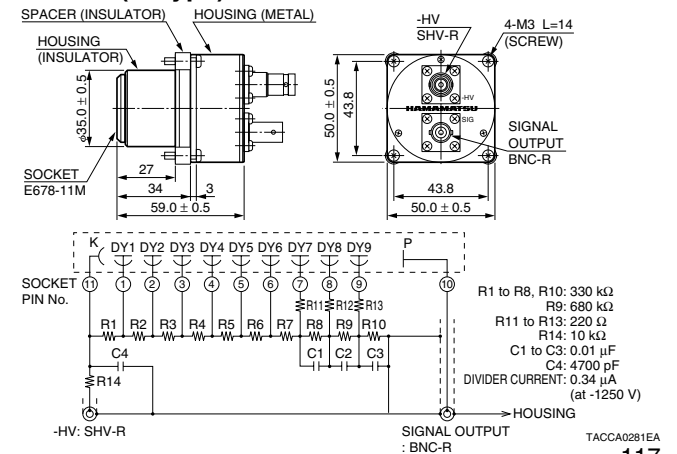


Sold Separately (Unit: mm)

●C9145 (DP Type)



●E9146 (D Type)



Magnetic Shield Cases

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

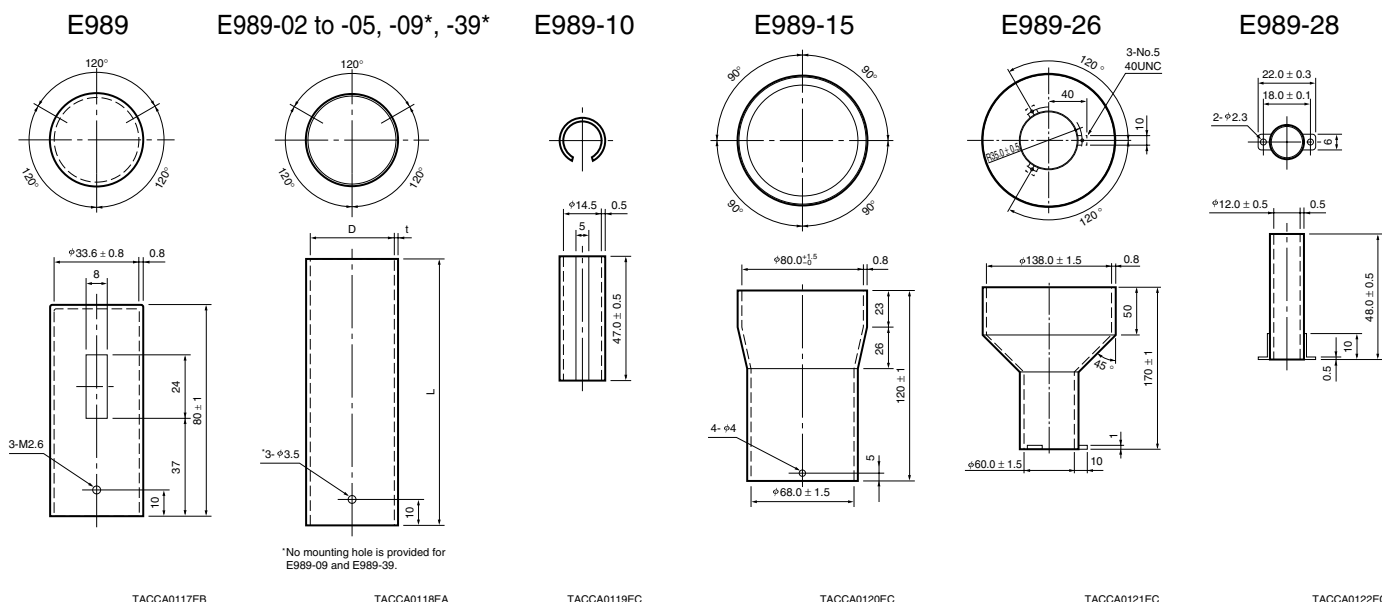
- Made of high-permeability permalloy (Ni: 78 %, Fe and others: 22 %)
- Various sizes available with inner diameters from 12 mm to 138 mm
- Lusterless black paint finish

Specifications

	Photomultiplier Tube Diameter	Type No.	Internal Dia. D (φmm)	Thickness t (mm)	Length L (mm)	Weight (g)
Side-on	φ 13 mm (1/2")	E989-10	14.5	0.5	47 ± 0.5	10
	φ 28 mm (1-1/8") *	E989	33.6 ± 0.8	0.8	80 ± 1	66
Head-on	φ 10 mm (3/8")	E989-28	12 ± 0.5	0.5	48 ± 0.5	9
	φ 13 mm (1/2")	E989-09	16 ± 0.5	0.8	75 ± 0.5	28
	φ 19 mm (3/4")	E989-02	23 ± 0.5	0.8	95 ± 1	50
	φ 25 mm (1")	E989-39	29 ± 0.5	0.8	48 ± 0.5	32
	φ 28 mm (1-1/8")	E989-03	32 ± 0.5	0.8	120 ± 1	90
	φ 38 mm (1-1/2")	E989-04	44 ⁺¹ ₋₀	0.8	100 ± 1	102
	φ 51 mm (2")	E989-05	60 ⁺¹ ₋₀	0.8	130 ± 1	180
	φ 76 mm (3")	E989-15	80 ^{+1.5} ₋₀	0.8	120 ± 1	200
	φ 127 mm (5")	E989-26	138 ± 1.5	0.8	170 ± 1	600

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

Dimensional Outlines (Unit: mm)



Housings, Power and Signal Cables, Connector Adapters

Housing E1341-01/-02

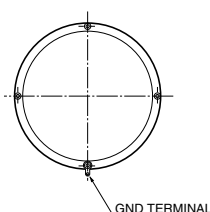
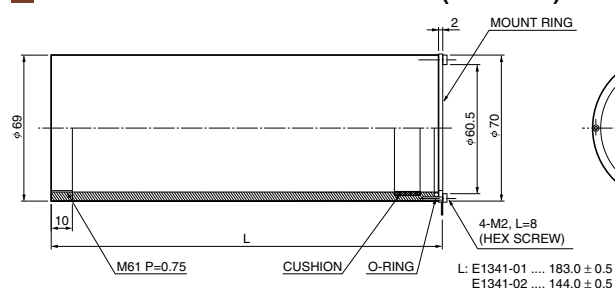


TACCF0177

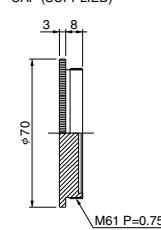
The E1341-01/-02 are metal housings designed for the D-type socket assembly E5859 series (for 51 mm diameter head-on photomultiplier tubes; see page 97) operated at room temperature. To install the E5859 series socket assembly into the E1341-01/-02 and to ensure complete light-shielding, a magnetic shield 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, R3310-02	E989-68

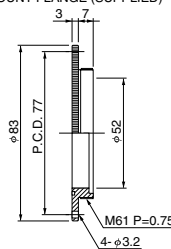
Dimensional Outline (Unit: mm)



CAP (SUPPLIED)



MOUNT FLANGE (SUPPLIED)



TACCA0228EB

Power and Signal Cables E1168 Series, Connector Adapters A4184 Series

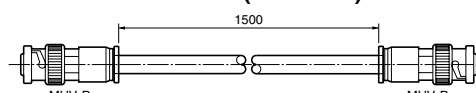


TACCF0153

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.

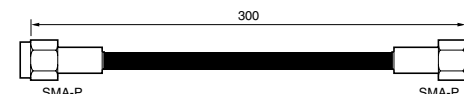
Dimensional Outlines (Unit: mm)

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	MHV-P—MHV-P
E1168-10				MHV-P—SHV-P
E1168-17				SHV-P—SHV-P
E1168-18	Custom High Voltage Cable (Red)	φ6.15 mm ±0.3 mm	5 kV	MHV-P—MHV-P
E1168-19				SHV-P—SHV-P
E1168-20				MHV-P—SHV-P

● For Low Voltage

Type No.	Cable Type	Connector Types
E1168-14	MVVS 2 × 0.3	SR30-10PQ-4P—SR30-10PQ-4P
E1168-24	Multiconductor	SR30-10PQ-4P—DIN6P Plug
E1168-26	Cable with Shield	DIN6P Plug—DIN6P Plug

● For Signal

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

● 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

Related Products for Photon Counting

Photon Counting Unit C9744



TACCF0195

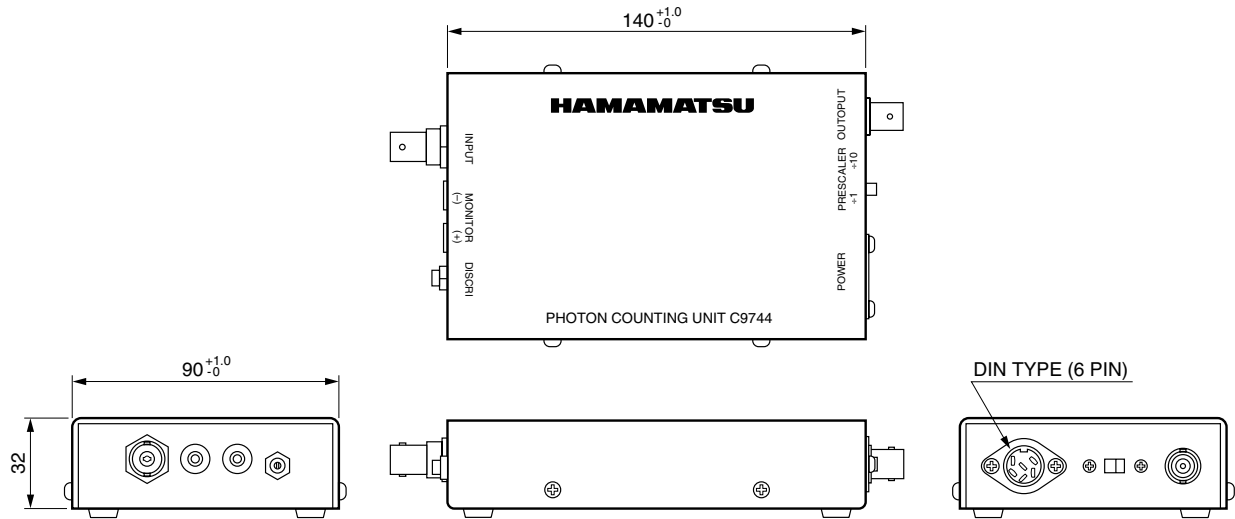
This photon counting unit contains an amplifier and discriminator to convert the single photoelectric pulses from a photomultiplier tube into a 5 V digital signal. The C9744 has an output linearity up to $1 \times 10^7 \text{ s}^{-1}$, and a high-speed counter is not required when set to division by 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		$\div 1 / \div 10$
Count Linearity	$\div 1$	$4 \times 10^6 \text{ s}^{-1}$
	$\div 10$	$1 \times 10^7 \text{ s}^{-1}$
Pulse-pair Resolution	$\div 1$	25 ns
	$\div 10$	10 ns
Output Pulse		CMOS 5 V, POSITIVE LOGIC
Output Pulse Width	$\div 1$	10 ns
	$\div 10$	Depends on count rate
Supply Voltage		+5.0 V $\pm$ 0.2 V, 130 mA / -5.0 V $\pm$ 0.2 V, 50 mA
Connector	Input	BNC-R
	Output	BNC-R
	Power	DIN (6 PIN) [Ⓑ]
Dimensions (W $\times$ H $\times$ D)		90 mm $\times$ 32 mm $\times$ 140 mm (excluding rubber feet and projecting parts)
Weight		Approx. 250 g
Operating Ambient Temperature / Humidity [Ⓐ]		0 $^{\circ}\text{C}$ to +50 $^{\circ}\text{C}$ / 80 % Max.
Storage Temperature / Humidity [Ⓐ]		-15 $^{\circ}\text{C}$ to +60 $^{\circ}\text{C}$ / 85 % Max.

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

Dimensional Outline (Unit: mm)



Counting Unit C8855



The C8855 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 includes two counter circuits (double counter method) capable of counting input signals with no dead time. The USB interface easily connects to a laptop PC allowing measurement in an even wider application field. When used with a photon counting head, the C8855 supplies power (+5 V / 200 mA) necessary to operate the photon counting head.

Since the C8855 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 is delivered by using the sample software that supplied with the C8855.

- **Time-resolved measurement (minimum resolution: 50 μ s) 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 is fully controlled by DLL (dynamic link library) functions that come with the C8855.

All information on these DLL functions is available to support software programming that handles various types of user measurement applications.

Specifications

Parameter		Description / Value
Input	Number of Input Signals	1 ch
	Signal Input Level	TTL positive logic
	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 μ s to 10 s (1, 2, 5 step)
Trigger	Trigger Method	External trigger / Software trigger
	External Trigger Signal	TTL negative logic
General Output Section		Open collector / 2 bits
Voltage Output		+5 V / 200 mA Max.
Compatible OS		Windows® 2000 / XP Pro
Interface		USB (Ver. 1.1)
Supply Voltage		+7 V / 500 mA Max. (supplied from AC adapter)
Dimensions (W $\times$ H $\times$ D)		148 mm $\times$ 30 mm $\times$ 96 mm (excluding rubber feet and projecting parts)
Weight		300 g
Operating Ambient Temperature / Humidity ^(A)		+5 $^{\circ}$ C to +45 $^{\circ}$ C / Below 80 %
Storage Temperature / Humidity ^(A)		0 $^{\circ}$ C to +50 $^{\circ}$ C / Below 85 %
CE Marking		Conforms to the EMC directive (89/336/EEC) and the low voltage directive (73/23/EEC) of the European Union.
AC Adapter	AC Input	90 V to 264 V
	Output	7 V / 1.6 A

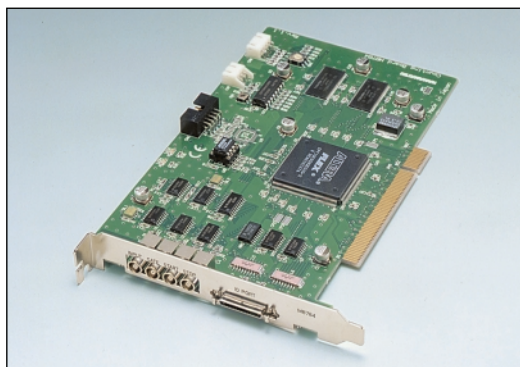
NOTE: (A) No condensation

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.

Related Products for Photon Counting

Photon Counting Board M8784



TPHOF0107

The M8784 counting board is a PCI bus add-in board type counter. The M8784 functions as a photon counter when combined with a photon counting head, etc. The counter of the M8784 includes two counter circuits (double counter method) capable of counting input signals with no dead time. The internal memory allows pulse counting over extended periods with a high time resolution (10 μ s).

A maximum of two M8784 boards can be simultaneously controlled from a PC, making it possible to perform simultaneous dual-channel measurements. Initial setting for the M8784 is simple and easy due to PnP (plug and play). You can start measurement on the day you receive the M8784.

- **Also ideal for long-term data collection such as in biological clock monitoring ^{*)}**

This is an ideal feature when the time needed to record count data in the memory is longer than the time needed to transfer the count data to a PC and write it into the storage medium. This allows time-resolved measurement (minimum resolution: 10 μ s) over a long period of time. Memory recording time is calculated from "counter operation time $\times$ memory length".

(Example: minimum resolution 10 μ s $\times$ maximum memory length 256 000 = 2.56 s)

^{*)} Standard sample software may not work at some conditions depending on the combination of measuring time and time resolution.

Please consult with our sales office in advance with information of your condition.

- **Time-resolved measurement of chemiluminescence (minimum resolution 10 μ s)**

- **Supports different kinds of measurements**

The M8784 is fully controlled by DLL (dynamic link library) functions that come with the M8784.

All information on these DLL functions is available to support software programming that handles various types of user measurement applications.

Specifications

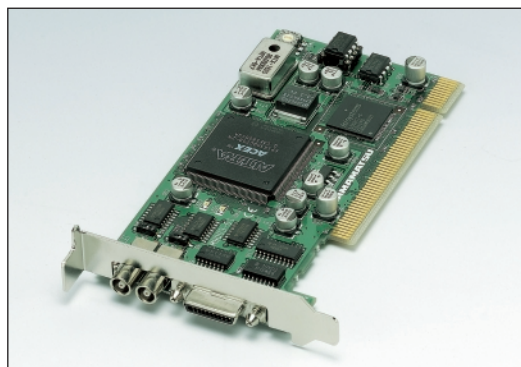
Parameter		Description / Value
Input	Number of Input Signals	1 ch
	Signal Input Level	TTL positive logic
	Signal Pulse Width	8 ns or longer
	Input Impedance	50 Ω
Counter	Counter Method	Double counter method
	Maximum Count Rate	50 MHz
	Maximum Counter Capacity	2 ³² counts / counter gate
Counter Gate	Counter Gate Mode	Internal, external, START-STOP
	Internal Counter Gate Time	10 μ s to 10 s (1, 2, 5 step)
	External Counter Gate Time	100 ns or longer
Trigger	Trigger Method	External trigger / Software trigger
	External Trigger Signal	TTL negative logic
Memory	Memory Method	Double memory method
	Memory Data Width	128 000 (when capacity of 2 ³² is selected) / 256 000 (when capacity of 2 ¹⁶ is selected)
	Memory Capacity	2 ³² (32 bit) / 2 ¹⁶ (16 bit)
General I/O	Input Signal	TTL negative logic / 8 bit
	Output Signal	Open collector / 8 bit
Compatible OS		Windows® 2000 / XP Pro [Ⓐ]
Bus Type		PCI bus interface (conforms to Rev. 2.1) [Ⓐ]
Size		PCI standard (half size)
Weight		150 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 EMC directive (89/336/EEC) of the European Union

NOTE: [Ⓐ]Cannot operate with a PC that supports PCI express. [Ⓑ]No condensation

Supplied: CD-ROM (containing instruction manual, device driver, DLL, sample software*, etc.), Signal input cable (E1168-22), General-purpose I/O connector (JAE: TXA20A-26PH1-D2P1-D1), Connection cable set (JAE: XHP-3, XHP-4)

* 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 k Ω (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 12.8 μ s
Trigger	Trigger Method	External trigger / Software trigger
	External Trigger Signal	TTL negative logic
	Trigger Signal Pulse Width	1 μ s or more
	Trigger Signal Output Timing	At start of counting by software trigger
General I/O	Input Signal	TTL level signal (7 bits)
	Input Strobe Signal	TTL level signal
	Output Signal	Open collector (8 bits)
	Output Strobe Signal	Open collector
Compatible OS		Windows [®] 2000 / XP Pro
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		80 g
Operating Ambient Temperature / Humidity [Ⓐ]		+5 °C to +45 °C / Below 80 %
Storage Temperature / Humidity [Ⓐ]		0 °C to +45 °C / Below 85 %
CE Marking		Conforms to EMC directives (89 / 336 / EEC) of the European Union

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 $\times$ 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

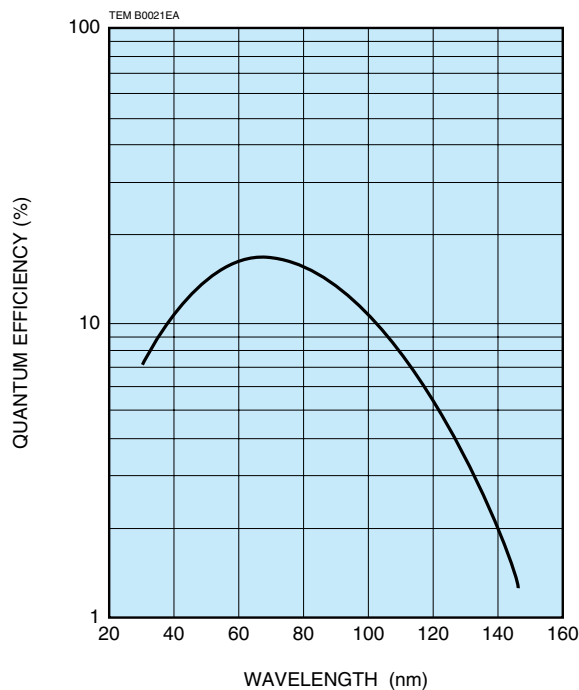
Electron multipliers (also called ion multipliers) are specially designed for the detection and measurement of electrons, ions, charged particles, VUV radiation and soft X-rays. Hamamatsu electron multipliers deliver high gain and low noise, making them ideal for the detection of very small or low energy 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.

py and ESCA.

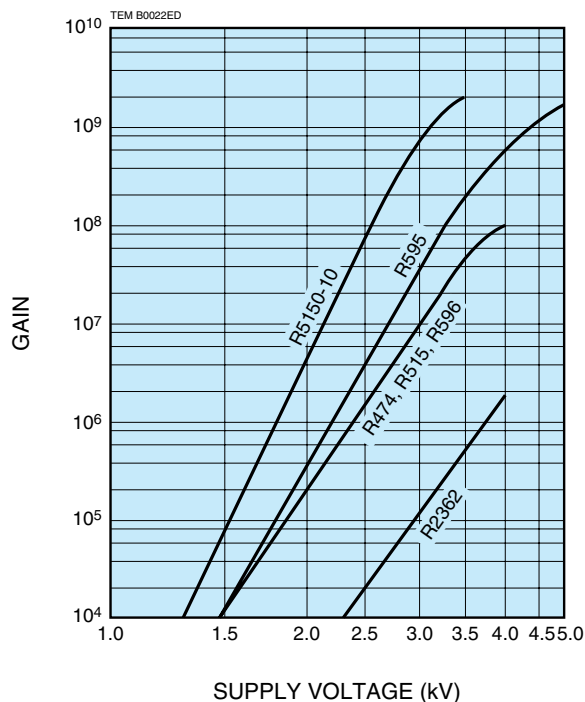
Each type has Cu-BeO dynodes connected by built-in divider resistors of 1 M Ω per stage. The first dynode can be replaced by a photocathode of Cs-I, K-Br, and so on for use in VUV spectroscopy. In applications where the operating vacuum level is inadequate, the R5150-10 is recommended. In TOF-MS applications, 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	①	17	Box and Line	Cu-BeO	φ8	2000	5 × 10 ⁶	1.7	4.0	3500	350	10	133 × 10 ⁻⁴
R2362	②	23	Mesh	Cu-BeO	φ20	3450	5 × 10 ⁵	3.5	23	4000	350	10	133 × 10 ⁻⁴
R474	③	16	Box and Grid	Cu-BeO	8 × 6	2400	1 × 10 ⁶	9.3	5.0	4000	350	10	133 × 10 ⁻⁴
R515	④	16	Box and Grid	Cu-BeO	8 × 6	2400	1 × 10 ⁶	9.3	4.0	4000	350	10	133 × 10 ⁻⁴
R596	⑤	16	Box and Grid	Cu-BeO	12 × 10	2400	1 × 10 ⁶	10	9.0	4000	400	10	133 × 10 ⁻⁴
R595	⑥	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)

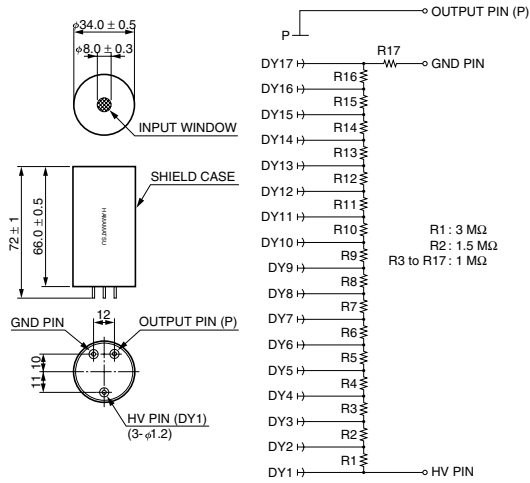


Gain



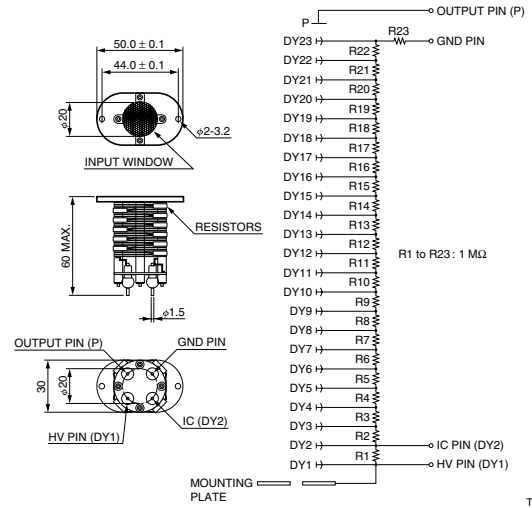
Dimensional Outlines (Unit: mm)

1 R5150-10



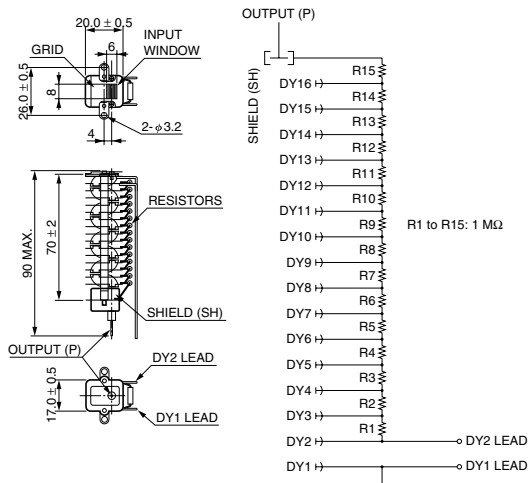
TEM A0015EB

2 R2362



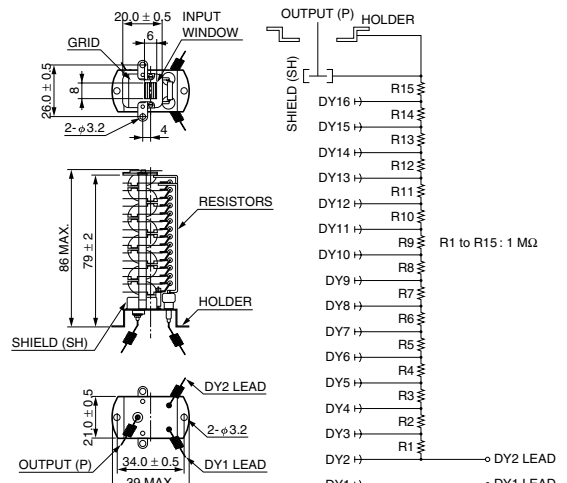
TEM A0009EC

3 R474



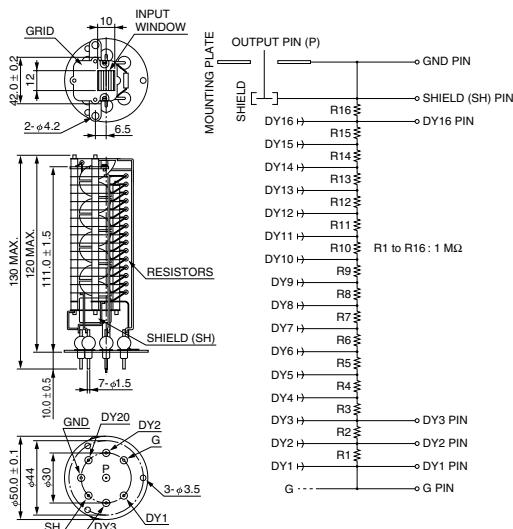
TEM A0005EC

4 R515



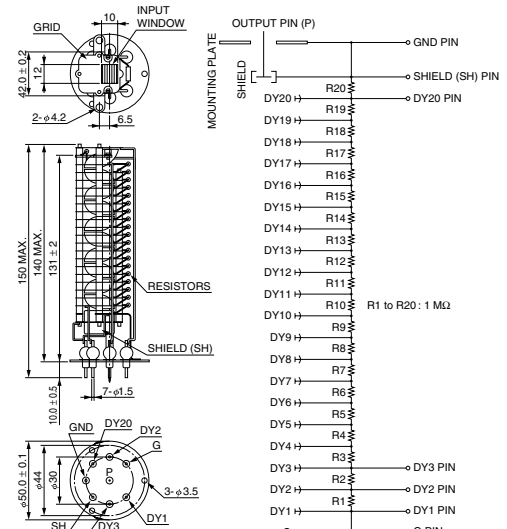
TEM A0006ED

5 R596



TEM A0007ED

6 R595



TEM A0008ED

Caution and Warranty

SAFETY PRECAUTIONS

WARNING



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.

* 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.) (nm)	Spectral Response					PMT Examples
				Range (nm)	Peak Wavelength				
					Radiant Sensitivity		QE		
					(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, R1893, 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, R980, R1307, R1548-07, R1635 R1924A, R5611A-01, 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, R4607-01
○	402K	Low noise Bialkali	Borosilicate	40	300 to 650	54	375	18	375	R2557, R3550A, R5610A
	430U	Bialkali	UV	50	185 to 650	62	375	20	300	R2693
○	500K(S-20)	Multialkali	Borosilicate	150	300 to 850	64	420	20	375	R550, R649, R1387, R1513, R1617, R1878, R1894, R1925A
○	500U	Multialkali	UV	150	185 to 850	64	420	25	280	R374, R1463, R2368
○	500S	Multialkali	Synthetic silica	150	160 to 850	64	420	25	280	R375
○	501K(S-25)	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*

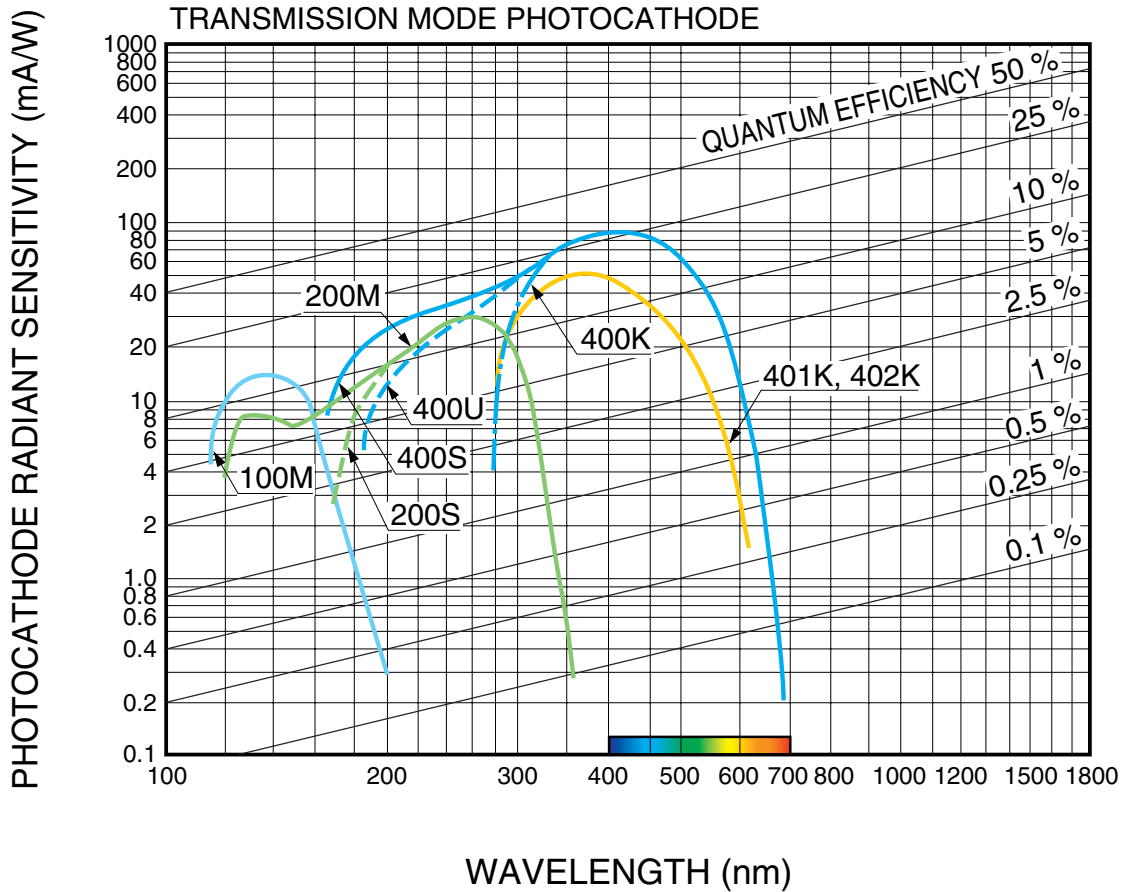
Reflection mode Photocathode

○	150M	Cs-I	MgF ₂	—	115 to 195	25.5	130	26	125	R7511, R8487
○	250S	Cs-Te	Synthetic silica	—	160 to 320	62	240	37	210	R6354, R7154
○	250M	Cs-Te	MgF ₂	—	115 to 320	63	220	35	220	R7311, R8486
○	350K(S-4)	Sb-Cs	Borosilicate	40	300 to 650	48	400	15	350	R105, 1P21, 931A
○	350U(S-5)	Sb-Cs	UV	40	185 to 650	48	340	20	280	R212, R3810, R6350, 1P28
○	351U(Ext'd S-5)	Sb-Cs	UV	70	185 to 750	70	410	25	280	R6925
○	452U	Bialkali	UV	120	185 to 750	90	420	30	260	R3788, R6352
	453K	Bialkali	Borosilicate	60	300 to 650	60	400	19	370	931B
○	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	R3811, 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
	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*

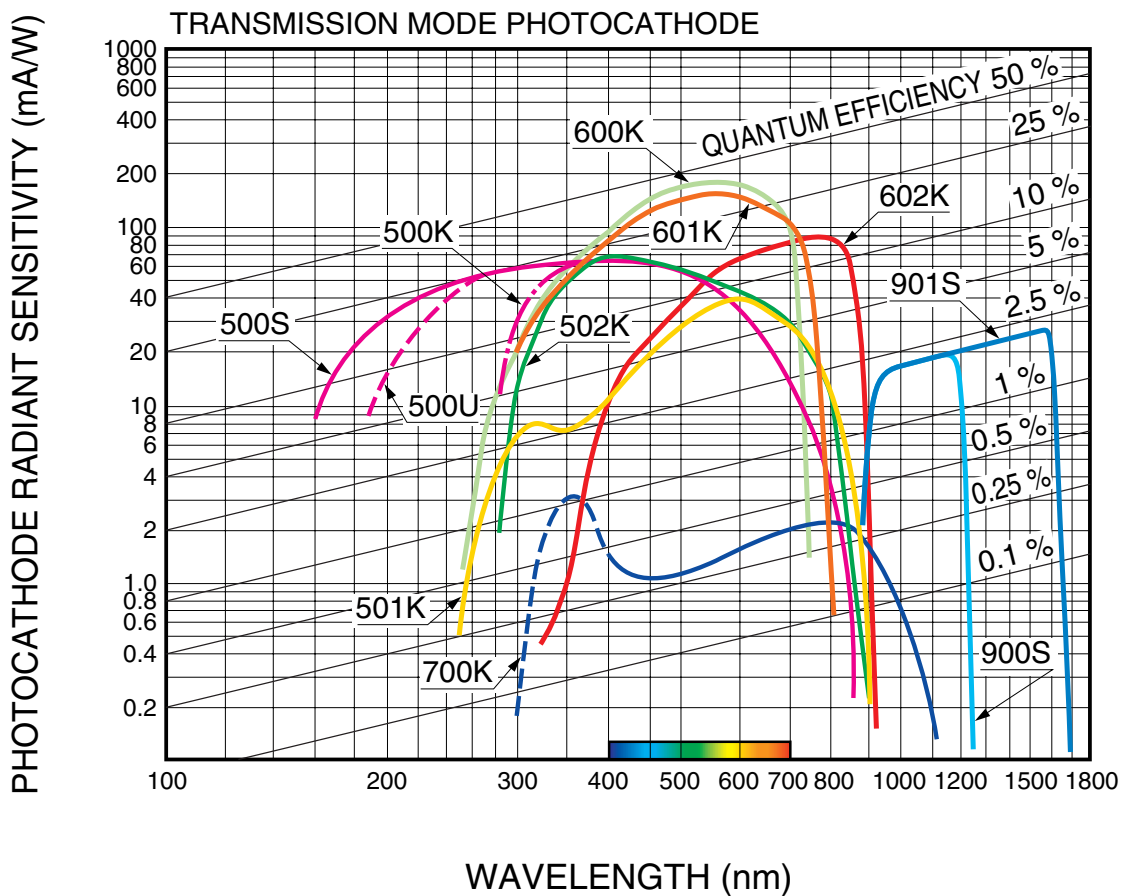
○: Spectral response curves are shown on page 128, 129

*: Products marked are not listed in this catalog.

SEMITRANSSPARENT PHOTOCATHODE SPECTRAL RESPONSE CHARACTERISTICS

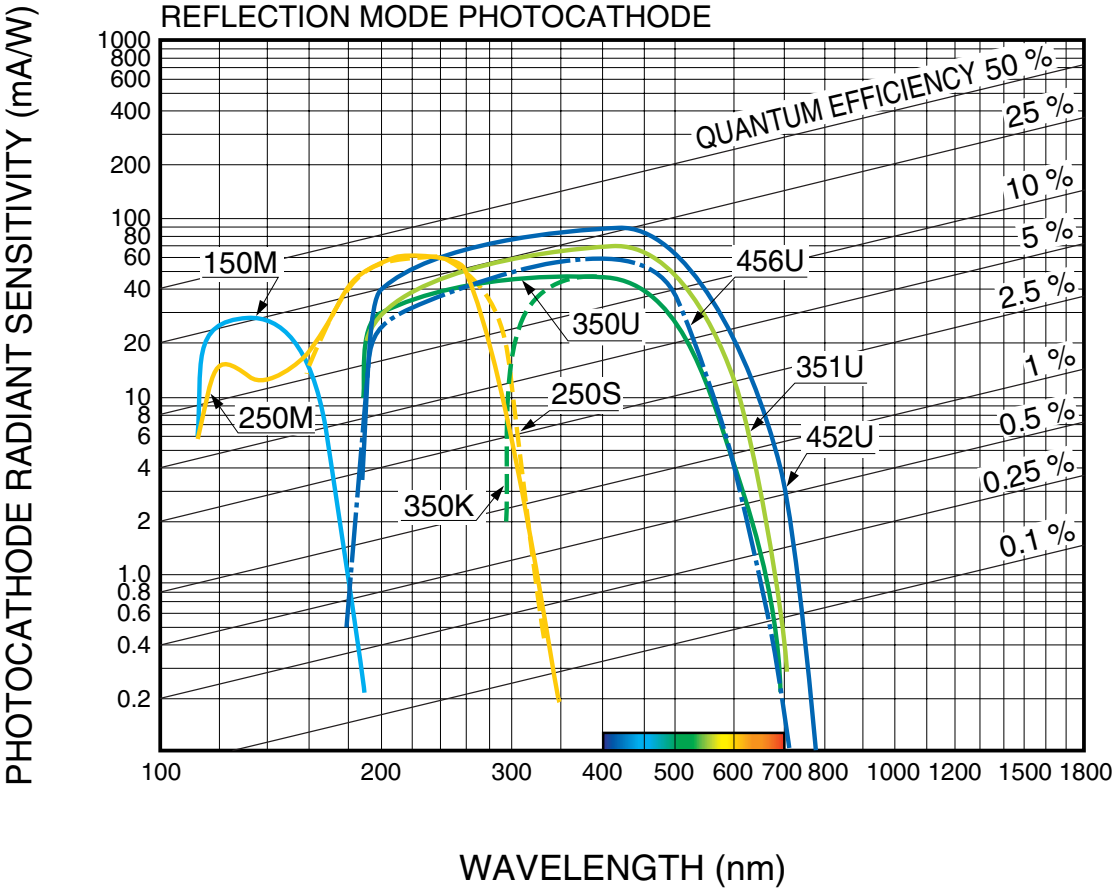


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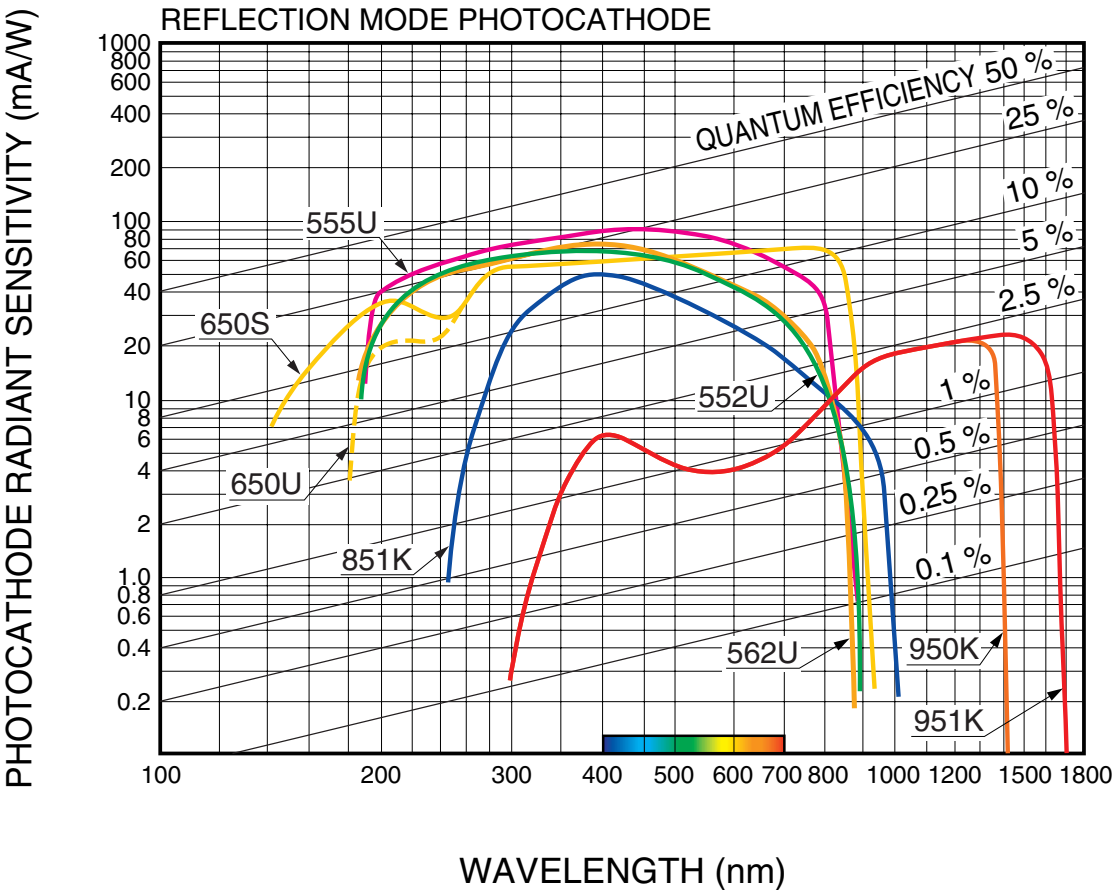


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OPAQUE PHOTOCATHODE SPECTRAL RESPONSE CHARACTERISTICS



TPMOB0079EG



TPMOB0080EJ

Notes

A Types marked * are newly listed in this catalog.

B See pages 128 and 129 for typical spectral response charts.

C Photocathode materials

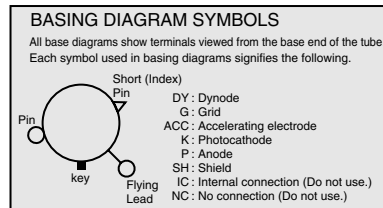
BA :	Bialkali
LBA :	Low noise bialkali
HBA :	High temperature bialkali
MA :	Multialkali
EMA :	Extended red multialkali
DIA :	Diamond

Other photocathodes are indicated by the element symbols.

D Window materials

MF :	MgF ₂
Q :	Quartz (Fused silica or synthetic silica)
K :	Borosilicate glass
U :	UV glass

E Base diagram



F Dynode structure

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

G See page 88 for suitable socket assemblies.

See page 72 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.

H 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.

J Averaged over any interval of 30 seconds maximum.

K Measured at the peak sensitivity wavelength.

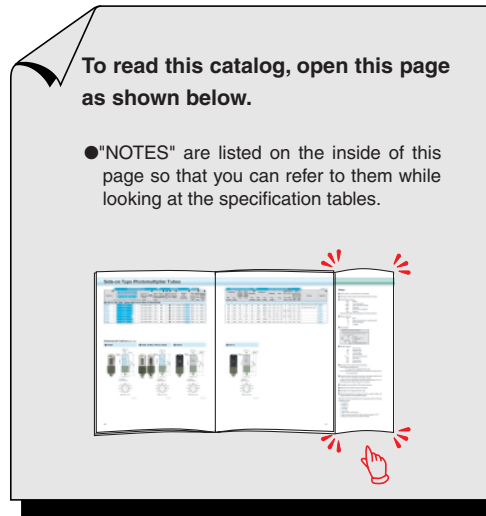
L See page 70 for voltage distribution ratio.

M 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.

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

How to Use This Folding Page



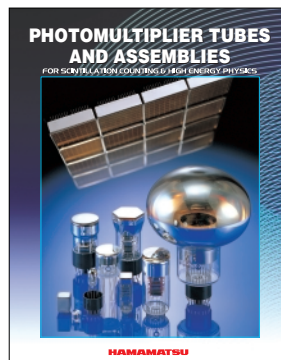
Related Product Catalogs

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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www.hamamatsu.com

Main Products

Electron Tubes

Photomultiplier Tubes
Light Sources
Microfocus X-ray Sources
Image Intensifiers
X-ray Image Intensifiers
Microchannel Plates
Fiber Optic Plates

Opto-semiconductors

Si Photodiodes
Photo IC
PSD
InGaAs PIN Photodiodes
Compound Semiconductor Photosensors
Image sensors
Light Emitting Diodes
Application Products and Modules
Optical Communication Devices
High Energy Particle/X-ray Detectors

Imaging and Processing Systems

Video Cameras for Measurement
Image Processing Systems
Streak Cameras
Optical Measurement Systems
Imaging and Analysis Systems

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