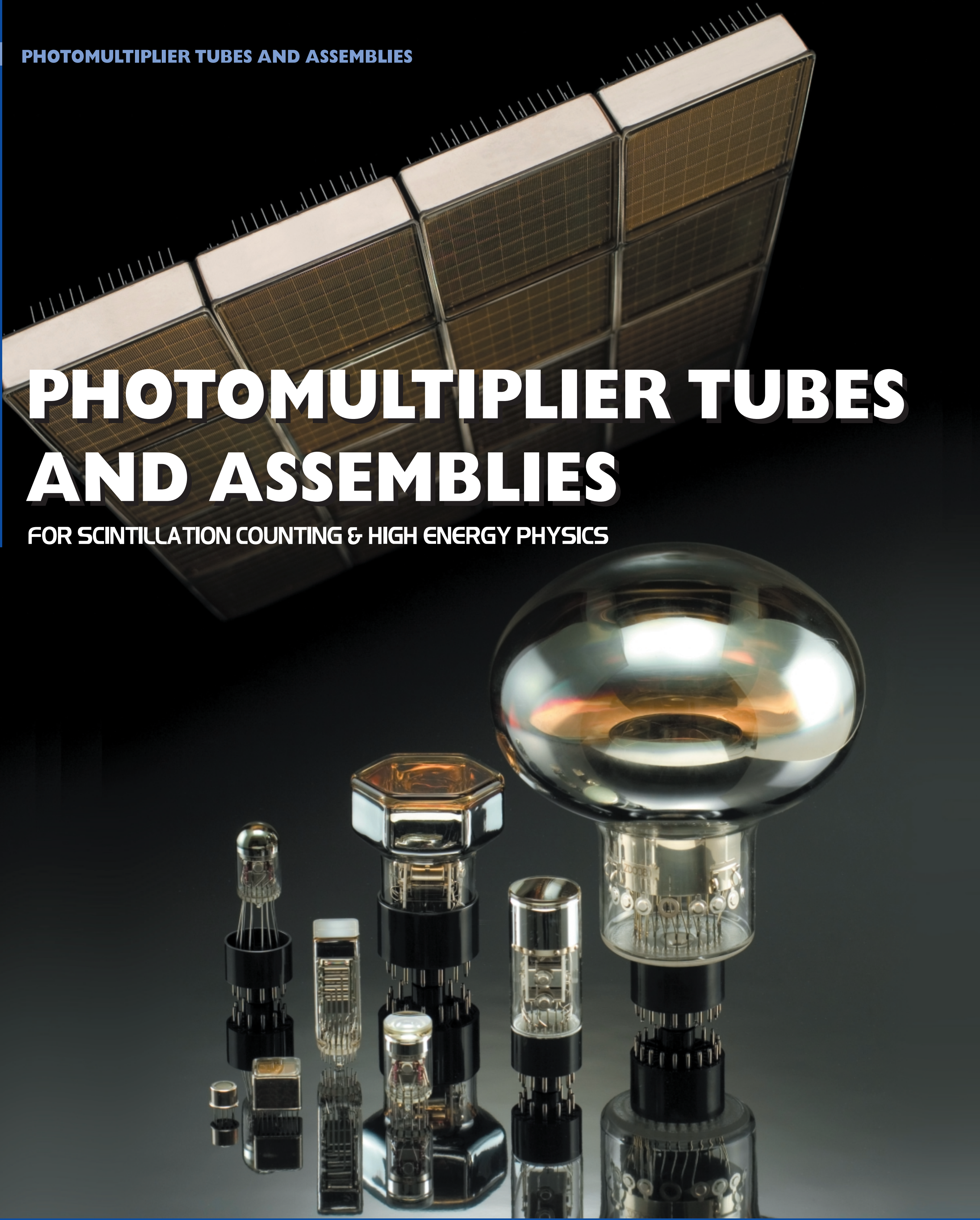
PHOTOMULTIPLIER TUBES AND ASSEMBLIES

FOR SCINTILLATION COUNTING & HIGH ENERGY PHYSICS



HAMAMATSU
PHOTON IS OUR BUSINESS

INTRODUCTION

In radiation measurements, scintillation counters which are combinations of scintillators and photomultiplier tubes are used as most common and useful devices in detecting X-, alpha-, beta-, gamma-rays and other high energy charged particles. A scintillator emits flashes of light in response to input radiations and a photomultiplier tube coupled to a scintillator detects these scintillation lights in a precise way.

In high energy physics experiments, one of important apparatuses is a Cherenkov counter in which photomultiplier tubes detect Cherenkov radiations emitted by high energy charged particles passing through a dielectric material.

To detect radiations accurately, photomultiplier tubes may be required to have high detecting efficiency (QE & energy resolution), wide dynamic range (pulse linearity), good time resolution (T.T.S.), high stablility & reliability, and to be operatable in high magnetic field environment or at high temperature condition. In addition, a ruggedized construction is required according to circumstances. On the other hand, several kinds of position sensitive photomultiplier tubes have been developed and are used in these measurements.

This catalog provides a quick reference for Hamamatsu photomultiplier tubes, especially designed or selected for scintillation counters and Cherenkov radiation detectors, and includes most of types currently available ranging in size from 3/8" through 20" in diameter. It should be noted that this catalog is just a starting point in describing Hamamatsu product line since new types are continuously under-development.

Please feel free to contact us with your specific requirements.

Photomultiplier Tubes and Assemblies

For Scintillation Counting and High Energy Physics

TABLE OF CONTENTS

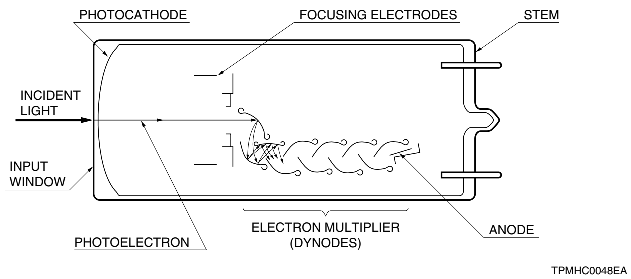
Operating Characteristics

This section describes the prime features of photomultiplier tube construction and basic operating characteristics.

1. GENERAL

The photomultiplier tube (PMT) is a photosensitive device consisting of an input window, a photocathode, focusing electrodes, an electron multiplier (dynodes) and an anode in a vacuum tube, as shown in Figure 1. When light enters the photocathode, the photocathode emits photoelectrons into vacuum by the external photoelectric effect. These photoelectrons are directed by the potential of focusing electrode towards the electron multiplier where electrons are multiplied by the process of secondary electron emission.
The multiplied electrons are collected to the anode to produce output signal.

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



2. PHOTOCATHODE

2.1 Spectral Response

The photocathode of PMT converts energy of incident light into photoelectrons by the external photoelectric effect. The conversion efficiency, that is photocathode sensitivity, varies with the wavelength of incident light. This relationship between the photocathode sensitivity and the wavelength is called the spectral response characteristics.
Typical spectral response curves of the variation of bialkali photocathodes are shown on the inside of the back cover.
The spectral response range is determined by the photocathode material on the long wavelength edge, and by the window material on the short wavelength edge.
In this catalog, the long wavelength cut-off of spectral response range is defined as the wavelength at which the cathode radiant sensitivity drops to 1 % of the maximum sensitivity.

2.2 Quantum Efficiency and Radiant Sensitivity

Spectral response is usually expressed in term of quantum efficiency and radiant sensitivity as shown on the inside the back cover.
Quantum efficiency (QE) is defined as the ratio of the number of photoelectrons emitted from the photocathode to the number of incident photons.
It's customarily stated as a percentage.
The equation of QE is as follows:

$$QE = \frac{\text{Number of Photoelectrons}}{\text{Number of Photons}} \times 100\ (\%)$$

Radiant sensitivity (S) is the photoelectric current from the photocathode divided by the incident radiant power at a given wavelength, expressed in A/W (ampere per watt).
The equation of S is as follows:

$$S = \frac{\text{Photoelectric Current}}{\text{Radiant Power of Light}}\ (\text{A/W})$$

Quantum efficiency and radiant sensitivity have the following relationship at a given wavelength.

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

where λ is the wavelength in nm (nanometer).

2.3 Window Materials

The window materials commonly used in PMT are as follows:

(1) Borosilicate glass

This is the most frequently used material. It transmits light from the infrared to approximately down to 300 nm.
For some scintillation applications where radioactivity of K40 contained in the glass affects the measurement, "K-free" glass is recommended.
As "K-free" glass contains very little amount of Potassium, the background counts originated by ^{40}K is minimized.

(2) UV-transmitting glass

This glass transmits ultraviolet light well as the name implies, and it is widely used. The UV cut-off wavelength is approximately 185 nm.

(3) Synthetic silica

This material transmits ultraviolet light down to 160 nm. Silica is not suitable for the stem material of tubes because it has a different thermal expansion coefficient from kovar metal which is used for the tube leads. Thus, borosilicate glass is used for the stem. In order to seal these two materials having different thermal expansion ratios, a technique called graded seal is used. This is a technique to seal several glass materials having gradually different thermal expansion ratios. Another feature of silica is superiority in radiation hardness.

2.4 Photocathode Materials

The photocathode is a photoemissive surface with very low work and high energy physics applications:

(1) Bialkali

This has a spectral response which fits the emission spectra of most scintillators. Thus, it is frequently used for scintillator applications.

(2) High Temperature Bialkali

This is particularly useful at higher operating temperatures up to 175 °C. Its major application is oil well logging. Also it can be operated with very low dark current at the room temperature.

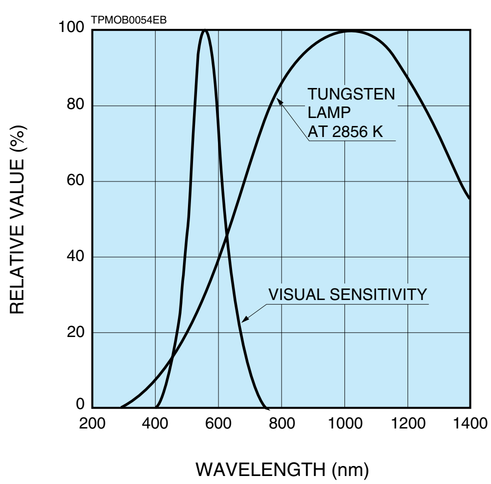
As stated above, the spectral response range is determined by the materials of the photocathode and the window as shown in Figure 33.
It is important to select appropriate materials which will suit the application.

2.5 Luminous and Blue Sensitivity

Since the measurement of spectral response characteristics of a PMT requires a sophisticated system and time, it isn't practical to provide spectral response data on each tube. Instead, cathode and anode luminous sensitivity data are usually attached.

The cathode luminous sensitivity is the photoelectric current from the photocathode per incident light flux (10^{-5} to 10^{-2} lumen) from a tungsten filament lamp operated at a distribution temperature of 2856 K.
The cathode luminous sensitivity is expressed in the unit of μA/lm (micro amperes per lumen).
Note that the lumen is a unit used for luminous flux in the visible region, therefore these values may be meaningless for tubes which are sensitive out of the visible region (refer to Figure 2).
The cathode blue sensitivity is the photoelectric current from the photocathode per incident light flux of a tungsten filament lamp at 2856 K passing through a blue filter. Corning CS-5-58 filter which is polished to half stock thickness is used for the measurement of this sensitivity. This filter is a band-pass filter and its peak wavelength of transmittance is 400 nm.
Since the light flux, once transmitted through the blue filter, can not be expressed in lumen, the blue sensitivity is usually represented by the blue sensitivity index.
The blue sensitivity is a very important parameter in the scintillation counting since most of the scintillators produce emission spectrum in the blue region, and it may dominant factor of energy resolution.
These parameters of cathode luminous and blue sensitivities are particularly useful when comparing tubes having the same or similar spectral response ranges. Hamamatsu final test sheets accompanied with tubes usually indicate these parameters.

Figure 2: Typical Human Eye Response and Spectral Distribution of 2856 K Tungsten Lamp



3. ELECTRON MULTIPLIER (DYNODES)

The superior sensitivity (high gain and high S/N ratio) of PMT is due to a low noise electron multiplier which amplifies electrons in a vaccum with cascade secondary emission process. The electron multiplier consists of several to up to 19 stages of electrodes which are called dynodes.

3.1 Dynode Types

There are several principal types of dynode structures. Features of each type are as follows:

(1) Linear focused type

Fast time response, high pulse linearity

(2) Box and grid type

Good collection efficiency, good uniformity

(3) Box and linear focused type

Good collection efficiency, good uniformity, low profile

(4) Circular cage type

Fast time response, compactness

(5) Venetian blind type

Good uniformity, large output current

(6) Fine mesh type

High immunity to magnetic fields, good uniformity, high pulse linearity, position detection possible.

(7) Coarse mesh type

Immunity to magnetic fields, high pulse linearity, position detection possible.

(8) Metal channel type

Compact dynode construction, fast time response, position detection possible.

Also hybrid dynodes combining two of the above dynodes have been developed. These hybrid dynodes are designed to provide the merits of each dynode type.

4. ANODE

The PMT anode output is the product of photoelectric current from the photocathode and gain. Photoelectric current is proportional to the intensity of incident light. Gain is determined by the applied voltage on a specified voltage divider.

4.1 Luminous sensitivity

The anode luminous sensitivity is the anode output current per incident light flux (10^{-10} to 10^{-5} lumen) from a tungsten filament lamp operated at a distribution temperature of 2856 K. This is expressed in the unit of A/lm (amperes per lumen) at a specified anode-to-cathode voltage with a specified voltage divider.

4.2 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 (cascade process), a high gain is achieved. Therefore a very small photoelectric current from the photocathode can be observed as a large output current from the anode of the PMT.

Gain is simply the ratio of the anode output current to the photoelectric current from the photocathode. Ideally, the gain of the PMT is defined as δn, where n is the number of dynode stage and δ is an average secondary emission ratio.

While the secondary electron emission ratio δ is given by

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

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

When a voltage V is applied between the cathode and the anode of the PMT having n dynode stages, gain G becomes

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

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

Figure 3: Example of Gain vs. Supply Voltage

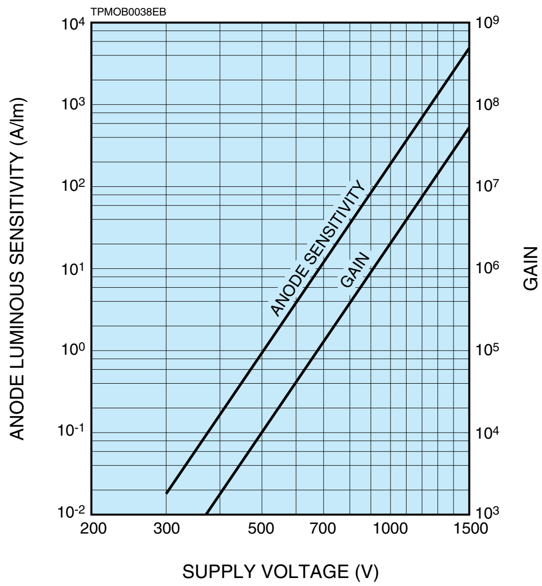


Figure 3 shows gain characteristics.

Since generally PMTs have 8 to 12 dynode stages, the anode output varies directly with the 6th to 10th power of the change in applied voltage. The output signal of the PMT is extremely susceptible to fluctuations in the power supply voltage, thus the power supply should be very stable and exhibit minimum ripple, drift and temperature coefficient. Regulated high voltage power supplies designed with this consideration are available from Hamamatsu.

5. ANODE DARK CURRENT

A small amount of output current flows in a PMT even when it is operated in complete darkness. This current is called the anode dark current. The dark current and the noise resulted from are critical factors to determin the lower limit of light detection.

The causes of dark current may be categorized as follows:

(1) Thermionic emission of electrons

Since the materials of the photocathode and dynodes have very low work functions, they emit thermionic electrons even at the room temperature. Most of the dark current originates from the thermionic emissions especially from the photocathode, and it is multiplied by the dynodes.

(2) Ionization of residual gases

Residual gases inside the PMT can be ionized by the flow of photoelectrons. When these ions strike the photocathode or earlier stages of dynodes, secondary electrons may be emitted, thus resulting 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 PMT's are designed to minimize afterpulses.

(3) Glass scintillation

In case electrons deviating from their normal trajectories strike the glass envelope, scintillations may occur and dark pulses may result. To eliminate these pulses, PMT's may be operated with the anode at high voltage and the cathode at the ground potential. Otherwise it is useful to coat the glass bulb with a conductive paint connected to the cathode (called HA treatment: see page 13).

(4) Ohmic leakage

Ohmic leakage resulting from insufficient insulation of the glass stem base and socket may be another source of dark current. This is predominant when a PMT is operated at a low voltage or low temperature.

Contamination by dirt and humidity on the surface of the tube may cause ohmic leakage, and therefore should be avoided.

(5) Field emission

When a PMT is operated at a voltage near the maximum rating value, some electrons may be emitted from electrodes by strong electric fields causing dark pulses. It is therefore recommended that the tube be operated at 100 volts to 300 volts lower than the maximum rating.

The anode dark current decreases along time after a PMT is placed in darkness. In this catalog, anode dark currents are specified as the state after 30 minutes storage in darkness.

6. TIME RESPONSE

In applications where forms of the incident light are pulses, the anode output signal should reproduce a waveform faithful to the incident pulse waveform.
This reproducibility depends on the anode pulse time response.

(1) Rise Time (refer to Figure 4)

The time for the anode output pulse to rise from 10 % to 90 % of the peak amplitude when the whole photocathode is illuminated by a delta-function light pulse.

(2) Electron Transit Time (refer to Figure 4)

The time interval between the arrival of a delta-function light pulse at the photocathode and the instant when the anode output pulse reaches its peak amplitude.

(3) T.T.S. (Transit Time Spread) (refer to Figure 5)

This is also called the transit time jitter. This is the fluctuation in transit time between individual pulses, and is defined as the FWHM of the frequency distribution of electron transit times. T.T.S. depends on the number of incident photons. The values in this catalog are measured in the single photoelectron state.

Figure 4: Definition of Rise Time and Transit Time

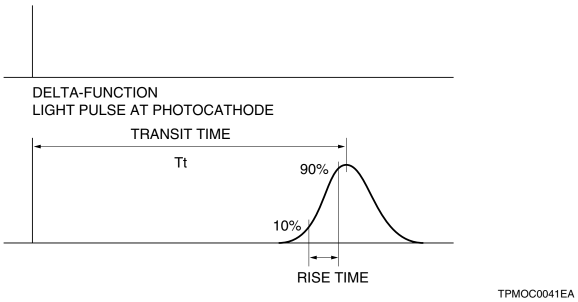
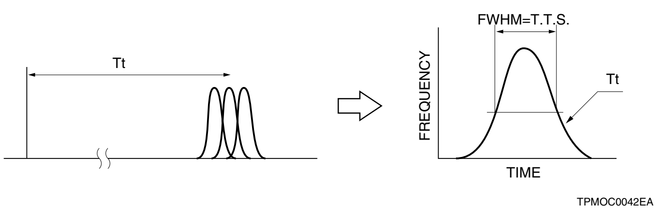


Figure 5: Definition of T.T.S.



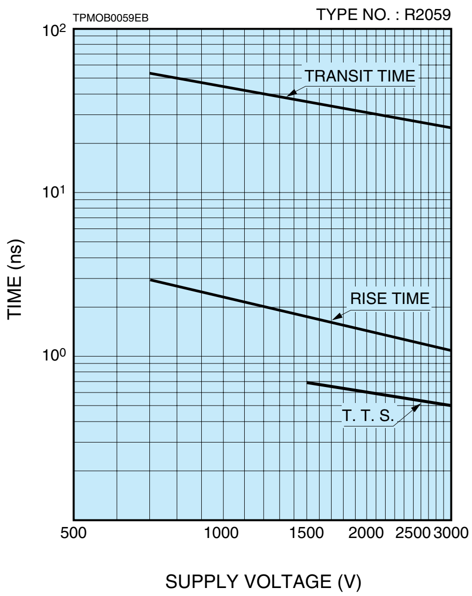
(4) C.R.T. (Coincident Resolving Time)

This is one of the important parameters in high energy physics applications and is defined as the FWHM of a coincident timing spectrum of a pair PMT's facing each other when they detect coincident gamma-ray emission due to positron annihilation of a radiation source (^{22}Na). The scintillators used are CsF, BGO or BaF_2 crystals. These PMT's can be selected for special requirements.

These parameters are affected by the dynode structure and applied voltage. In general, PMTs of the linear focused or circular cage structure exhibit better time response than that of the box-and-grid or venetian blind structure.

Figure 6 shows typical time response characteristics vs. applied voltage for types R2059 (51 mm dia. head-on, 12-stage, linear-focused type).

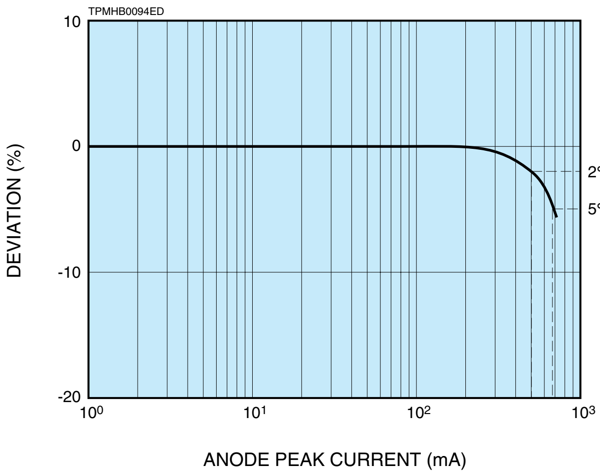
Figure 6: Time Response Characteristics vs. Supply Voltage



7. PULSE LINEARITY

The definition of the pulse linearity is proportionality between the input light amount and the output current in the pulse operation mode. When intense light pulses are to be measured, it's necessary to know the pulse linearity range of the PMT.
In this catalog, typical values of pulse linearity are specified at two points (±2 % and ±5 % deviations from linear proportionality), as shown in Figure 7.
The two-pulse technique is employed in this measurement. LED's are used for a pulsed light source. Its pulse width is 50 ns and the repetition rate is 1 kHz.
The deviation from the proportionality is called non-linearity in this catalog. The cause of non-linearity is mainly a space charge effect in the later stages of an electron multiplier. This space charge effect depends on the pulse height of the PMT output current and the strength of electric fields between electrodes.

Figure 7: Example of Pulse Linearity Characteristic



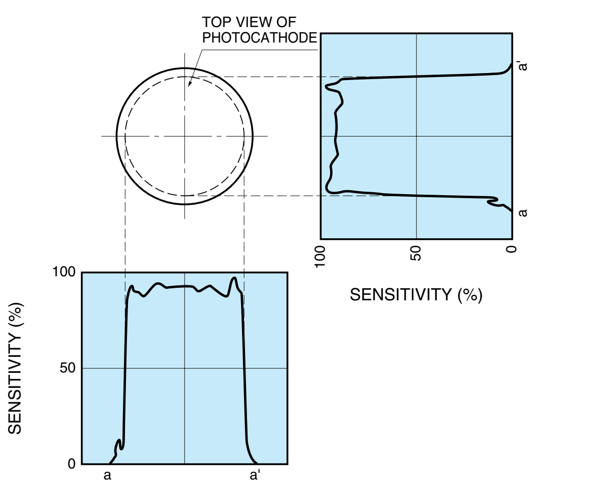
The special voltage distribution ratios are designed to achieve strong electric fields in the later stages of the electron multiplier. Some types are specified with these special voltage dividers.

8. UNIFORMITY

Although the focusing electrodes of a PMT 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 and collection efficiency is degraded. 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.

PMTs especially designed for gamma camera applications have excellent spatial uniformity. Example of spatial uniformity is shown in Figure 8.

Figure 8: Example of Spatial Uniformity



9. STABILITY

In scintillation counting, there are two relevant stability characteristics for the PMT in pulse height mode operation, the long term and the short term. In each case a ^{137}Cs source (662 keV), and an NaI(Tl) scintillator, and a multichannel pulse height analyzer are used. PMT's are warmed up for about one hour in the dark with voltage applied.

9.1 Long Term Stability (Mean gain deviation)

This is defined as follows when the PMT is operated for 16 hours at a constant count rate of 1000 s^{-1}:

$$Dg = \frac{\sum_{i=1}^{n} |P-Pi|}{n} \bullet \frac{100}{P} \ (\%)$$

where P is the mean pulse height averaged over n readings, Pi is the pulse height at the i-th reading, and n is the total number of readings.

9.2 Short Term Stability

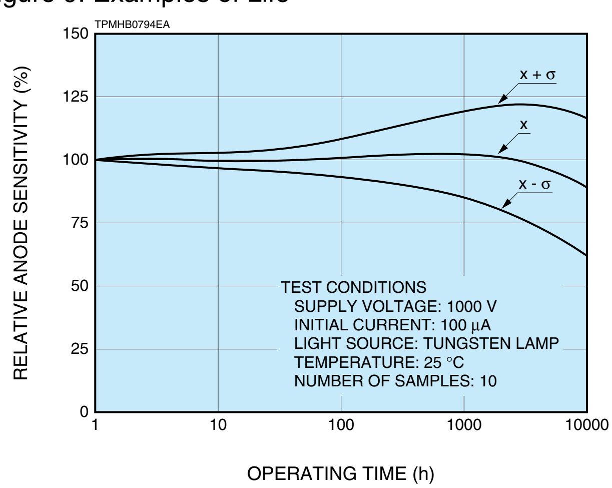
This is the gain shift against count rate change. The tube is initially operated at about 10000 s^{-1}. The photo-peak count rate is then decreased to approximately 1000 s^{-1} by increasing the distance between the ^{137}Cs source and the scintillator coupled to the PMT.

9.3 Drift and Life Characteristics

While operating a photomultiplier tube continuously over a long period, anode output current of the photomultiplier tube may vary slightly with time, although operating conditions have not changed. This change is reffered to as drift or in the case where the operating time is 1000 hours to 10000 hours it is called life characteristics. Figure 9 shows typical life characteristics.

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, the use of average anode current of 1 µA or less is recommended.

Figure 9: Examples of Life

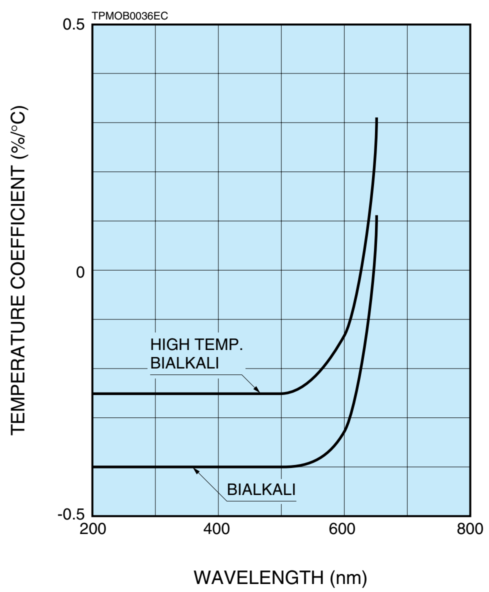


10. ENVIRONMENT

10.1 Temperature Characteristics

The sensitivity of the PMT varies with the temperature. Figure 10 shows typical temperature coefficients of anode sensitivity around the room temperature for bialkali and high temp. bialkali photocathode types. In the ultraviolet to visible region, the temperature coefficient of sensitivity has a negative value, while it has a positive value near the longer wavelength cut-off.
Since the temperature coefficient change is large near the longer wavelength cut-off, temperature control may be required in some applications.

Figure 10: Typical Temperature Coefficients of Anode Sensitivity



10.2 Magnetic Field

Most PMTs 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 loss of gain depends on the type of the PMT and its orientation in the magnetic field. Figure 11 shows typical effects of magnetic fields on some types of PMTs. In general, a PMT having a long path from the photocathode to the first dynode are very sensitive to magnetic fields. Therefore head-on types, especially of large diameter, tend to be more adversely influenced by magnetic fields.
When a PMT has to be operated in magnetic fields, it may be necessary to shield the PMT with a magnetic shield case. (Hamamatsu provides a variety of magnetic shield cases.)

For example, the shield case, of which inner diameter is 60 mm and the thickness is 0.8 mm, can be used in a magnetic field of around 5 mT without satulation. If a magnetic field strength is more than 10 mT, the double shielding method is necessary for a conventional PMT, otherwise proximity mesh types should be used. It should be noted that the magnetic shielding effect decreases towards the edge of the shield case as shown in Figure 12. It is suggested to cover a PMT with a shield case longer than the PMT length by at least half the PMT diameter.

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

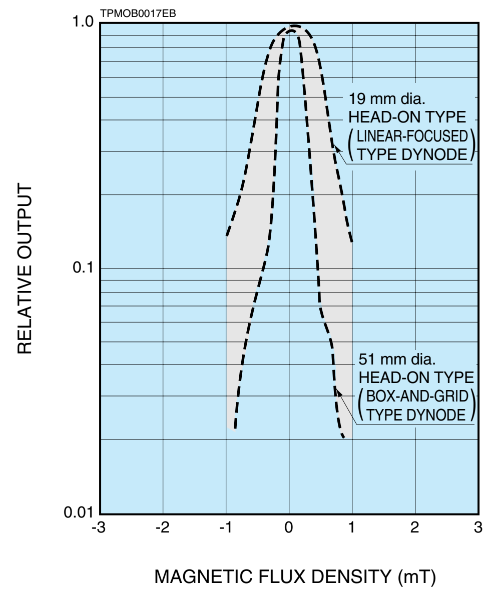
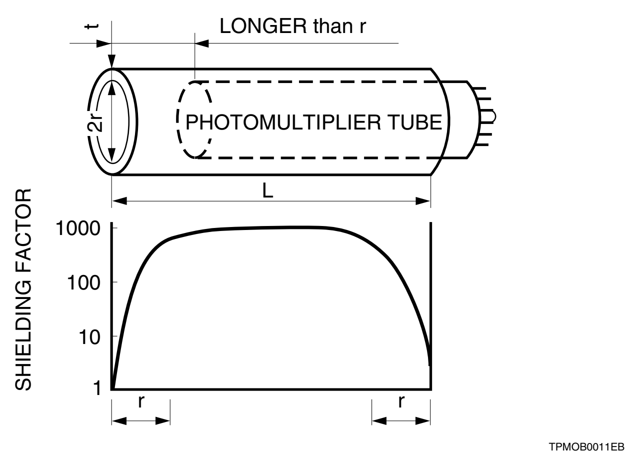


Figure 12: Edge Effect of Magnetic Shield Case



The proximity mesh made of non-magnetic material has been introduced as alternate dynodes in PMT's. These types (see page 24) exhibit much higher immunity to external magnetic fields than the conventional PMT's. Also triode and three types (see page 24) are useful for applications at high light intensities.

11. 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 13 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 13: Schematic Representation of Photomultiplier Tube Operation

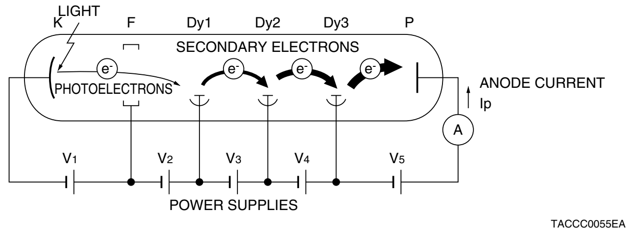
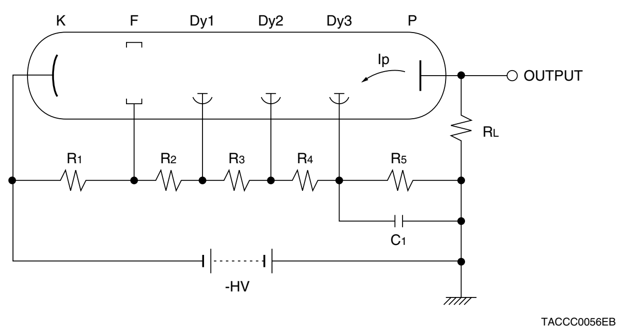


Figure 14 shows a typical voltage divider circuit using resistors, with the anode side grounded. The capacitor C_1 connected in parallel to the resistor R_5 in the circuit is called a decoupling capacitor and improves the output linearity when the photomultiplier tube is used in pulse operation, and not necessarily used in providing DC output. In some applications, transistors or Zener diodes may be used in place of these resistors.

Figure 14: Anode Grounded Voltage Divider Circuit

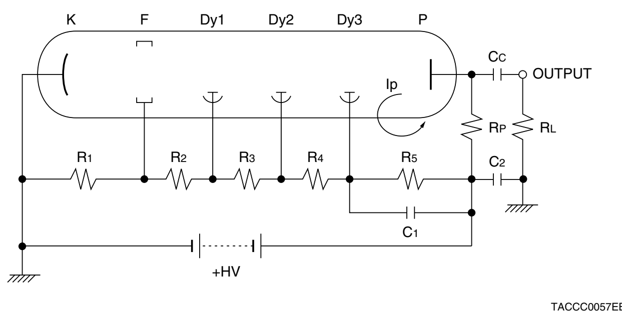


11.1 Anode Grounding and Photocathode Grounding

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 14. 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 15, along with the coupling capacitor Cc 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.

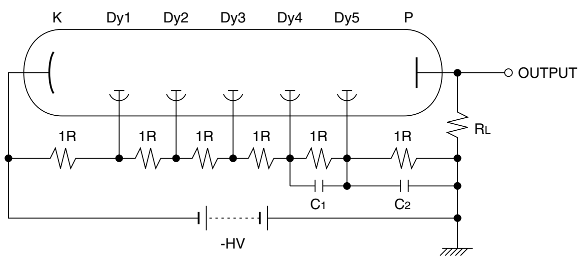
Figure 15: Photocathode Grounded Voltage Divider Circuit



11.2 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 as shown in Figure 16.

Figure 16: Equally Divided Voltage Divider Circuit



TACCC0058EB

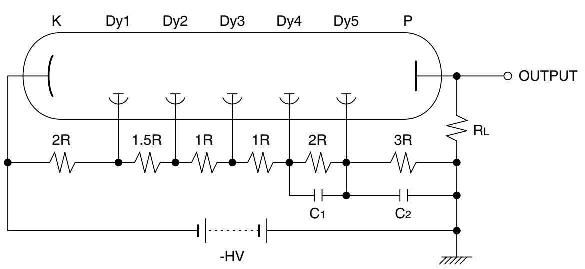
11.3 Tapered Voltage Divider Circuits

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 17. This is called a tapered voltage divider circuit and is effective in improving various characteristics. However it should be noted that the overall gain decreases as the voltage gradient becomes greater. In addition, care is required regarding the interstage voltage tolerance of the photomultiplier tube as higher voltage is supplied. The tapered voltage circuit types and their suitable applications are listed below.

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

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

Figure 17: Tapered Voltage Divider Circuit

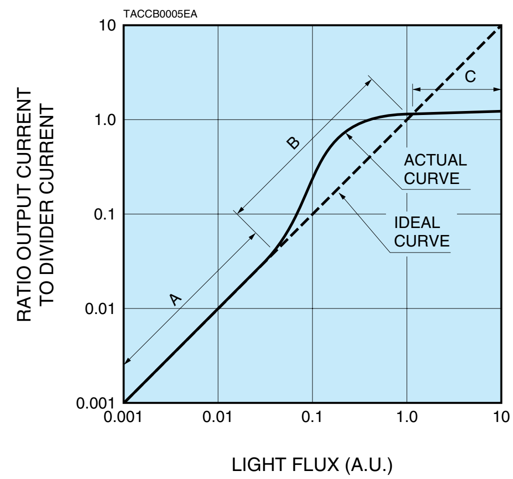


TACCC0059EB

11.4 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 18, region A maintains good linearity, and region B is the so-called overlinearity range in which the output increase is larger than the ideal level. In region C, the output goes into saturation and becomes smaller than the ideal level. When accurate measurement with good linearity is essential, the maximum output current must be within region A. In contrast, the lower limit of the output current is determined by the dark current and noise of the photomultiplier tube as well as the leakage current and noise of the external circuit.

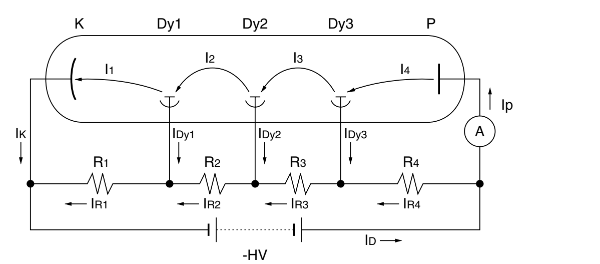
Figure 18: Output Linearity of Photomultiplier Tube



11.5 Output Linearity in DC Mode

Figure 19 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 19: Basic Operation of Photomultiplier Tube and Voltage Divider Circuit



TACCC0060EA

[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 20 (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

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

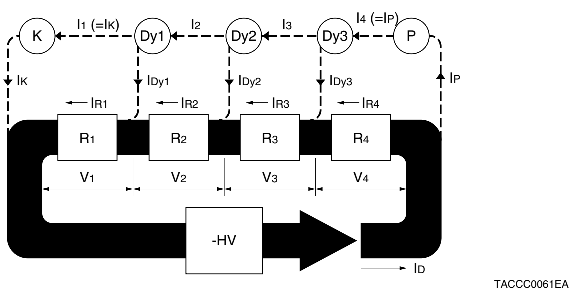
Voltage divider circuit current

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

Voltage divider circuit voltage

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

Figure 20: 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 20, the resulting currents can be considered to flow through the photomultiplier tube and the voltage divider circuit as schematically illustrated in Figure 21. Here, all symbols used to represent the current and voltage are expressed with a prime ('), to distinguish them from those in dark state operation.

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

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

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

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

Figure 21: Operation with Light Input

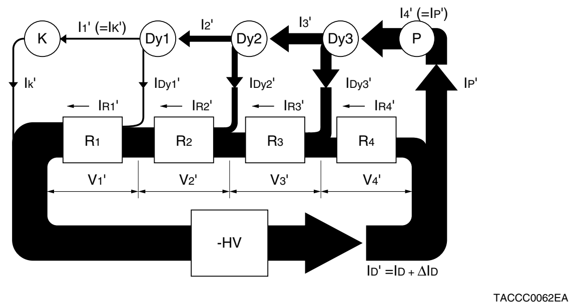
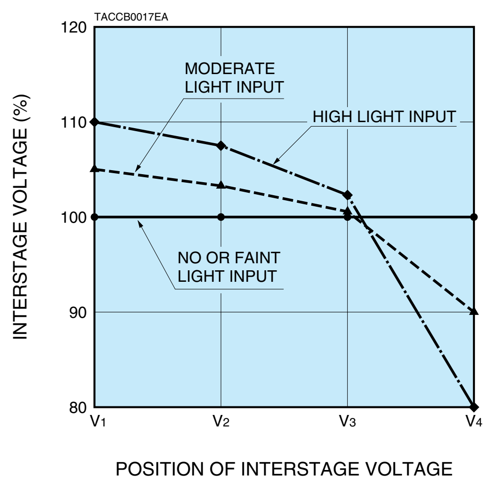


Figure 22 shows changes in the interstage voltages as the incident light level varies. The interstage voltage V_4' with light input drops significantly compared to V_4 in dark state operation. This voltage loss is redistributed to the other stages, resulting an increases in V_1', V_2' and V_3' which are higher than those in dark state operation. The interstage voltage V_4' is only required to collect the secondary electrons emitted from the last dynode to the anode, so it has little effect on the anode current even if dropped to 20 or 30 volts. In contrast, the increases in V_1', V_2' and V_3' directly raise the secondary emission ratios (δ_1, δ_2 and δ_3) at the dynodes Dy1, Dy2 and Dy3, and thus boost the overall gain m ($= \delta_1 \bullet \delta_2 \bullet \delta_3$). This is the cause of overlinearity in region B in Figure 10. As the incident light level further increases so that V4' approaches 0 volts, output saturation occurs in region C.

Figure 22: Changes in Interstage Voltages at Different Incident Light Levels



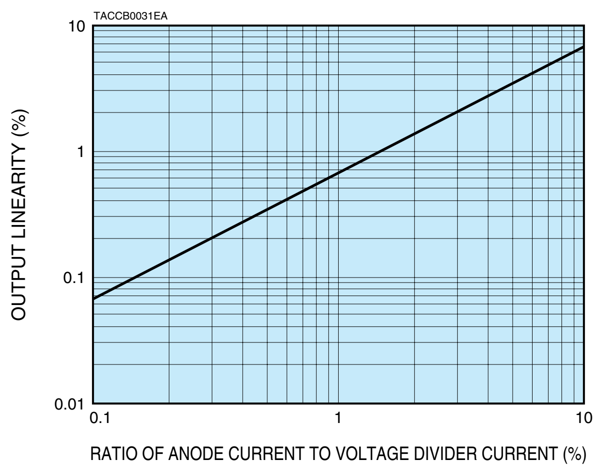
11.6 Linearity Improvement in DC Output Mode

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

①Increasing the voltage divider current
Figure 23 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 %.

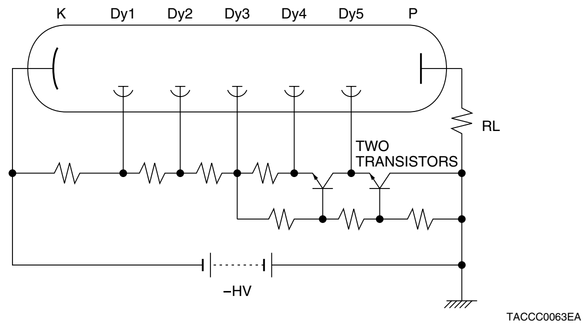
Figure 23: Output Linearity vs. Anode Current to Voltage Divider Current Ratio



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

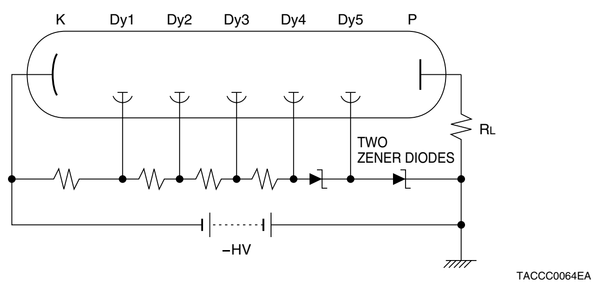
②Using the active voltage divider circuit
Use of a voltage divider circuit having transistors in place of the dividing resistors in last few stages (for example, Hamamatsu E6270 series using FETs) is effective in improving the output linearity. This type of voltage divider circuit ensures good linearity 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 24.

Figure 24: Active Voltage Divider Circuit



③Using Zener Diodes
The output linearity can be improved by using Zener diodes in place of the dividing resistors in the last few stages, because the Zener diodes serve to maintain the interstage voltages at a constant level. However, if the supply voltage is greatly varied, the voltage distribution may be imbalanced compared to other interstage voltages, thus limiting the adjustable range of the voltage with this technique. In addition, if the supply voltage is reduced or if the current flowing through the Zener diodes becomes insufficient due to an increase in the anode current, noise may be generated from the Zener diodes. Precautions should be taken when using this type of voltage divider circuit. Figure 25 shows a typical voltage divider circuit using Zener diodes.

Figure 25: Voltage Divider Circuit Using Zener Diodes

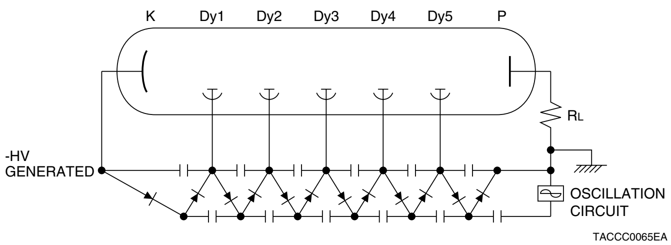


④Using Cockcroft-Walton Circuit

When a Cockcroft-Walton circuit as shown in Figure 26 is used to operate a 28 mm (1-1/8") diameter side-on photomultiplier tube with a supply voltage of 1000 volts, good DC linearity can be obtained up to 200 µA and even higher. Since a high voltage is generated by supplying a low voltage to the oscillator circuit, there is no need for using a high voltage power supply.

This Cockcroft-Walton circuit achieves superior DC output linearity as well as low current consumption.

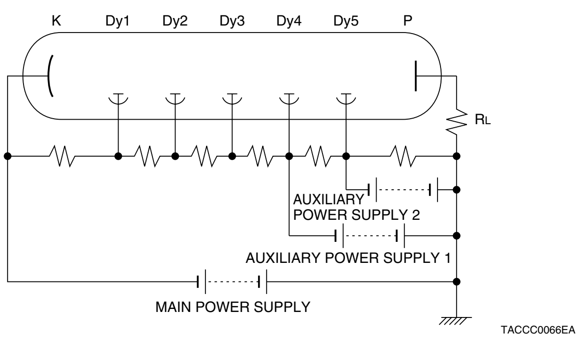
Figure 26: Cockcroft-Walton Circuit



⑤Using multiple high voltage power supplies

As shown in Figure 27, 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 27: Voltage Divider Circuit Using Multiple Power Supplies (Booster Method)



11.7 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.

11.8 Improving Linearity in Pulsed Output Mode

①Using decoupling 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 decoupling capacitors as shown in Figure 28. There are two methods for connecting these decoupling capacitors: the serial method and the parallel method. As Figures 28 and 29 show, the serial method is more widely used since it requires lower tolerance voltages of the capacitors. The capacitance value C (farads) of the decoupling capacitor between the last dynode and the anode should be at least 100 times the output charge as follows:

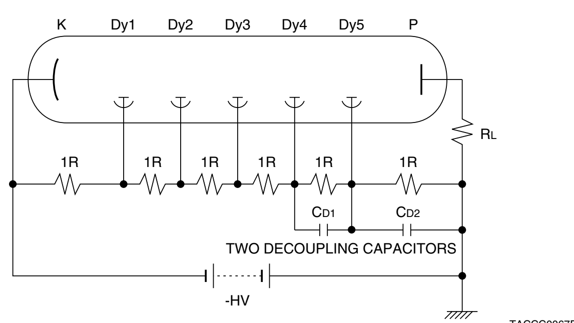
$$C > 100 \cdot Q/V$$

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 28: Equally Divided Voltage Divider Circuit and Decoupling Capacitors

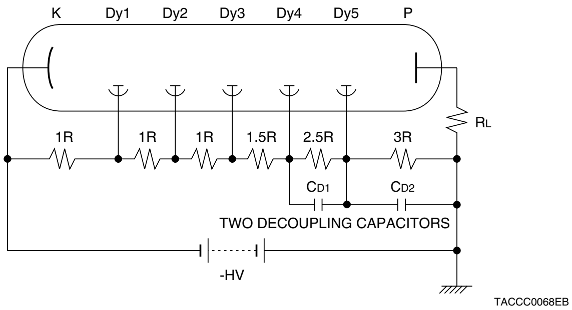


②**Using tapered voltage divider circuit with decoupling capacitors**

Use of the above voltage divider circuit having decoupling 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 29. 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 29: Tapered Voltage Divider Circuit Using Decoupling Capacitors



12. EXTERNAL POTENTIAL

If the input window or glass envelope near the photocathode is grounded, slight conductivity of glass material causes a current flow between the photocathode, which has a high negative potential, and ground.

This may cause electrolysis of photocathode, leading to significant deterioration.

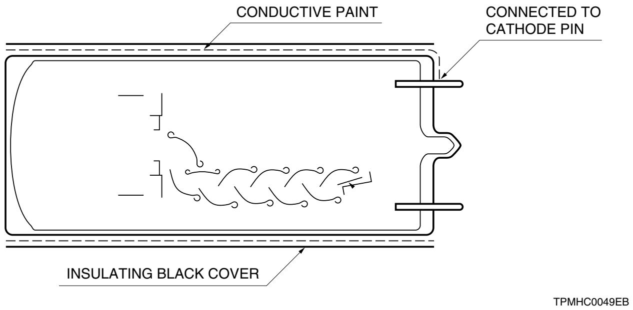
Also this may cause noise resulted from the light flashes at the above input window or glass envelope.

For those reasons, when designing a PMT housing with an electrostatic or magnetic shield case, extreme care should be required.

When the anode ground scheme is used, bringing a grounded metallic holder or magnetic shield case near the glass envelope of PMT can cause electrons to strike the inner glass wall, resulting in the noise.

This problem can be solved by applying a black conductive paint around the glass envelope and connecting it to the cathode potential. Then PMT is wrapped with an insulating black cover, as shown in Figure 30. This method is called HA treatment.

Figure 30: HA Treatment



13. SCINTILLATION COUNTING

13.1 General

Scintillation counting is one of the most common and effective methods in detecting radiation particles. It uses a PMT coupled to a scintillator which produces light by incidence of radiation particles.

In radiation particle measurement, there are two parameters that should be measured. One is the energy of individual particle and the other is the amount of particles. When radiation particles enter the scintillator, they produce light flashes in response to each particle. The amount of flash is proportional to the energy of the incident particle and individual light flashes are detected by the PMT. Consequently, the output pulses obtained from the PMT contain information on both the energy and number of pulses, as shown in Figure 31.

Figure 31: Incident Particles and PMT Output

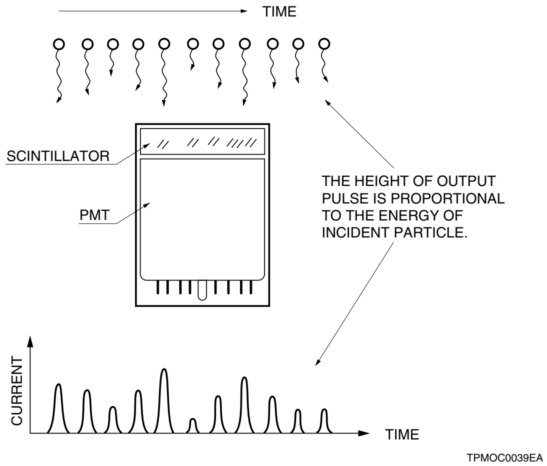
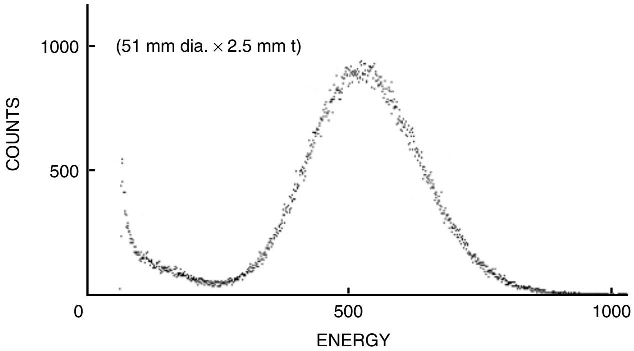
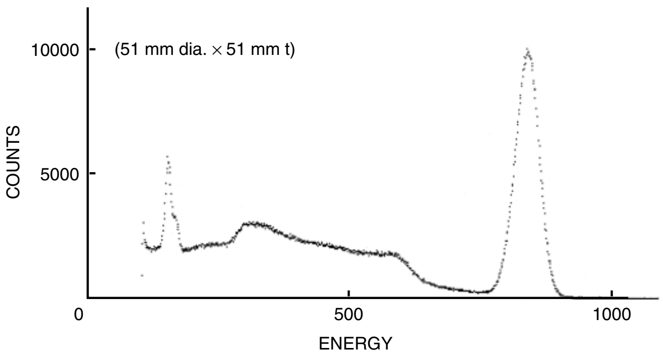


Figure 32: Typical Pulse Height Distribution (Energy Spectral)

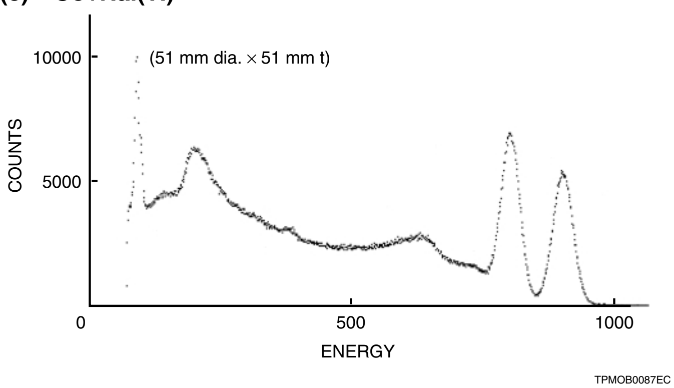
(a) ^{55}Fe+NaI(Tl)



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



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

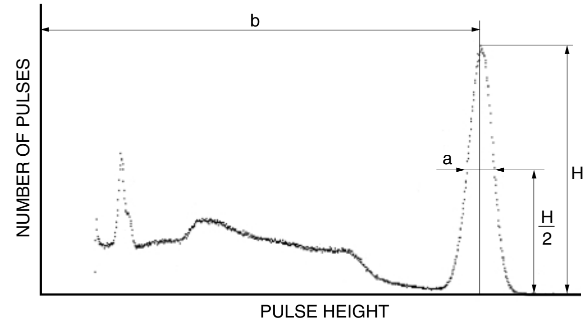


By analyzing these output pulses using a multichannel analyzer (MCA), pulse height distribution (PHD), or energy spectra, as shown in Figure 32, are obtained. From the PHD, the number of incident particles at various energy levels can be measured.

13.2 Energy Resolution

For the energy spectrum measurement, it is very important to have a distinct peak at each energy level. This characteristic is evaluated as the pulse height resolution or the energy resolution and is most significant in the radiation particle identification.
Figure 33 shows the definition of the energy resolution using NaI(Tl) scintillator and ^{137}Cs γ-ray source. It is customarily stated as a percentage.

Figure 33: Definition of Pulse Height Resolution



Energy Resolution (FWHM) = $\frac{a}{b} \times 100$ %

TPMOB0088EA

The following factors determin the energy resolution.

(1) Energy conversion efficiency of the scintillator
(2) Intrinsic energy resolution of the scintillator
(3) Quantum efficiency of the photocathode
(4) Collection efficiency of photoelectrons at the first dynode
(5) Secondary emission yield of dynodes (especially first dynode)

The equation of the pulse height resolution is described as follows:

$$R(E)^2 = R_S(E)^2 + R_P(E)^2$$

where R(E) : energy resolution
$R_S(E)$: energy resolution of a scintillator
$R_P(E)$: energy resolution of a PMT

$R_P(E)^2$ is described as follows:

$$R(E)^2 = \frac{2.35^2}{N\eta\alpha} \times \frac{\delta}{\delta - 1}$$

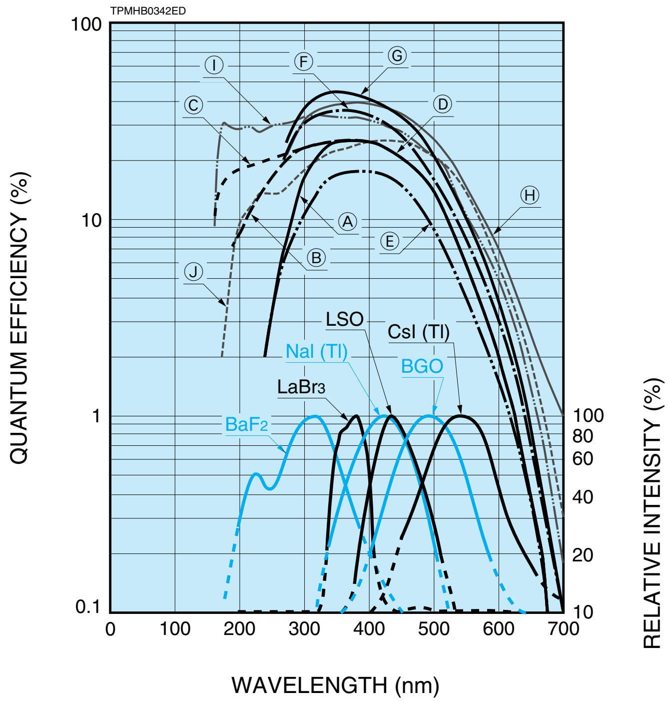
where N : mean number of incident photon
η : quantum efficiency
α : collection efficiency
δ : mean secondary emission yield of each dynode

To obtain a good energy resolution, it is important to use a good scintillator having a high efficiency and a good intrinsic energy resolution. It is also important to reduce a light loss between a PMT and a scintillator. For this purpose, it is useful to couple them with silicon oil having a refractive index close to that of the faceplate window of the PMT or scintillator material or its protective window.

13.3 Emission Spectrum of Scintillator

The quantum efficiency of the PMT is one of the main factors to determine its energy resolution. It is necessary to choose a PMT whose spectral response matches the scintillator emission. Figure 34 shows PMT typical spectral response vs. emission spectra of scintillators. For NaI(Tl), which is the most popular scintillator, bialkali photocathode PMTs are widely used.

Figure 34: Typical Spectral Response and Emission Spectra of Scintillators



Ⓐ: Bialkali Photocathode (Borosilicate Glass)
Ⓑ: Bialkali Photocathode (UV Glass)
Ⓒ: Bialkali Photocathode (Synthetic Silica)
Ⓓ: Bialkali Photocathode
Ⓔ: High Temp. Bialkali Photocathode
Ⓕ: Super Bialkali
Ⓖ: Ultra Bialkali
Ⓗ: Extended Green Bialkali
Ⓘ: Low Temp. (down to -110 °C) Bialkali Photocathode
Ⓙ: Low Temp. (down to -186 °C) Bialkali Photocathode

13.4 Features of Scintillators

Figure 35 shows typical temperature responses of various scintillators. These characteristics should be considered in the actual operation.
Table 1 shows a summary of scintillator characteristics.
These data are reported by scintillator manufactures.

Figure 35: Typical Temperature Response of Various Scintillators

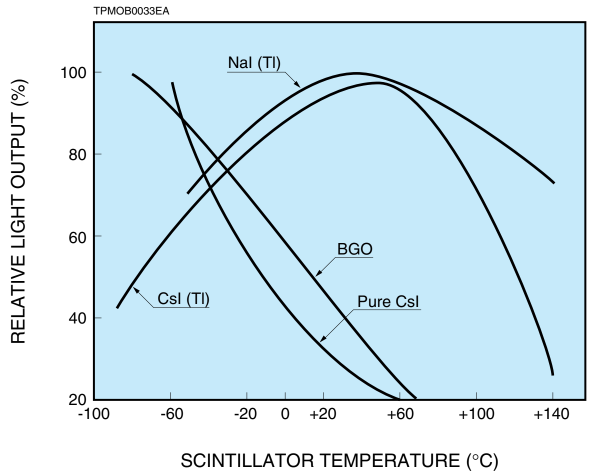


Table 1: Summary of Scintillator Characteristics

	NaI(Tl)	BGO	CsI(Tl)	Pure CsI	BaF_2	GSO: Ce	Plastic	$LaBr_3$: Ce	LSO: Ce	YAP: Ce
Density (g/cm^3)	3.67	7.13	4.51	4.51	4.88	6.71	1.03	5.29	7.35	5.55
L_{rad} (cm)	2.59	1.12	1.85	1.85	2.10	1.38	40	2.1	0.88	2.70
Refractive Index	1.85	2.15	1.80	1.80	1.58	1.85	1.58	1.9	1.82	1.97
Hygroscopic	Yes	No	Slightly	Slightly	Slightly	No	No	Yes	No	No
Luminescence (nm)	410	480	530	310	220 / 325	430	400	380	420	380
Decay time (ns)	230	300	1000	10	0.9 / 630	30	2.0	16	40	30
Relative Light Output	100	15	45 to 50	<10	20	20	25	165	70	40

14. METAL PACKAGE PHOTOMULTIPLIER TUBE

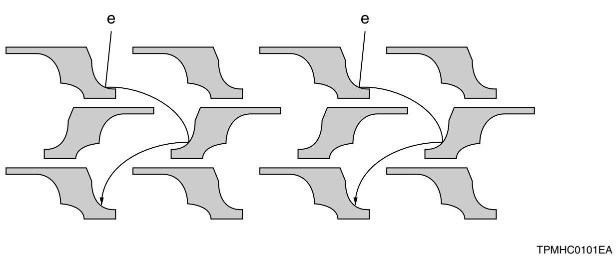
In general including, the development of more compact and portable equipment has continuously progressed. This has led to a strong demand for miniaturization of highly sensitive photodetectors like PMTs. However, it is difficult to miniaturize conventional PMTs with glass envelopes and sophisticated electrode structures.

Accordingly, PMTs have been mainly used in high-precision photometric systems, while semiconductor sensors have been used in general purpose, compact and portable equipments/applications. To meet the increasing needs for small photodetectors with high sensitivity, Hamamatsu has developed subminiature PMTs (R7400 series) using a metal package in place of the traditional glass envelope. These tubes have a size as small as semiconductor sensors, without sacrificing high sensitivity, and have the high speed response offered by conventional PMTs. The remarkable features of R7400 series are: smallest size, fast time response, ability of low light level detection and good immunity to magnetic fields.

R7400 series are a subminiature PMT that incorporates an eight stages electron multiplier constructed with stacked thin electrodes (metal channel dynode) into a TO-8 type metal can package of 15 mm in diameter and 10 mm in height. The development of this metal package and its unique thin electrodes have made the fabrication of this subminiature PMT possible. The electrode structure of the electron multiplier was designed by means of advanced computer simulation and electron trajectory analysis.

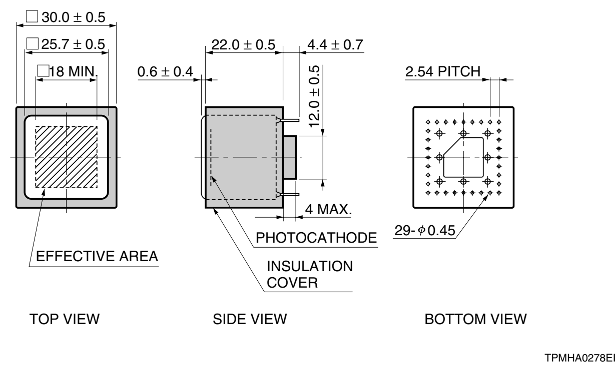
Furthermore, our long experience with micromachining technology has achieved a closed proximity assembly of these thin electrodes. Figure 36 shows a cross section of the metal channel dynode with simulated electron trajectories.

Figure 36: Cross Section of Metal Channel Dynode with Electron Trajectories



The R5900 / R7600 / R8900 series is another version of metal package PMT. It incorporates 10 to 12 stages of metal channel dynodes into a metal package of 26 mm × 26 mm square and 20 mm in height. The prime features are similar to those of R7400 series, but its effective area is 18 mm × 18 mm instead of 8 mm diameter of R7400. The dimensional outline of R7600U is shown in Figure 37. In this figure, "U" means a tube having an insulation plastic cover. It is necessary to prevent electric shock with some insulation material, because a metal package has a cathode potential voltage.

Figure 37: Insulation Plastic Cover of R7600U



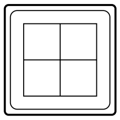
As the metal channel dynode is a sort of an array of small linear focused dynodes, secondary electrons hardly go to the adjacent dynode channel in a process of multiplication. It is possible to make multi-anode PMTs utilizing this feature. R7600 series is offering 6 various types of anode shapes as well as single channel type. These anode shapes are categorized into 3 groups. The first group is multianode in matrix. 4 (2 × 2), 16 (4 × 4) and 64 (8 × 8) matrix channels types are available. (see Figure 38-A) Those are suitable for scintillating fiber readout as well as RICH (Ring Image CHerenkov counter). The second group is linear anode. 16 (1 × 16) and 32 (1 × 32) linear channels types are available. (see Figure 38-B) Those are suitable for coupling with slit shape scintillators and ribbon-shaped scintillating fiber bundle. The third one is crossed-plate anode. 6X + 6Y type is available. (see Figure 38-C) It is possible to get position information by using a center-of-gravity method, this PMT is suitable for compact PET and radiation imaging.

R8900 series are wider effective area and longer length compare with those of R7600 series. Those are also offering matrix channel type as well as single channel type (see Figure 38-D).

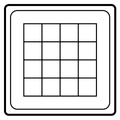
Flat panel PMT assemblies use a 52 mm square photomultiplier tube having an effective area ratio of 89 % and a 64-channel or 256-channel multianode. These flat panel PMTs offer a wide photosensitive area and come in thin, compact shape. These PMTs can be efficiently arrayed in rows or matrices with almost no unused space between them. (See figure 38-E)

Figure 38: Various Anode Shape

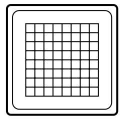
(A) Matrix Channel Type



R7600U-00-M4

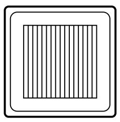


H8711
(R7600-00-M16)

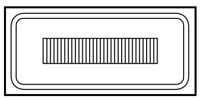


H7546B
(R7600-00-M64)

(B) Liner Channel Type



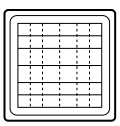
R5900U-00-L16



H7260K
(R7259K)

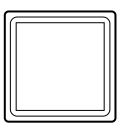
* R5900 series has flange at the bottom of the metal package, whereas R7600 series doesn't have it.

(C) Cross-plate Anode Type

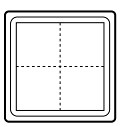


R8900U-00-C12

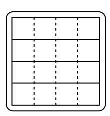
(D) R8900 Series



R8900U



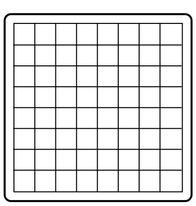
R8900U-00-M4



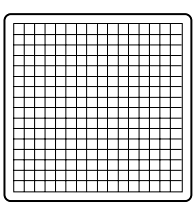
R8900-00-M16

* R8900 series have wider effective area and longer length compared with those of R7600 series.

(E) Flat Panel Type



H8500C
(R10551-00-M64)



H9500
(R8400-00-M256)

TPMHC0204EB

List Guide for Photomultiplier Tubes

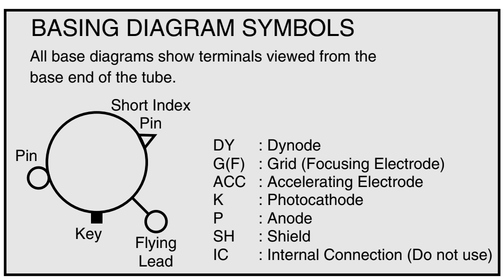
Tube Diameter	Type No.	❶ Spectral Response Range (nm) / Curve Code	❷ Outline No.	❸ Socket & Socket Assembly	❹ Dynode Structure / No. of Stages	Cathode Sensitivity			Anode Sensitivity				
						❺ Luminous Typ. (µA/lm)	❻ Blue Sens. Index (CS 5-58) Typ.	❼ Q.E. at Peak Typ. (%)	❽ Anode to Cathode Supply Voltage (V)	❾ Gain Typ.	❿ Luminous Typ. (A/lm)	⓫ Dark Current	
												Typ. (nA)	Max. (nA)

❶ Spectral Response

The relationship between photocathode sensitivity and wavelength of input light.
Curve code corresponds to that of spectral response curve on the inside back cover.
(Refer to section 2 on page 2 for further details.)

❷ Outline No.

This number corresponds to that of PMT dimensional outline drawing shown on later pages.
Basing diagram symbols are explained as follows:



TPMOC0068EB

❸ Socket & Socket Assembly

★ mark : A socket will be supplied with a PMT.
no mark : A socket will be supplied as an option.
The number in square corresponds to the outline number of the PMT socket assembly on page 58 and 59.

❹ Dynode

<Dynode Structure>
Each mark means dynode structure as follows:

- LINE : linear focused
- BOX : box and grid
- B + L : box and linear focused
- C + L : circular and linear focused
- CC : circular cage
- VB : venetian blind
- FM : fine mesh
- CM : coarse mesh
- MC : metal channel

<No. of Stages>
The number of dynodes used.
(Refer to section 3 on page 4 for further details.)

❺ Cathode Sensitivity (Luminous)

The photoelectric current from the photocathode per incident light flux from a tungsten filament lamp operated at 2856 K.
(Refer to section 2.5 on page 3 for further details.)

❻ Cathode Blue Sensitivity Index

The photoelectric current from the photocathode per incident light flux from a tungsten filament lamp operated at 2856 K passing through a blue filter which is Corning CS 5-58 polished to 1/2 stock thickness.
(Refer to section 2.5 on page 3 for further details.)

❼ QE (Quantum Efficiency)

The ratio of the number of photoelectrons emitted from the photocathode to the number of incident photons.
This catalog shows quantum efficiency at the peak wavelength.
(Refer to section 2.2 on page 2 for further details.)

❽ Anode to Cathode Voltage

The voltage indicates a standard applied voltage used to measure characteristics. The number in circles corresponds to that of the voltage distribution ratio on page 46 and 47.

❾ Gain (Current Amplification)

The ratio of the anode output current to the photoelectric current from the photocathode.
(Refer to section 4.2 on page 4 for further details.)

❿ Anode Sensitivity (Luminous)

The output current from the anode per incident light flux from a tungsten filament lamp operated at 2856 K.
(Refer to section 4.1 on page 3 for further details.)

(at 25 °C)

Maximum Rating ⓬		Time Response ⓭			⓮	Stability ⓯		Pulse Linearity ⓰		Note	Type No.
Anode to Cathode Voltage (V)	Average Anode Current (mA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)	T.T.S. Typ. (FWHM) (ns)	Typical Pulse Height Resolution (%)	Long Term (%)	Short Term (%)	±2 % Deviation (mA)	±5 % Deviation (mA)		

⓫ Anode Dark Current

The output current from the anode measured after 30 minutes storage in complete darkness.
(Refer to section 5 on page 4 for further details.)

⓬ Maximum Rating

<Anode to Cathode Voltage>
The maximum anode to cathode voltages are limited by the internal structure of the PMT.
Excessive voltage causes electrical breakdown. The voltage lower than the maximum rating should be applied to the PMT.

<Average Anode Current>
This indicates the maximum averaged current over any interval of 30 seconds. For practical use, operating at lower average anode current is recommended.
(Refer to section 9.3 on page 6 for further details)

★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.

⓭ Time Response

<Rise Time>
The time for the anode output pulse to rise from 10 % to 90 % of the peak amplitude.

<Electron Transit Time>
The time interval between the arrival of a delta function light pulse at the photocathode and the instant when the anode output pulse reaches its peak amplitude.

<T.T.S. (Transit Time Spread)>
This is the fluctuation in transit time among individual pulses, and is defined as the FWHM of the frequency distribution of transit time.

<C.R.T. (Coincident Resolving Time)>
This is defined as the FWHM of a coincident timing spectrum of a pair PMT's. The scintillator used are BGO, BaF_2 or CsF crystals.
(Refer to section 6 on page 5 for further details.)

⓮ Pulse Height Resolution (P.H.R.)

The P.H.R. is measured with the combination of an NaI(Tl) scintillator and a ^{137}Cs source as a standard measurement. If other scintillators or γ-ray sources are used, note is attached.
(Refer to section 13.2 on page 14 for further details.)

⓯ Stability

<Long Term Stability (Mean Gain Deviation)>
This is defined as follows under the operation for 16 hours at a constant count rate of 1000 s^{-1}:

$$Dg = \frac{\sum_{i=1}^{n} |P-Pi|}{n} \bullet \frac{100}{P} \ (\%)$$

where P is the mean pulse height averaged over n readings, Pi is the pulse height at the i-th reading, and n is the total number of readings.

<Short Term Stability>
This is the gain shift on count rate charge. The tube is first operated at about 10000 s^{-1}. The photo-peak count rate is then decreased to about 1000 s^{-1} by increasing the distance between the ^{137}Cs source and the tube coupled to the NaI(Tl) scintillator.
(Refer to section 9 on page 6 for further details.)

⓰ Pulse Linearity

Typical values of pulse linearity are specified at two points (±2 % and ±5 % deviation points from linear proportionality).
(Refer to section 7 on page 5 and 6 for further details.)

Photomultiplier Tubes

10 mm (3/8 inch) to 38 mm (1-1/2 inch) Dia. Types

Tube Diameter	Type No.	(1) Spectral Response Range (nm) / Curve Code	(2) Outline No.	(3) Socket & Socket Assembly	(4) Dynode Structure / No. of Stages	Cathode Sensitivity: (5) Luminous Typ. (µA/lm)	Cathode Sensitivity: (6) Blue Sens. Index (CS 5-58) Typ.	Cathode Sensitivity: (7) Q.E. at Peak Typ. (%)	(8) Anode to Cathode Supply Voltage (V)	Anode Sensitivity: (9) Gain Typ.	Anode Sensitivity: (10) Luminous Typ. (A/lm)	Anode Sensitivity: (11) Dark Current Typ. (nA)	Anode Sensitivity: (11) Dark Current Max. (nA)
10 mm (3/8")	R1635	300 to 650/A-D	1	E678-11N* [1]	LINE / 8	100	10.0	25	1250 (4)	1.0×10^6	100	1	50
	R2496	160 to 650/C-D	1	E678-11N* [1]	LINE / 8	100	10.0	25	1250 (6)	1.0×10^6	100	2	50
13 mm (1/2")	R647-01	300 to 650/A-D	3	E678-13F* [2]	LINE / 10	110	10.0	25	1000 (17)	1.4×10^6	150	1	2
	R4124	300 to 650/A-D	2	E678-13F* [3]	LINE / 10	100	10.0	25	1000 (30)	1.0×10^6	100	1	15
	R4177-06	300 to 650/A-E	3	E678-13E*	LINE / 10	30	4.5	12	1500 (17)	5.0×10^5	15	0.5	10
19 mm (3/4")	R1166	300 to 650/A-D	4	E678-12L* [4]	LINE / 10	110	10.5	26	1000 (21)	1.0×10^6	110	1	5
	R1450	300 to 650/A-D	5	E678-12L* [4]	LINE / 10	115	11.0	27	1500 (27)	1.7×10^6	200	3	50
	R3478	300 to 650/A-D	6	E678-12L* [5]	LINE / 8	115	11.0	27	1700 (11)	1.7×10^6	200	10	300
	R3991A-04	300 to 650/A-E	7	E678-12R*	LINE / 10	30	4.5	12	1500 (29)	3.3×10^5	10	0.1	10
	R4125	300 to 650/A-D	5	E678-12L* [6]	LINE / 10	115	11.0	27	1500 (22)	8.7×10^5	100	10	50
	R5611A-01	300 to 650/A-D	7	E678-12A*	LINE / 10	90	10.5	26	1000 (29)	5.5×10^5	50	3	20
25 mm (1")	R1288A-06	300 to 650/A-E	8	E678-14-03*	LINE / 10	30	4.5	12	1500 (29)	3.3×10^5	10	0.1	10
	R1924A	300 to 650/A-D	8	E678-14C* [11]	LINE / 10	90	10.5	26	1000 (29)	2.0×10^6	180	3	20
	R4998	300 to 650/A-D	9	E678-12A*	LINE / 10	70	9.0	22	2250 (19)	5.7×10^6	400	100	800
	R5505-70	300 to 650/A-D	10	E678-17A* [8]	FM / 15	80	9.5	23	2000 (65)	5.0×10^5	40	5	30
	R7899-01	300 to 650/A-D	11	E678-12A*	LINE / 10	95	11.0	27	1250 (30)	2.0×10^6	190	2	15
									1500 (31)	1.7×10^6	160	2	20
	R8619	300 to 650/A-D	12	E678-12A*	LINE / 10	95	11.0	27	1000 (30)	2.6×10^6	250	2	15
	R9800	300 to 650/A-D	13	E678-12A*	LINE / 8	95	11.0	27	1300 (10)	1.1×10^6	100	5	50
28 mm (1-1/8")	R3998-02	300 to 650/A-D	14	E678-14C*	B+L / 9	90	10.5	26	1000 (15)	1.3×10^6	120	2	10
	R6427	300 to 650/A-D	15	E678-14C* [12][13]	LINE / 10	95	11.0	27	1500 (33)	5.0×10^6	475	10	200
									1500 (34)	2.0×10^6	190	4	80
	R7111	300 to 650/A-D	16	E678-14C* [11]	LINE / 10	90	10.5	26	1000 (29)	2.0×10^6	180	3	20
	R7525	300 to 650/A-D	17	E678-14C*	LINE / 8	95	11.0	27	1500 (7)	5.0×10^5	45	5	100
									1500 (8)	2.0×10^5	19	2	40
38 mm (1-1/2")	R580	300 to 650/A-D	18	E678-12A* [14]	LINE / 10	95	11.0	27	1250 (24)	1.1×10^6	100	3	20
									1500 (26)	7.9×10^5	75	2	15
	R11102	300 to 650/A-D	19	E678-12A* [14]	C+L / 10	120	11.5	28	1000 (24)	1.0×10^6	120	2	20
	R3886A	300 to 650/A-D	20	E678-12A* [14]	CC / 10	90	10.5	26	1000 (24)	2.0×10^6	180	3	20
	R7761-70	300 to 650/A-D	21	—	FM / 19	80	9.5	23	2000 (66)	1.0×10^7	800	15	100
	R9420	300 to 650/A-D	22	E678-12A*	LINE / 8	95	11.0	27	1300 (10)	5.0×10^5	47	10	100

Note: The data shown in ☐ is measured with tapered voltage distribution ratio.
Please refer to page 18 and 19 for each item in the above list.

(at 25 °C)

Maximum Rating 12		Time Response 13			14	Stability 15		Pulse Linearity 16				
Anode to Cathode Voltage (V)	Average Anode Current (mA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)	T.T.S. Typ. (FWHM) (ns)	Typical Pulse Height Resolution (%)	Long Term (%)	Short Term (%)	±2 % Deviation (mA)	±5 % Deviation (mA)	Note	Assembly Type	Type No.
1500	0.03	0.8	9	0.5	23 / BGO *1	1.0	2.0	3	7	UV type (R3878)	H3164-10	R1635
1500	0.03	0.7	9	0.5	23 / BGO *1	1.0	2.0	3	7		H3695-10	R2496
1250	0.1	2.1	22	2.0	7.8	1.0	2.0	3	7	SILICA (R760) and UV (R960) types	H3165-10	R647-01
1250	0.03	1.1	12	0.5	8.1	1.0	2.0	2	5	UV type (R4141)		R4124
1800	0.02	2.0	20	—	12.0	2.0	2.0	8	13	Flying Lead type (R4177-04)		R4177-06
1250	0.1	2.5	27	2.8	7.8	1.0	2.0	4	7	SILICA (R762) and UV (R750) types	H6520	R1166
1800	0.1	1.8	19	0.76	7.8	1.0	2.0	4	8		H6524	R1450
1800	0.1	1.3	14	0.36	7.8	1.0	2.0	4	8	SILICA (R2076) and UV (R3479) types	H6612	R3478
1800	0.02	1.0	10	—	11.0	2.0	2.0	20	40			R3991A-04
1800	0.1	2.5	16	0.85	7.8	1.0	2.0	100	170			R4125
1250	0.1	1.3	12	0.8	8.0	1.0	2.0	10	20	Glass Base type (R5611A)	H8135	R5611A-01
1800	0.02	1.3	13	—	9.0	1.0	2.0	20	40	Flying Lead type (R1288A-04)		R1288A-06
1250	0.1	1.5	17	0.9	7.8	1.0	2.0	20	40	Flying Lead type (R1924A-01)		R1924A
2500	0.1	0.7	10	0.16	8.0	1.0	2.0	40	70	SILICA type (R5320)	H6533	R4998
2300	0.01	1.5	5.6	0.35	9.5	2.0	2.0	180	250	For +HV operation	H6152-70	R5505-70
1800	0.1	1.6	17	0.6	7.8	1.0	2.0	30	50	Glass Base type (R7899)	H8643	R7899-01
1800	0.1	1.6	16	0.7	7.8	1.0	2.0	100	150			
1500	0.1	2.5	28	1.2	10 / LSO	1.0	2.0	5	8			R8619
1500	0.1	1.0	11	0.27	7.8	1.0	2.0	30	50		H10580	R9800
1500	0.1	4.4	32	3.5	7.5	1.0	1.0	8	10			R3998-02
2000	0.2	1.7	16	0.5	7.8	1.0	2.0	10	30	UV type (R7056)	H7415	R6427
2000	0.2	1.8	17	0.5	7.8	1.0	2.0	100	150			
1250	0.1	1.6	18	0.9	7.8	1.0	2.0	30	50			R7111
1750	0.2	1.3	14	—	7.8	1.0	2.0	10	30			R7525
1750	0.2	1.3	15	—	7.8	1.0	2.0	100	150			
1750	0.1	2.7	37	4.5	7.7	1.0	1.0	40	60		H3178-51	R580
1750	0.1	2.7	40	4.5	7.7	1.0	1.0	150	200			
1250	0.1	3.2	34	4.8	7.6	0.5	0.5	10	30			R11102
1250	0.1	2.6	30	2.0	7.5	1.0	2.0	10	20			R3886A
2300	0.01	2.1	7.5	0.35	9.5	2.0	2.0	350	500	For +HV operation		R7761-70
1500	0.1	1.6	17	0.55	7.8	1.0	2.0	30	50			R9420

Note 1: This data is measured with ^{22}Na source and BGO scintillator.

Tube Diameter	Type No.	❶ Spectral Response Range (nm) / Curve Code	❷ Outline No.	❸ Socket & Socket Assembly	❹ Dynode Structure / No. of Stages	Cathode Sensitivity ❺ Luminous Typ. (µA/lm)	❻ Blue Sens. Index (CS 5-58) Typ.	❼ Q.E. at Peak Typ. (%)	Anode Sensitivity ❽ Anode to Cathode Supply Voltage (V)	❾ Gain Typ.	❿ Luminous Typ. (A/lm)	⓫ Dark Current Typ. (nA)	Dark Current Max. (nA)

51 mm (2 inch) to 508 mm (20 inch) Dia. Types

Tube Diameter	Type No.	Spectral Response Range (nm) / Curve Code	Outline No.	Socket & Socket Assembly	Dynode Structure / No. of Stages	Luminous Typ. (µA/lm)	Blue Sens. Index (CS 5-58) Typ.	Q.E. at Peak Typ. (%)	Anode to Cathode Supply Voltage (V)	Gain Typ.	Luminous Typ. (A/lm)	Dark Current Typ. (nA)	Dark Current Max. (nA)
51 mm (2")	R329-02	300 to 650/A-D	23	E678-21C* 20	LINE / 12	90	10.5	26	1500 52 2000 56	1.1×10^6 3.0×10^6	100 270	6 10	40 100
	R331-05	300 to 650/A-D	24	E678-21C* 20	LINE / 12	90	10.5	26	1500 52	1.3×10^6	120	1000 s^{-1} *2	2000 s^{-1} *2
	R1306	300 to 650/A-D	25	E678-14W 17 18	BOX / 8	110	12.0	30	1000 2	2.7×10^5	30	2	20
	R1828-01	300 to 650/A-D	26	E678-20B* 16	LINE / 12	90	10.5	26	2500 44 2500 45	2.0×10^7 1.0×10^7	1800 900	50 25	400 200
	R1840	300 to 650/A-D	27	E678-14W	CM / 10	60	8.0	20	1250 24 1250 25	1.7×10^5 1.3×10^5	10 8	5 5	50 50
	R2083	300 to 650/A-D	28	E678-19J*	LINE / 8	80	10.0	25	3000 12	2.5×10^6	200	100	800
	R2154-02	300 to 650/A-D	29	E678-14W 15	LINE / 10	90	10.5	26	1250 24 1500 26	1.0×10^6 6.0×10^5	90 54	5 3	20 15
	R4607A-06	300 to 650/A-E	30	E678-15C*	CC / 10	30	4.5	12	1500 24	3.3×10^5	10	3	50
	R5924-70	300 to 650/A-D	31	—	FM / 19	70	9.0	22	2000 66	1.0×10^7	700	30	200
	R6041	300 to 650/A-D	32	—	MC / 12	60	8.5	20	800 48	1.0×10^6	60	5	50
	R6041-406	160 to 650/I	33	—	MC / 12	100	12.5	30	800 48	1.0×10^6	100	5	50
	R6041-506	160 to 650/J	33	—	MC / 12	100	11.5	25	800 48	1.0×10^6	100	5	50
	R6231	300 to 650/A-D	34	E678-14W 19	B+L / 8	110	12.0	30	1000 5	2.7×10^5	30	2	20
	R7723	300 to 650/A-D	35	E678-21C*	LINE / 8	90	10.5	26	1750 9	1.0×10^6	90	3	20
	R7724	300 to 650/A-D	35	E678-21C*	LINE / 10	90	10.5	26	1750 35	3.3×10^6	300	6	40
	R7725	300 to 650/A-D	35	E678-21C*	LINE / 12	90	10.5	26	1750 53	6.7×10^6	600	9	60
	R9779	300 to 650/A-D	36	E678-20B*	LINE / 8	95	11.0	27	1500 3	5.0×10^5	47.5	15	100
	R10533	300 to 650/A-D	37	E678-14W	LINE / 8	95	11.0	—	1750 20	4.0×10^6	400	50	300
60 mm	R6232	300 to 650/A-D	38	E678-14W 19	B+L / 8	110	12.0	30	1000 5	2.7×10^5	30	2	20
76 mm (3")	R1307	300 to 650/A-D	39	E678-14W 17 18	BOX / 8	110	12.0	30	1000 2	2.7×10^5	30	2	20
	R4143	300 to 650/A-D	40	E678-20B*	LINE / 12	80	9.5	23	2500 43 2500 44	5.0×10^6 5.6×10^5	400 45	50 10	500 50
	R6091	300 to 650/A-D	41	E678-21C* 20	LINE / 12	90	10.5	26	1500 51 2000 54	5.0×10^6 1.0×10^7	450 900	10 30	60 120
	R6233	300 to 650/A-D	42	E678-14W 19	B+L / 8	110	12.0	30	1000 5	2.7×10^5	30	2	20
	R11065	200 to 650/J	43	E678-20B*	B+L / 12	60	10	—	1500 57	8.3×10^6	500	6	40
	R11410	160 to 650/I	43	E678-20B*	B+L / 12	90	10	—	1500 54	5.0×10^6	450	10	100
90 mm (3.5")	R10233	300 to 650/A-D	44	E678-14W 19	B+L / 8	110	12.0	30	1000 6	2.7×10^5	30	2	20
127 mm (5")	R877	300 to 650/A-D	45	E678-14W 21 22	BOX / 10	90	10.5	26	1250 18	4.4×10^5	40	10	50
	R1250	300 to 650/A-D	46	E678-20B* 23	LINE / 14	70	9.0	22	2000 60 2500 61	1.4×10^7 4.0×10^7	1000 2800	50 300	300 1800
	R1584	185 to 650/B-D	47	E678-20B* 23	LINE / 14	70	9.0	22	2000 60	1.4×10^7	1000	50	300
	R6594	300 to 650/A-D	48	E678-20B*	B+L / 10	80	10.0	25	1500 36 1500 37	3.0×10^6 2.0×10^6	240 160	30 20	300 200
204 mm (8")	R5912	300 to 650/A-D	49	E678-20B* 24	B+L / 10	80	10.0	25	1500 62	1.0×10^7	800	100	1000
	R5912-02	300 to 650/A-D	49	E678-20B*	B+L / 14	80	10.0	25	1500 64	1.0×10^9	80 000	5000	10 000
254 mm (10")	R7081	300 to 650/A-D	50	E678-20B* 24	B+L / 10	80	10.0	25	1500 62	1.0×10^7	800	100	1000
	R7081-20	300 to 650/A-D	50	E678-20B*	B+L / 14	80	10.0	25	1500 64	1.0×10^9	80 000	5000	10 000
332 mm (13")	R8055	300 to 650/A-D	51	E678-20B*	B+L / 10	60	8.0	20	2000 63	5.0×10^7	3000	200	1000
508 mm (20")	R3600-02	300 to 650/A-D	52	E678-20B*	VB / 11	60	8.0	20	2000 40	1.0×10^7	600	200	1000
	R7250	300 to 650/A-D	53	E678-20B*	B+L / 10	60	8.0	20	2000 63	1.0×10^7	600	200	1000

Note: The data shown in [shaded cells] is measured with tapered voltage distribution ratio.
Please refer to page 18 and 19 for each item in the above list.

Note 2: Dark count

(at 25 °C)

Maximum Rating 12		Time Response 13			14	Stability 15		Pulse Linearity 16		Note	Assembly Type	Type No.
Anode to Cathode Voltage (V)	Average Anode Current (mA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)	T.T.S. Typ. (FWHM) (ns)	Typical Pulse Height Resolution (%)	Long Term (%)	Short Term (%)	±2 % Deviation (mA)	±5 % Deviation (mA)			
2700	0.2	2.6	48	1.1	7.6	1.0	1.0	15	30	SILICA type (R2256-02)	H6410 / H7195	R329-02
2700	0.2	2.7	40	1.1	7.6	1.0	1.0	100	200	UV type (R5113-02)		
2500	0.2	2.6	48	1.1	—	—	—	15	30			R331-05
1500	0.1	7.0	60	—	6.3 (8.5) *3	0.5	0.5	1	5	K-FREE type (R1306-15)		R1306
3000	0.2	1.3	28	0.55	7.8	1.0	1.0	100	200	SILICA type (R2059)	H1949-50 / H1949-51	R1828-01
3000	0.2	1.7	32	0.55	7.8	1.0	1.0	250	500	UV type (R4004)		
1500	0.1	5.0	15	0.7	8.5	0.5	1.0	80	200			R1840
1500	0.1	5.0	17	1.3	8.5	0.5	1.0	200	400			
3500	0.2	0.7	16	0.37	7.8	1.0	2.0	100	150	SILICA type (R3377)	H2431-50	R2083
1750	0.1	3.4	31	3.6	7.6	1.0	1.0	50	70	Glass Base type (R3149)		R2154-02
1750	0.1	3.4	33	3.6	7.6	1.0	1.0	150	200			
1800	0.02	2.6	28	—	10.0	2.0	2.0	30	60			R4607A-06
2300	0.1	2.5	9.5	0.44	9.5	2.0	2.0	500	700	For +HV operation	H6614-70	R5924-70
1000	0.1	2.3	16	0.75	—	—	—	40	—			R6041
1000	0.1	2.3	16	0.75	—	—	—	40	—	For Low Temperature Operation Down to -110 °C Low Radicoactivity Material		R6041-406
1000	0.1	2.3	16	0.75	—	—	—	40	—	For Low Temperature Operation Down to -186 °C Low Radicoactivity Material		R6041-506
1500	0.1	8.5	48	6.9	6.3 (8.5) *3	0.5	0.5	5	10	Semiflexible Lead type (R6231-01)		R6231
2000	0.2	1.7	23	1.1	7.6	1.0	1.0	80	100			R7723
2000	0.2	2.1	29	1.2	7.6	1.0	1.0	60	90			R7724
2000	0.2	2.5	35	1.3	7.6	1.0	1.0	40	80			R7725
1750	0.1	1.8	20	0.25	7.6	1.0	1.0	50	80		H10570	R9779
2000	0.1	2.0	24	0.28	—	—	—	50	80			R10533
1500	0.1	9.5	52	8.5	6.3 (8.5) *3	0.5	0.5	5	10	Semiflexible Lead type (R6232-01)		R6232
1500	0.1	8.0	64	—	6.3 (8.5) *3	0.5	0.5	1	5	K-FREE type (R1307-07)		R1307
3000	0.2	1.8	32	0.6	7.8	1.0	1.0	100	180	UV type (R4885)	H6525	R4143
3000	0.2	1.8	36	0.6	7.8	1.0	1.0	150	250			
2500	0.2	2.6	48	2	7.8	1.0	1.0	40	60		H6559	R6091
2500	0.2	2.7	40	1.5	7.8	1.0	1.0	80	110			
1500	0.1	9.5	52	8.5	6.3 (8.5) *3	0.5	0.5	5	10	Semiflexible Lead type (R6233-01)		R6233
1750	0.1	—	41	—	—	—	—	13	—	For Low Temperature Operation Down to -186 °C Low Radicoactivity Material		R11065
1750	0.1	5.5	46	—	—	—	—	20	50	For Low Temperature Operation Down to -110 °C Low Radicoactivity Material		R11410
1500	0.1	10.0	52	9.4	6.3 (8.5)	0.5	0.5	5	10	Semiflexible Lead type (R10233-01)		R10233
1500	0.1	20.0	115	—	8.0	0.5	0.5	10	20	K-FREE type (R877-01)		R877
3000	0.2	2.5	54	1.2	8.3	1.0	1.0	100	150		H6527	R1250
3000	0.2	2.2	53	1.2	8.3	1.0	1.0	160	250			
3000	0.2	2.5	54	1.2	—	—	—	100	150		H6528	R1584
2000	0.1	3.5	45	1.5	—	—	—	30	50			R6594
2000	0.1	3.5	45	1.5	—	—	—	100	150			
2000	0.1	3.6	54	2.4	—	—	—	40	60			R5912
2000	0.1	4.4	72	3.0	—	—	—	30	60			R5912-02
2000	0.1	3.8	62	3.4	—	—	—	40	60			R7081
2000	0.1	5.0	80	3.9	—	—	—	30	60			R7081-20
2500	0.1	5.3	88	2.8	—	—	—	60	80			R8055
2500	0.1	10.0	95	5.5	—	—	—	20	40		R3600-06	R3600-02
2500	0.1	7.0	110	3.5	—	—	—	60	80			R7250

Note 3: This data in parenthese is measured with ^{57}Co.

Tube Diameter	Type No.	❶ Spectral Response Range (nm) / Curve Code	❷ Outline No.	❸ Socket & Socket Assembly	❹ Dynode Structure / No. of Stages	Cathode Sensitivity			Anode Sensitivity				
						❺ Luminous Typ. (µA/lm)	❻ Blue Sens. Index (CS 5-58) Typ.	❼ Q.E. at Peak Typ. (%)	❽ Anode to Cathode Supply Voltage (V)	❾ Gain Typ.	❿ Luminous Typ. (A/lm)	⓫ Dark Current Typ. (nA)	Dark Current Max. (nA)
Metal Package Photomultiplier and Assemblies													
	R8520-406	160 to 650/I	54	E678-32B	MC / 10	100	11.0	—	800 (16)	1.0×10^6	100	2	20
	R8520-506	160 to 650/J	54	E678-32B	MC / 10	100	9.0	—	800 (16)	1.0×10^6	100	2	20
30 mm square type	R7600U	300 to 650/A-D	55	E678-32B 25	MC / 10	80	9.5	24	800 (23)	2.0×10^6	160	2	20
30 mm square type	R7600U -00-M4	300 to 650/A-D	56	E678-32B 26	MC / 10	80	9.5	24	800 (23)	1.8×10^6	140	0.5/ch	5/ch
30 mm square type	R5900U -00-L16	300 to 650/A-D	57	E678-32B 27	MC / 10	70	8.5	21	800 (17)	4.0×10^6	280	0.2	2
30 mm square type	R8900U-00-M4	300 to 650/A-D	58	E678-32B	MC / 10	80	9.5	24	800 (16)	1.0×10^6	80	1/ch	5/ch
30 mm square type	R8900-00-M16	300 to 650/A-D	59	— 30	MC / 12	80	9.5	24	800 (41)	1.0×10^6	80	0.8/ch	4/ch
30 mm square type	R11265U	300 to 650/A-D	60	E678-19K 31	MC / 12	80	9.5	24	900 (49) 900 (51)	9.4×10^5 3.8×10^5	75 30	2 2	20 20
Assemblies	H8711	300 to 650/A-D	P55 27	—	MC / 12	80	9.5	24	800 (47)	3.5×10^6	280	0.8/ch	4/ch
Assemblies	H7546B	300 to 650/A-D	P55 28	—	MC / 12	80	9.5	24	800 (50)	6.0×10^5	50	0.2/ch	2/ch
Assemblies	H8804	300 to 650/A-D	P56 29	—	MC / 12	80	9.5	24	800 (50)	6.0×10^5	50	0.2/ch	2/ch
Assemblies	H7260	300 to 650/A-D	P56 30	—	MC / 10	70	8.5	21	800 (17)	2.0×10^6	140	0.2	2
Assemblies	H8500C	300 to 650/A-D	P56 31	—	MC / 12	60	9.5	24	1000 (58)	1.5×10^6	90	0.1/ch	—
Assemblies	H9500	300 to 650/A-D	P57 33	—	MC / 12	60	9.5	24	1000 (59)	1.5×10^6	90	0.05/ch	—
Assemblies	H10966A	300 to 650/A-D	P56 31	—	MC / 8	60	9.5	24	1000 (13)	3.3×10^5	20	0.06/ch	—
Fine Mesh Photomultipliers													
25 mm (1")	R5505-70	300 to 650/A-D	10	E678-17A* 8	FM / 15	80	9.5	23	2000 (65)	5.0×10^5	40	5	30
39 mm (1.5")	R7761-70	300 to 650/A-D	21	—	FM / 19	80	9.5	23	2000 (66)	1.0×10^7	800	15	100
51 mm (2")	R5924-70	300 to 650/A-D	31	—	FM / 19	70	9.0	22	2000 (66)	1.0×10^7	700	30	200
Square, Rectangular Shape Photomultipliers													
10 mm (3/8")	R2248	300 to 650/A-D	61	E678-11N* 1	LINE / 8	95	9.5	23	1250 (4)	1.1×10^6	100	1	50
60 mm	R6236	300 to 650/A-D	62	E678-14W 19	B+L / 8	110	12.0	30	1000 (5)	2.7×10^5	30	2	20
76 mm (3")	R6237	300 to 650/A-D	63	E678-14W 19	B+L / 8	110	12.0	30	1000 (5)	2.7×10^5	30	2	20
25 mm (1")	R1548-07	300 to 650/A-D	64	E678-17A* 7	LINE / 10	80	9.5	23	1250 (33)	2.5×10^6	200	20	250
38 mm (1-1/2")	R8997	300 to 650/A-D	65	E678-20B*	L+VB / 10	80	9.5	23	1250 (32)	1.2×10^6	100	10	200
38 mm (1-1/2")	R10550	300 to 650/A-D	66	E678-20B*	LINE / 8	100	10.0	—	1300 (10)	1.0×10^6	100	10	100
Hexagonal Shape Photomultipliers													
60 mm	R6234	300 to 650/A-D	67	E678-14W 19	B+L / 8	110	12.0	30	1000 (5)	2.7×10^5	30	2	20
76 mm (3")	R6235	300 to 650/A-D	68	E678-14W 19	B+L / 8	110	12.0	30	1000 (5)	2.7×10^5	30	2	20
2π Shape Photomultipliers													
25 mm (1")	R7373A-01	300 to 650/A-D	69	E678-12A*	LINE / 10	90	10.5	26	1000 (29)	1.1×10^6	100	3	20
28 mm (1-1/8")	R8143	300 to 650/A-D	70	E678-14C*	BOX / 11	90	10.5	26	1000 (39)	2.2×10^6	200	2	10

Note: The data shown in [shaded] is measured with tapered voltage distribution ratio.
Please refer to page 18 and 19 for each item in the above list.

(at 25 °C)

Maximum Rating ⓬		Time Response ⓭			⓮	Stability ⓯		Pulse Linearity ⓰		Note	Type No.
Anode to Cathode Voltage (V)	Average Anode Current (mA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)	T.T.S. Typ. (FWHM) (ns)	Typical Pulse Height Resolution (%)	Long Term (%)	Short Term (%)	±2 % Deviation (mA)	±5 % Deviation (mA)		
900	0.1	1.8	12.4	0.8	—	—	—	30	60	For Low Temperature Operation Down to -110 °C Low Radioactivity Material	R8520-406
900	0.1	1.8	12.4	0.8	—	—	—	30	60	For Low Temperature Operation Down to -186 °C Low Radioactivity Material	R8520-506
900	0.1	1.6	9.6	0.35	—	1.0	2.0	30	60	UV type (R7600U-03) is available	R7600U
900	0.1	1.2	9.5	0.36	—	—	—	10	30	*4	R7600U -00-M4
900	0.1	0.60	7.4	0.18	—	—	—	0.8	1.2	*4	R5900U -00-L16
900	0.1	1.4	11.4	0.95	—	—	—	5	10	*4	R8900U-00-M4
1000	0.1	1.3	13	0.75	—	—	—	1.5	3.5	*4	R8900-00-M16
1000	0.1	1.3	5.8	0.27	—	—	—	20	60		R11265U
1000	0.1	1.3	5.8	0.3	—	—	—	300	400		
1000	0.017	0.83	12	0.33	—	—	—	0.5	1	*4, Assembly with divider network	H8711
1000	0.023	1.0	12	0.38	—	—	—	0.3	0.6	*4, Assembly with divider network	H7546B
1000	0.023	1.0	12	0.38	—	—	—	0.3	0.6	*4, Assembly with divider network	H8804
900	0.1	0.60	6.8	0.18	—	—	—	0.6	0.8	*4, Assembly with divider network	H7260
1100	0.1	0.8	6.0	0.4	—	—	—	1/ch	2/ch	*4, Assembly with divider network	H8500C
1100	0.1	0.8	6.0	0.4	—	—	—	0.2/ch	1/ch	*4, Assembly with divider network	H9500
1100	0.1	0.4	4.0	—	—	—	—	1.2/ch	3/ch	*4, Assembly with divider network	H10966A
2300	0.01	1.5	5.6	0.35	9.5	2.0	2.0	180	250	For +HV operation	R5505-70
2300	0.01	2.1	7.5	0.35	9.5	2.0	2.0	350	500	For +HV operation	R7761-70
2300	0.1	2.5	9.5	0.44	9.5	2.0	2.0	500	700	For +HV operation	R5924-70
1500	0.03	0.9	9.0	0.6	23 / BGO*1	1.0	2.0	3	7		R2248
1500	0.1	9.5	52	8.5	6.3 (8.5)*3	0.5	0.5	5	10	Semiflexible Lead type (R6236-01) is available	R6236
1500	0.1	9.5	52	8.5	6.3 (8.5)*3	0.5	0.5	5	10	Semiflexible Lead type (R6237-01) is available	R6237
1750	0.1	1.8	20	1.0	20 / BGO*1	1.0	2.0	10	15	*4, Dual (2) channel	R1548-07
1600	0.1	5.0	25	2.8	16 / BGO*1	2.0	2.0	4	10	*4, Quadrant (4) channel	R8997
1600	0.1	1.3	12	0.6	—	—	—	10	30	*4, Quadrant (4) channel	R10550
1500	0.1	9.5	52	8.5	6.3 (8.5)*3	0.5	0.5	5	10	Semiflexible Lead type (R6234-01) is available	R6234
1500	0.1	9.5	52	8.5	6.3 (8.5)*3	0.5	0.5	5	10	Semiflexible Lead type (R6235-01) is available	R6235
1250	0.1	2	19	1.1	7.8	1.0	2.0	15	30		R7373A-01
1250	0.1	25	72	—	8	1.0	2.0	0.2	0.5		R8143

Note 1: This data is measured with ^{22}Na source and BGO scintillator.
Note 3: This data in parenthese is measured with ^{57}Co.
Note 4: Dark current, time response and pulse linearity data is typical value for channel.

Tube Diameter	Type No.	❶ Spectral Response Range (nm) / Curve Code	❷ Outline No.	❸ Socket & Socket Assembly	❹ Dynode Structure / No. of Stages	Cathode Sensitivity ❺ Luminous Typ. (µA/lm)	❻ Blue Sens. Index (CS 5-58) Typ.	❼ Q.E. at Peak Typ. (%)	Anode Sensitivity ❽ Anode to Cathode Supply Voltage (V)	❾ Gain Typ.	❿ Anode Luminous Sensitivity Typ. (A/lm)	⓫ Dark Current (After 30 min) Typ. (nA)	Max. (nA)
UBA (Ultra Biallali), SBA (Super Bialkali), Extended Green Bialkali Photomultipliers													
Metal Package PMT 30 mm square type	R5900U-100-L16	300 to 650 / F	57	E678-32B 27	MC / 10	105	13.5	35	800 (17)	3.0×10^6	320	0.2/ch	2/ch
	R5900U-200-L16	300 to 650 / G	57	E678-32B 27	MC / 10	135	15.5	43	800 (17)	3.0×10^6	400	0.2/ch	2/ch
	R7600U-100	300 to 650 / F	55	E678-32B 25	MC / 10	105	13.5	35	800 (23)	1.0×10^6	105	2	20
	R7600U-200	300 to 650 / G	55	E678-32B 25	MC / 10	135	15.5	43	800 (23)	1.0×10^6	135	2	20
	R7600U-100-M4	300 to 650 / F	56	E678-32B 26	MC / 10	105	13.5	35	800 (23)	1.3×10^6	140	0.5/ch	5/ch
	R7600U-200-M4	300 to 650 / G	56	E678-32B 26	MC / 10	135	15.5	43	800 (23)	1.3×10^6	175	0.5/ch	5/ch
	R8900U-100-M4	300 to 650 / F	58	E678-32B	MC / 10	105	13.5	35	800 (16)	1.0×10^6	105	1/ch	5/ch
	R8900-100-M16	300 to 650 / F	59	— 30	MC / 12	105	13.5	35	800 (41)	1.0×10^6	105	0.8/ch	8/ch
	R8900-100-C12	300 to 650 / F	P44 1	E678-32B 28	MC / 11	105	13.5	35	800 (38)	5.4×10^5	70	2	20
	R11265U-100	300 to 650 / F	60	E678-19K 31	MC / 12	95	13.5	35	900 (49) 900 (51)	8.4×10^5 3.7×10^5	80 35	2 2	20 20
	R11265U-200	300 to 650 / G	60	E678-19K 31	MC / 12	120	15.5	43	900 (49) 900 (51)	1.3×10^6 5.0×10^5	160 60	2 2	20 20
Metal Package PMT assem-blies	H8711-100	300 to 650 / F	P55 27	—	MC / 12	105	13.5	35	-800 (47)	2.0×10^6	210	0.8/ch	4/ch
	H8711-200	300 to 650 / G	P55 27	—	MC / 12	135	15.5	43	-800 (47)	2.0×10^6	270	0.8/ch	4/ch
	H7546B-100	300 to 650 / F	P55 28	—	MC / 12	105	13.5	35	-800 (50)	5.0×10^5	53	0.2/ch	2/ch
	H7546B-200	300 to 650 / G	P55 28	—	MC / 12	135	15.5	43	-800 (50)	5.0×10^5	68	0.2/ch	2/ch
	H8804-100	300 to 650 / F	P56 29	—	MC / 12	105	13.5	35	-800 (50)	5.0×10^5	53	0.2/ch	2/ch
	H8804-200	300 to 650 / G	P56 29	—	MC / 12	135	15.5	43	-800 (50)	5.0×10^5	68	0.2/ch	2/ch
	H7260-100	300 to 650 / F	P56 30	—	MC / 10	105	13.5	35	-800 (17)	2.0×10^6	210	0.2/ch	2/ch
	H7260-200	300 to 650 / G	P56 30	—	MC / 10	135	15.5	43	-800 (17)	2.0×10^6	270	0.2/ch	2/ch
	H10966A-100	300 to 650 / F	P56 31	—	MC / 8	95	13.5	35	-1000 (13)	3.2×10^5	30	0.1/ch	—
	H10966B-100	300 to 650 / F	P57 32	—	MC / 8	95	13.5	35	-1000 (13)	3.2×10^5	30	0.1/ch	—
25 mm (1")	R9800-100	300 to 650 / F	13	E678-12A 10	L / 8	130	13.5	35	1300 (10)	1.1×10^6	140	10	100
28 mm (1-1/8")	R3998-100-02	300 to 650 / F	14	E678-14C	B+L / 9	130	13.5	35	1000 (15)	1.0×10^6	130	5	25
38 mm (1-1/2")	R9420-100	300 to 650 / F	22	E678-12A 19	L / 8	130	13.5	35	1300 (10)	3.7×10^5	48	10	100
51 mm (2")	R6231-100	300 to 650 / F	34	E678-14W 19	B+L / 8	130	13.5	35	1000 (5)	2.3×10^5	30	10	30
	R7724-100	300 to 650 / F	35	E678-21C 19	L / 10	130	13.5	35	1750 (35)	2.0×10^6	430	10	50
76 mm (3")	R6233-100	300 to 650 / F	42	E678-14W 19	B+L / 8	130	13.5	35	1000 (5)	2.3×10^5	30	10	30
90 mm (3.5")	R10233-100	300 to 650 / F	44	E678-14W 19	B+L / 8	130	13.5	35	1000 (6)	2.3×10^5	30	10	30
127 mm (5")	R877-100	300 to 650 / F	45	E678-14W	B / 10	105	13.5	35	1250 (18)	4.4×10^5	46	20	100
204 mm (8")	R5912-100	300 to 650 / F	49	E678-20B	B+L / 10	130	13.5	35	1500 (62)	1.0×10^7	1300	500	1000
254 mm (10")	R7081-100	300 to 650 / F	50	E678-20B	B+L / 10	130	13.5	35	1500 (62)	1.0×10^7	1300	500	1000
Metal Package PMT 30 mm square type	R7600U-300	300 to 700 / H	55	E678-32B 25	MC / 10	160	14	39	800 (23) 800 (28)	2.0×10^6 5.0×10^5	320 80	2 1	20 10
	R7600U-300-M4	300 to 700 / H	56	E678-32B 26	MC / 10	160	14	39	800 (23)	1.3×10^6	210	0.5/ch	5/ch
Metal Package PMT assem-blies	H8711-300	300 to 700 / H	P55 28	—	MC / 12	160	14	39	-800 (47)	2.5×10^6	400	0.8/ch	4/ch
	H7546B-300	300 to 700 / H	P55 29	—	MC / 12	160	14	39	-800 (50)	5.0×10^5	80	0.2/ch	2/ch
	H8804-300	300 to 650 / H	P56 30	—	MC / 12	160	14	39	-800 (50)	5.0×10^5	80	0.2/ch	2/ch

Note: The data shown in is measured with tapered voltage distribution ratio. Please refer to page 18 and 19 for each item in the above list.

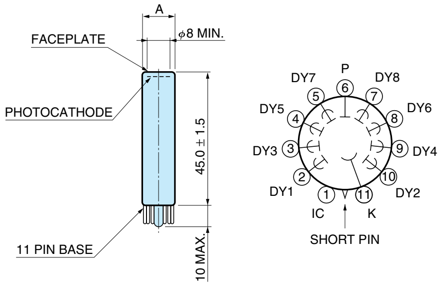
(at 25 °C)

Maximum Rating ⑫		Time Response ⑬			⑭	Stability ⑮		Pulse Linearity ⑯		Note	Type No.
Anode to Cathode Voltage (V)	Average Anode Current (mA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)	T.T.S. Typ. (FWHM) (ns)	Typical Pulse Height Resolution (%)	Long Term (%)	Short Term (%)	±2 % Deviation (mA)	±5 % Deviation (mA)		
900	0.1	0.6	7.4	0.18	—	—	—	0.8/ch	1.2/ch	SBA type	R5900U-100-L16
900	0.1	0.6	7.4	0.18	—	—	—	0.8/ch	1.2/ch	UBA type	R5900U-200-L16
900	0.1	1.6	9.6	0.35	—	—	—	30	60	SBA type	R7600U-100
900	0.1	1.6	9.6	0.35	—	—	—	30	60	UBA type	R7600U-200
900	0.1	1.2	9.5	0.36	—	—	—	10/ch	30/ch	SBA type	R7600U-100-M4
900	0.1	1.2	9.5	0.36	—	—	—	10/ch	30/ch	UBA type	R7600U-200-M4
900	0.1	1.4	11.4	0.95	—	—	—	5/ch	10/ch	SBA type	R8900U-100-M4
1000	0.1	1.3	13	0.75	—	—	—	—	3.5/ch	SBA type	R8900-100-M16
1000	0.1	2.2	11.9	0.75	—	—	—	2	15	SBA type	R8900U-100-C12
1000	0.1	1.3	5.8	0.27	—	—	—	20	60	SBA type	R11265U-100
1000	0.1	1.3	5.8	0.3	—	—	—	300	400		
1000	0.1	1.3	5.8	0.27	—	—	—	20	60	UBA type	R11265U-200
1000	0.1	1.3	5.8	0.3	—	—	—	300	400		
-1000	0.017	0.83	12	0.33	—	—	—	0.5/ch	1/ch	SBA type	H8711-100
-1000	0.017	0.83	12	0.33	—	—	—	0.5/ch	1/ch	UBA type	H8711-200
-1000	0.023	1.0	12	0.38	—	—	—	0.3/ch	0.6/ch	SBA type	H7546B-100
-1000	0.023	1.0	12	0.38	—	—	—	0.3/ch	0.6/ch	UBA type	H7546B-200
-1000	0.023	1.0	12	0.38	—	—	—	0.3/ch	0.6/ch	SBA type	H8804-100
-1000	0.023	1.0	12	0.38	—	—	—	0.3/ch	0.6/ch	UBA type	H8804-200
-900	0.1	0.6	6.8	0.18	—	—	—	0.6/ch	0.8/ch	SBA type	H7260-100
-900	0.1	0.6	6.8	0.18	—	—	—	0.6/ch	0.8/ch	UBA type	H7260-200
-1100	0.1	0.4	4	—	—	—	—	1.2/ch	3/ch	SBA type	H10966A-100
-1100	0.1	0.4	4	—	—	—	—	1.2/ch	3/ch	SBA type	H10966B-100
1500	0.1	1.0	11	0.27	—	—	—	30	—	SBA type	R9800-100
1500	0.1	3.4	23	3	7.0	1.0	1.0	8	10	SBA type	R3998-100-02
1500	0.1	1.6	17	0.55	7.0	1.0	2.0	30	50	SBA type	R9420-100
1500	0.1	8.5	48	6.9	6.1	0.5	0.5	5	10	SBA type	R6231-100
2000	0.2	2.0	350	1.1	—	1.0	1.0	60	80	SBA type	R7724-100
1500	0.1	9.5	52	8.5	6.1	0.5	0.5	5	10	SBA type	R6233-100
1500	0.1	10	52	9.4	6.1	0.5	0.5	5	10	SBA type *	R10233-100
1500	0.1	20	115	—	7.6	0.5	0.5	10	20	SBA type	R877-100
2000	0.1	3.6	54	2.4	—	—	—	40	60	SBA type	R5912-100
2000	0.1	3.8	62	3.4	—	—	—	40	60	SBA type	R7081-100
900	0.1	1.6	9.6	0.35	—	—	—	30	—	Extended Green Bialkali Photomultipliers	R7600U-300
900	0.1	1.6	9.6	0.35	—	—	—	100	—		
900	0.1	1.2	9.5	0.36	—	—	—	10/ch	30/ch	Extended Green Bialkali Photomultipliers	R7600U-300-M4
-1000	0.017	0.83	12	0.33	—	—	—	0.5/ch	1/ch	Extended Green Bialkali Photomultipliers	H8711-300
-1000	0.023	1.0	12	0.38	—	—	—	0.3/ch	0.6/ch	Extended Green Bialkali Photomultipliers	H7546B-300
-1000	0.023	1.0	12	0.38	—	—	—	0.3/ch	0.6/ch	Extended Green Bialkali Photomultipliers	H8804-300

Dimensional Outline and Basing Diagrams

For Photomultiplier Tubes

1 R1635, R2496

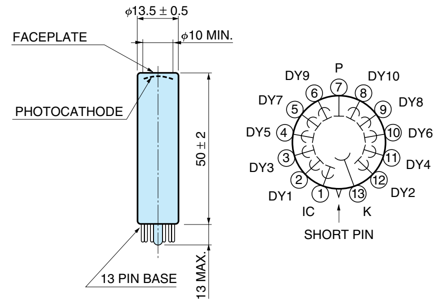


	A
R1635	9.7 ± 0.4
R2496	10.5 ± 0.5

R2496 has a plano-concave faceplate.

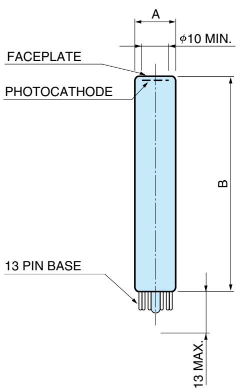
TPMHA0343EB

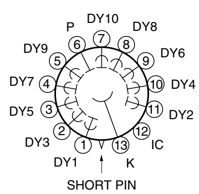
2 R4124



TPMHA0102EA

3 R647-01, R4177-06

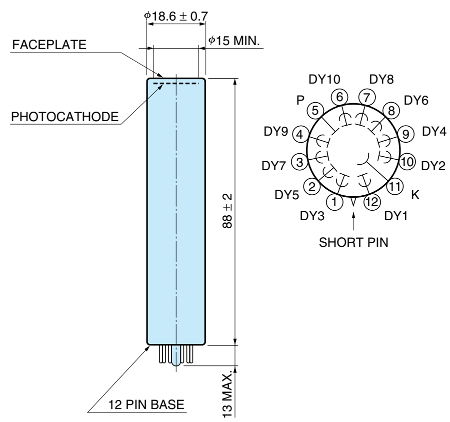




	A	B
R647-01	φ13.5 ± 0.5	71 ± 2
R4177-06	φ14.5 ± 0.7	61 ± 2

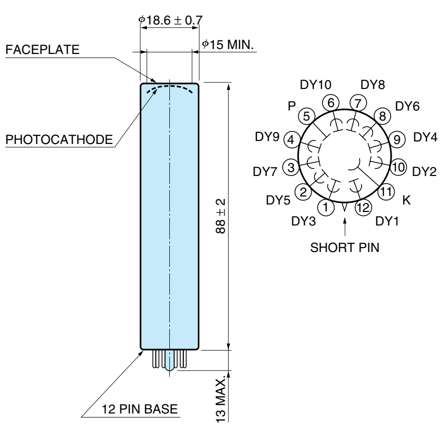
TPMHA0120EA

4 R1166



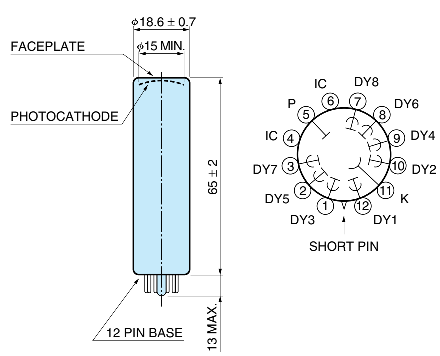
TPMHA0344EA

5 R1450, R4125



TPMHA0307EA

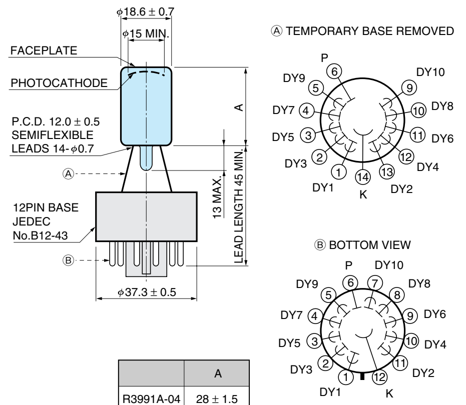
6 R3478



TPMHA0431EB

(Unit: mm)

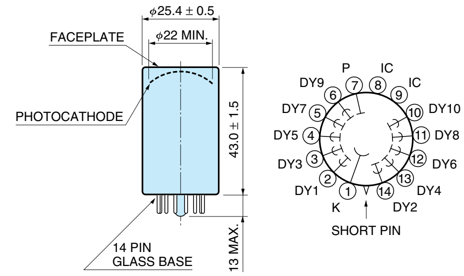
7 R3991A-04, R5611A-01



	A
R3991A-04	28 ± 1.5
R5611A-01	30 ± 1.5

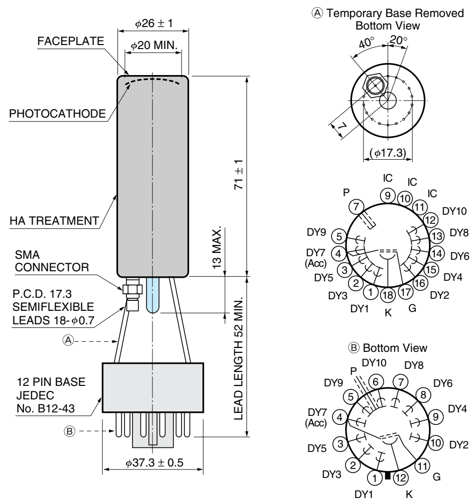
TPMHA0117EC

8 R1288A-06, R1924A



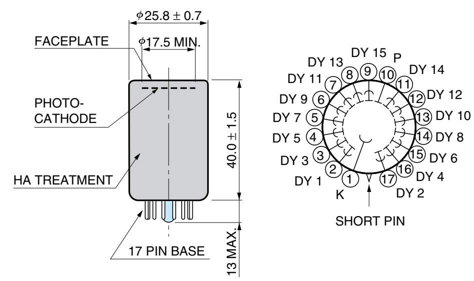
TPMHA0040EC

9 R4998



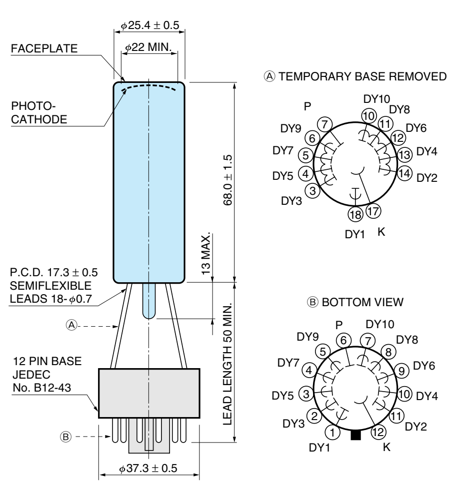
TPMHA0093EE

10 R5505-70



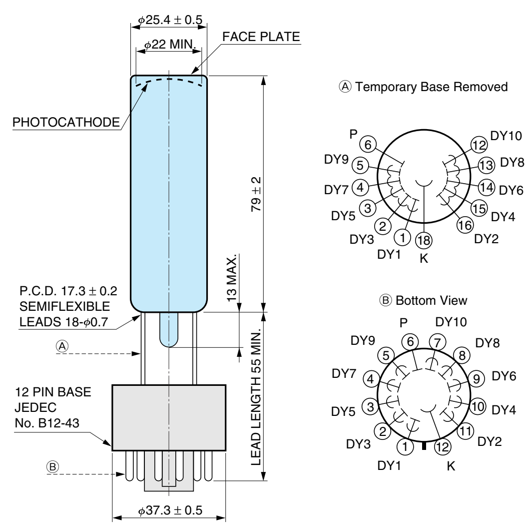
TPMHA0236EB

11 R7899-01



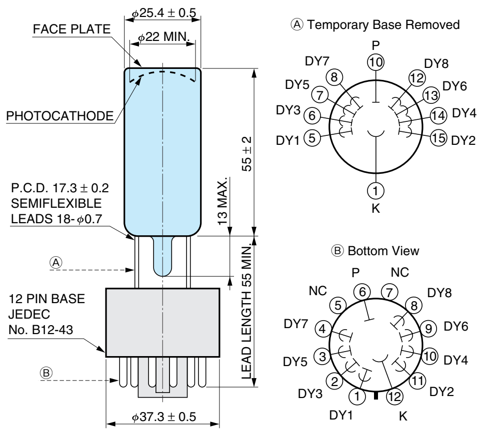
TPMHA0474EB

12 R8619



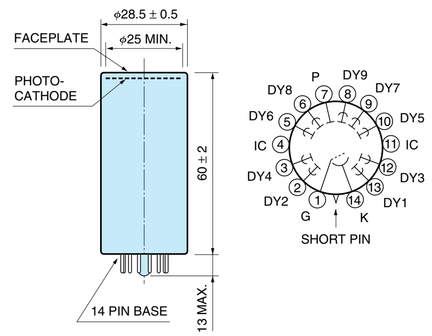
TPMHA0551EC

⑬ R9800



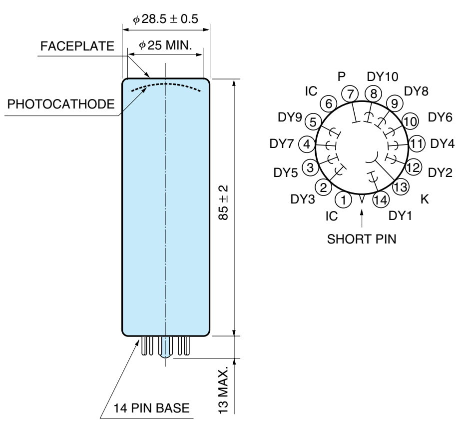
TPMHA0521EC

⑭ R3998-02, R3998-100-02



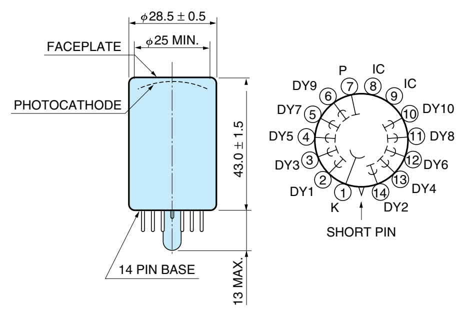
TPMHA0114EA

⑮ R6427



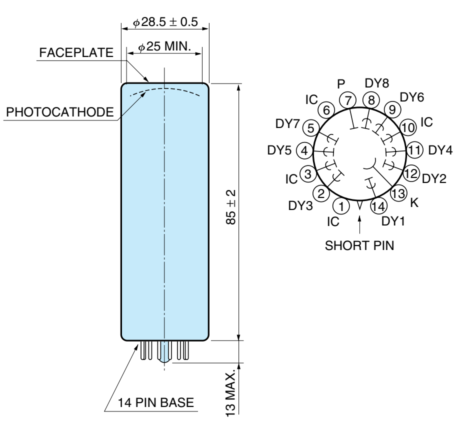
TPMHA0387EB

⑯ R7111



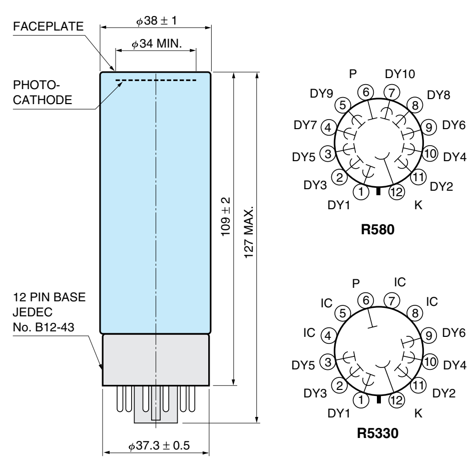
TPMHA0506EA

⑰ R7525



TPMHA0450EB

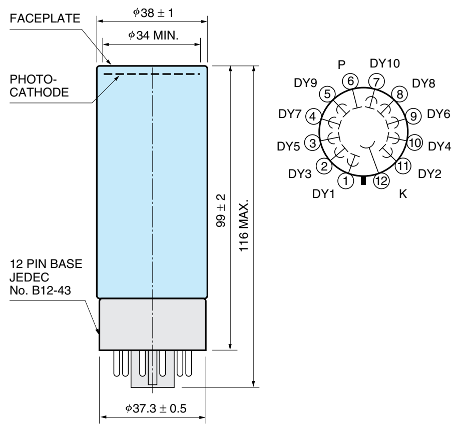
⑱ R580



TPMHA0121EA

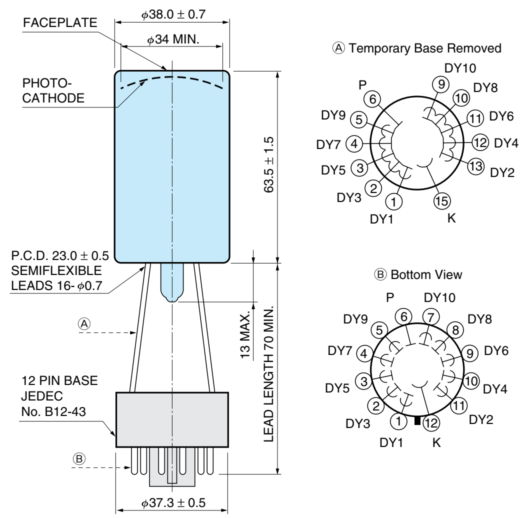
(Unit: mm)

⑲ R11102



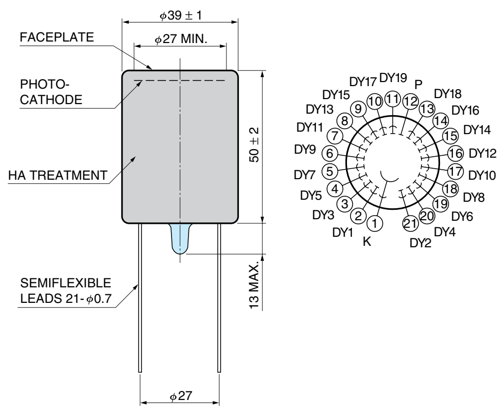
TPMHA0228EA

⑳ R3886A



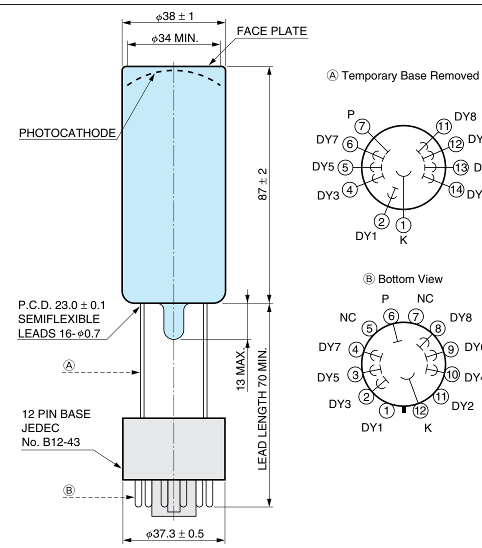
TPMHA0104EB

㉑ R7761-70



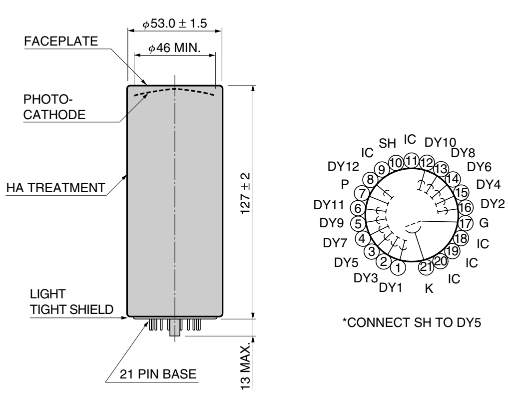
TPMHA0469ED

㉒ R9420, R9420-100



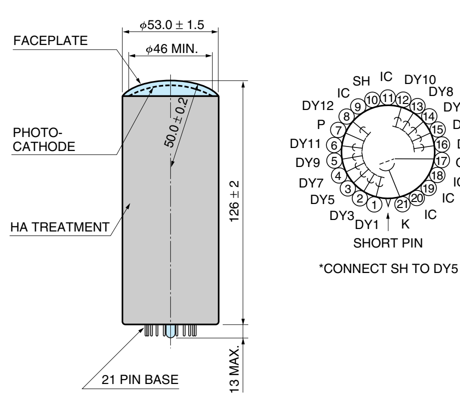
TPMHA0519ED

㉓ R329-02



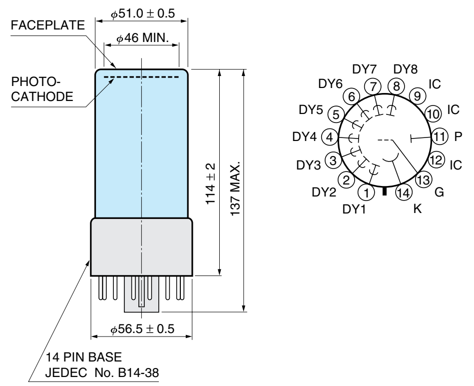
TPMHA0123EG

㉔ R331-05



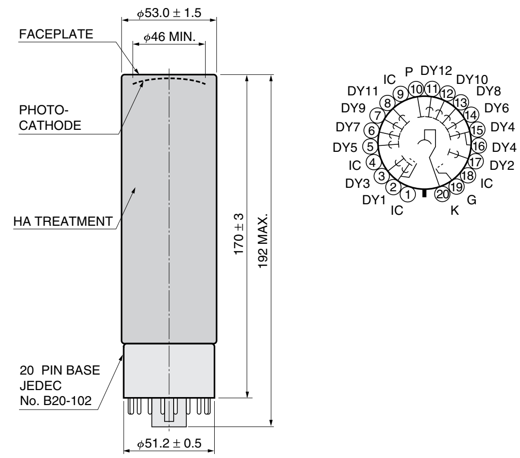
TPMHA0072EF

㉕ R1306



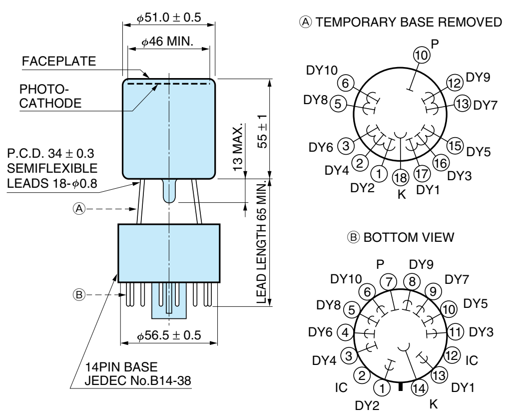
TPMHA0089EC

㉖ R1828-01



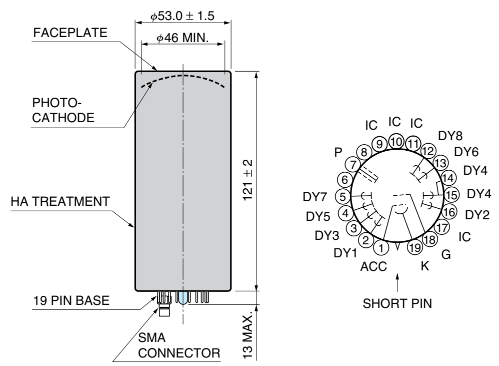
TPMHA0064EE

㉗ R1840



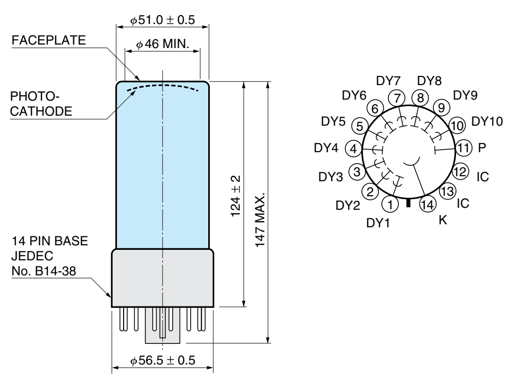
TPMHA0095EC

㉘ R2083



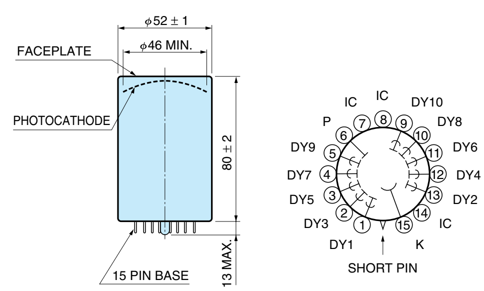
TPMHA0185EE

㉙ R2154-02



TPMHA0296EB

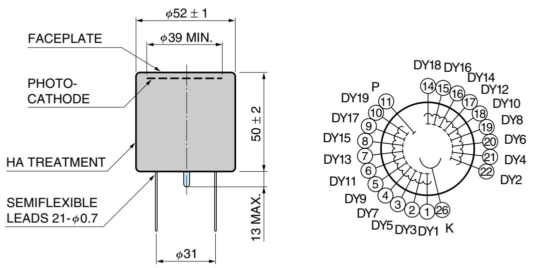
㉚ R4607A-06



TPMHA0003EC

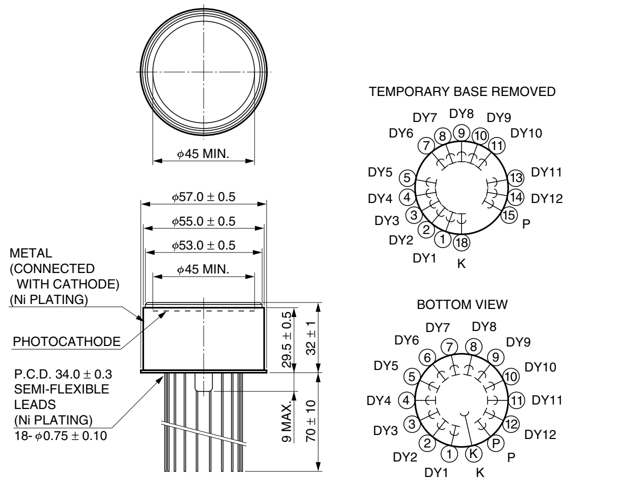
(Unit: mm)

㉛ R5924-70



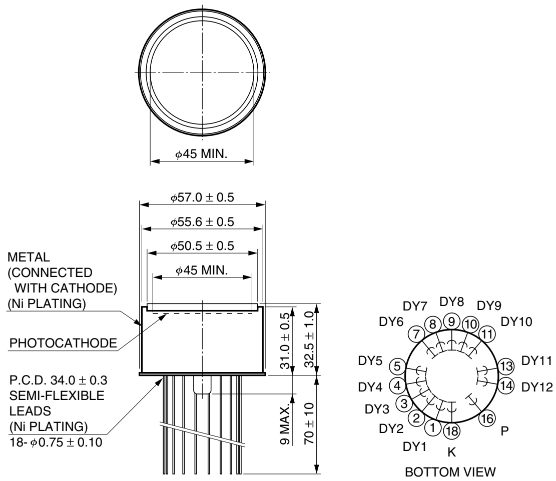
TPMHA0490EB

㉜ R6041



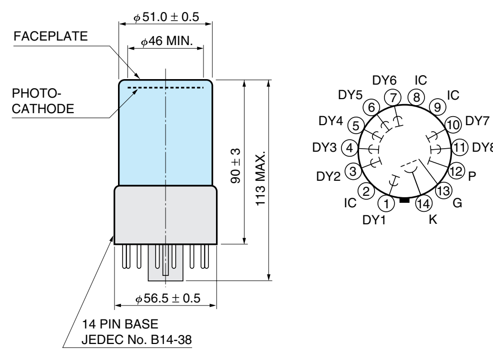
TPMHA0578EA

㉝ R6041-406, R6041-506



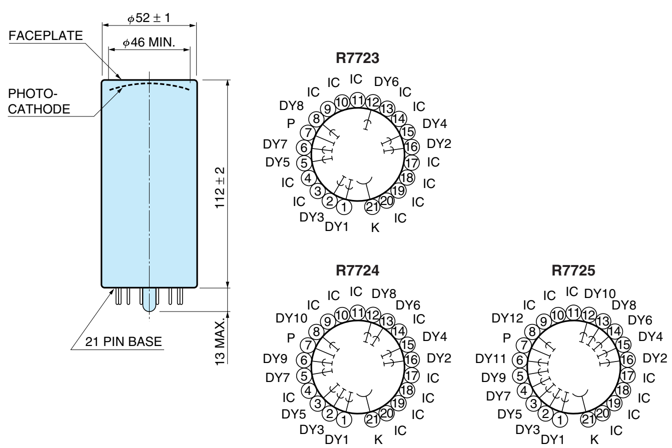
TPMHA0579EA

㉞ R6231, R6231-100



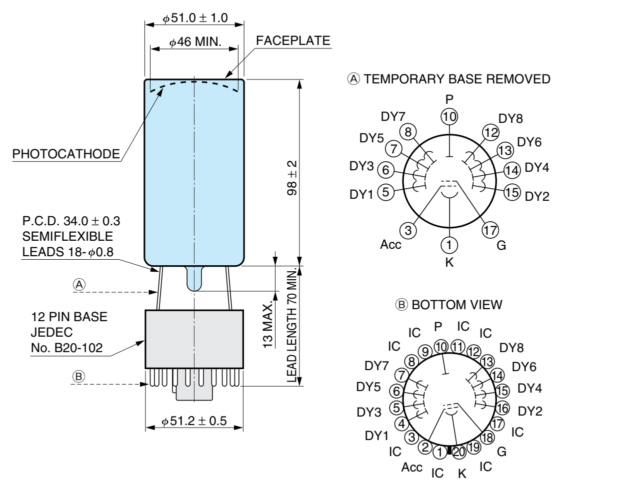
TPMHA0388EB

㉟ R7723, R7724, R7725



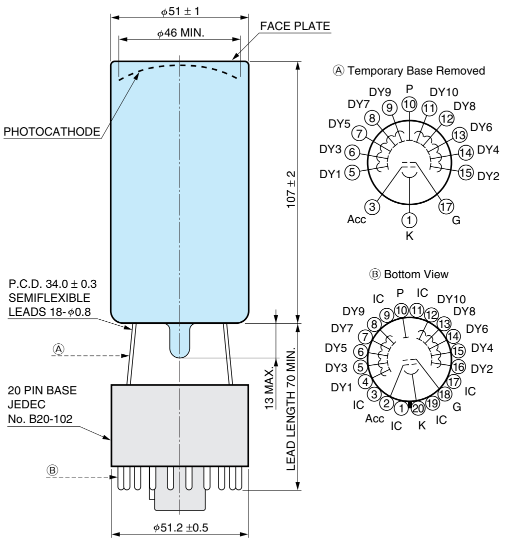
TPMHA0509EC

㊱ R9779



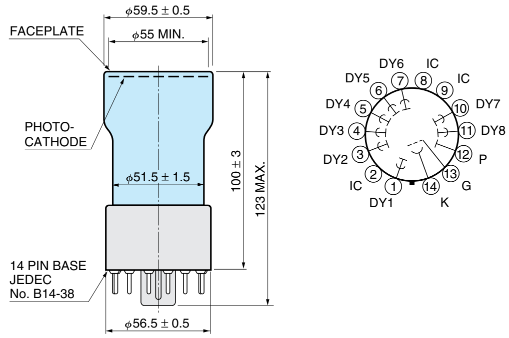
TPMHA0520EF

37 R10533



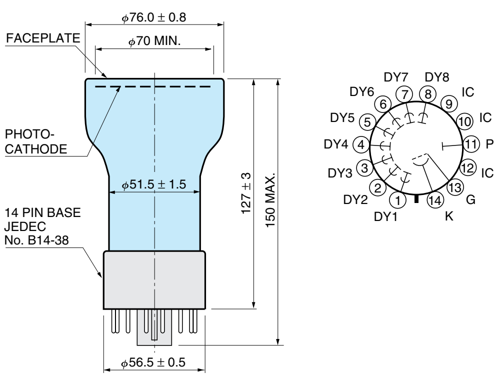
TPMHA0556EB

38 R6232



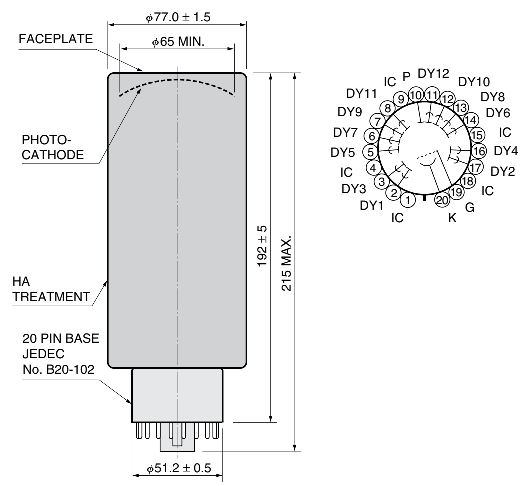
TPMHA0510EA

39 R1307



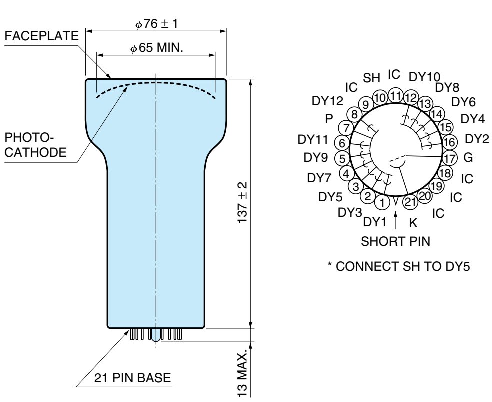
TPMHA0078EA

40 R4143



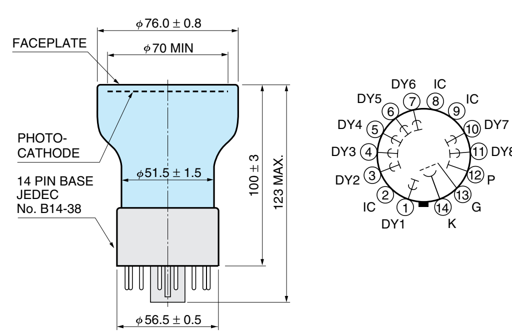
TPMHA0112ED

41 R6091



TPMHA0285ED

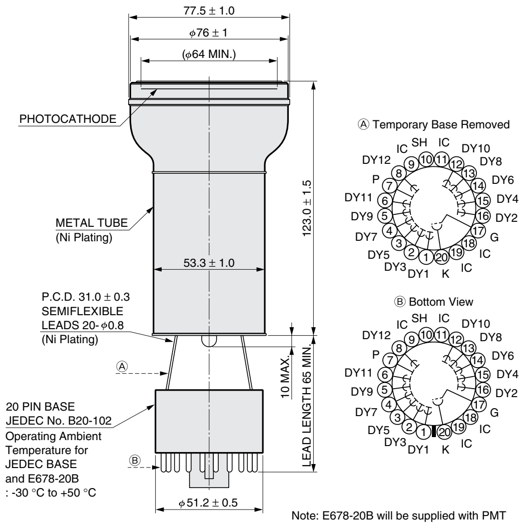
42 R6233, R6233-100



TPMHA0389EB

(Unit: mm)

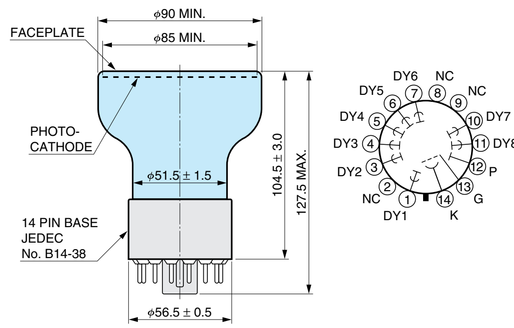
43 R11065, R11410



Note: E678-20B will be supplied with PMT

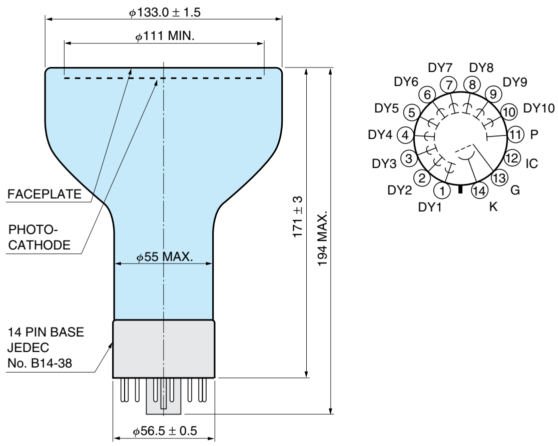
TPMHA0573EA

44 R10233, R10233-100



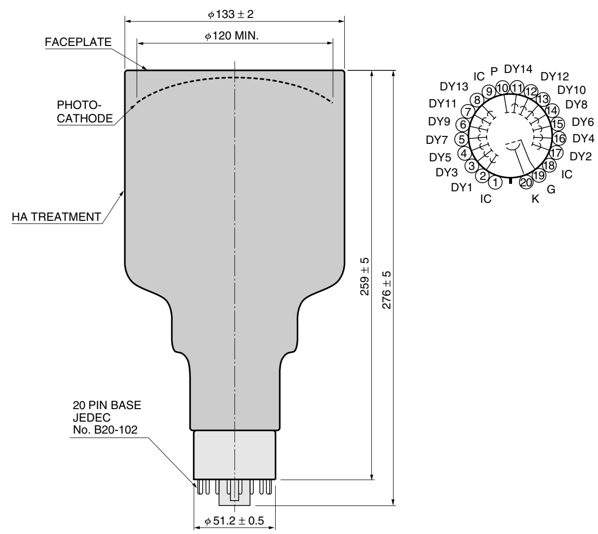
TPMHA0580EA

45 R877, R877-100



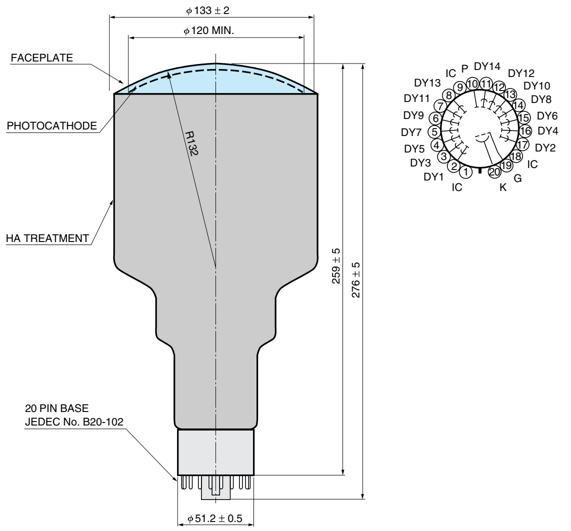
TPMHA0074EC

46 R1250



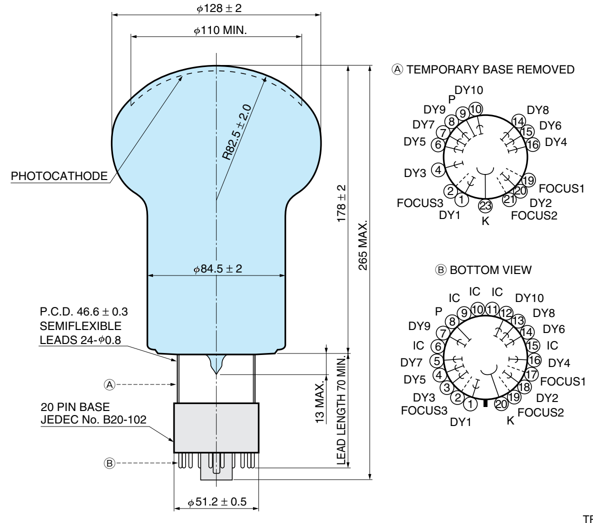
TPMHA0018ED

47 R1584



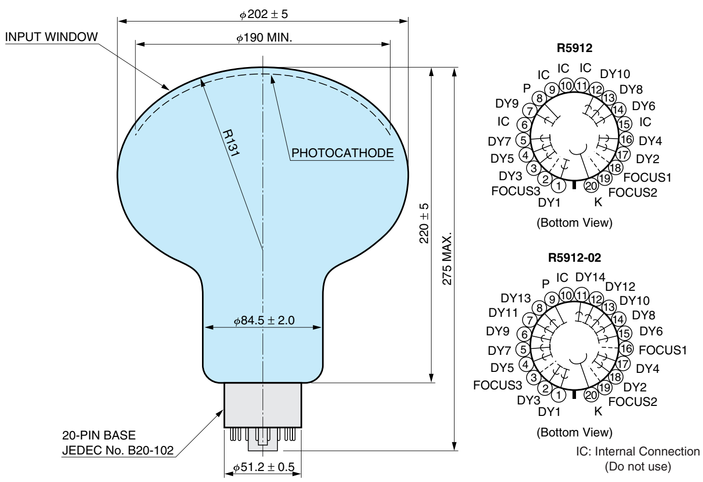
TPMHA0187EE

48 R6594



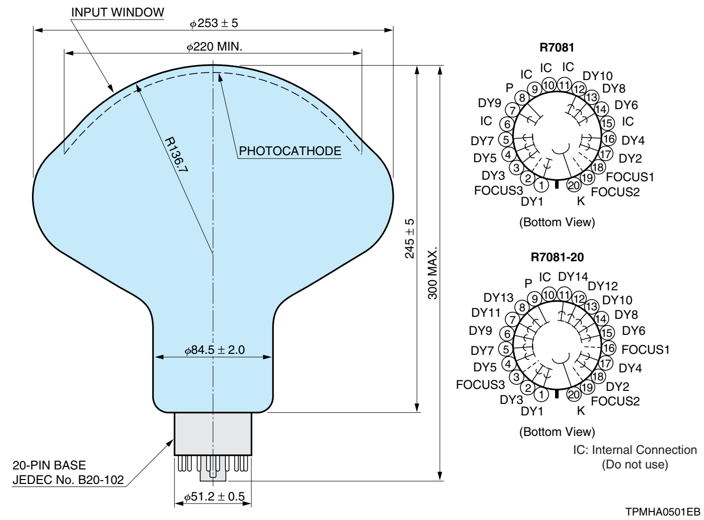
TPMHA0373EE

49 R5912, R5912-02



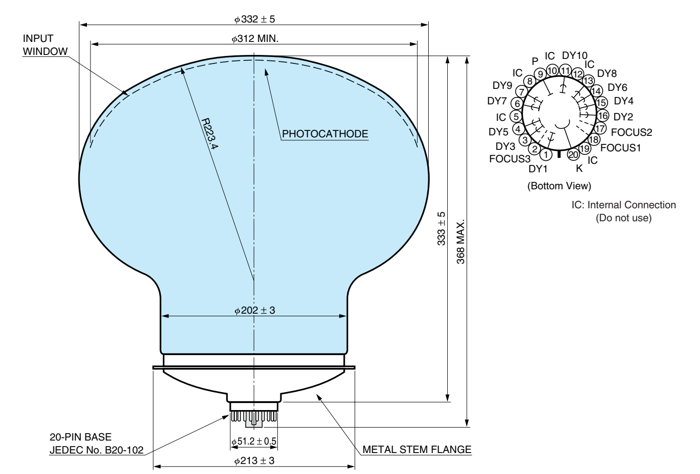
TPMHA0500EB

50 R7081, R7081-20



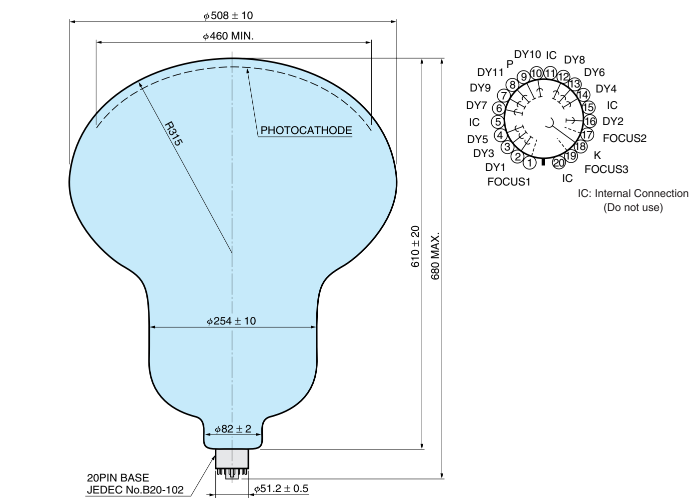
TPMHA0501EB

51 R8055



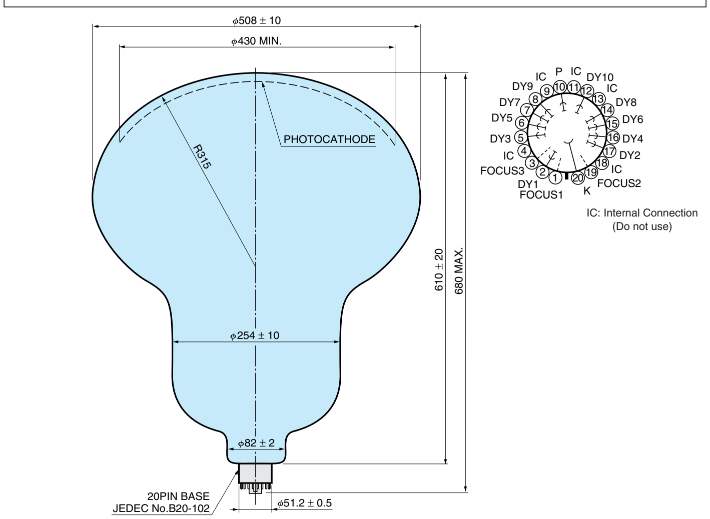
TPMHA0502EB

52 R3600-02



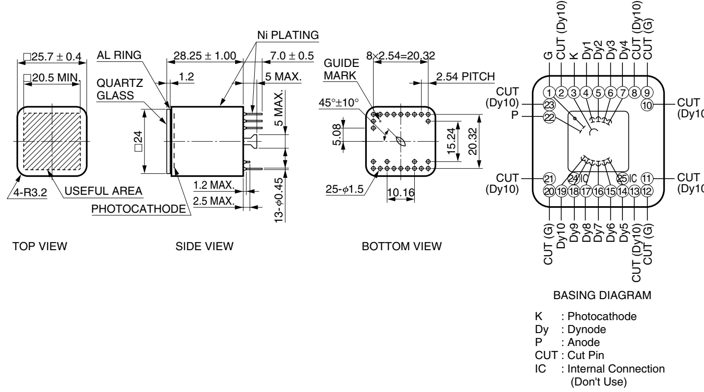
TPMHA0092EF

53 R7250



TPMHA0475EE

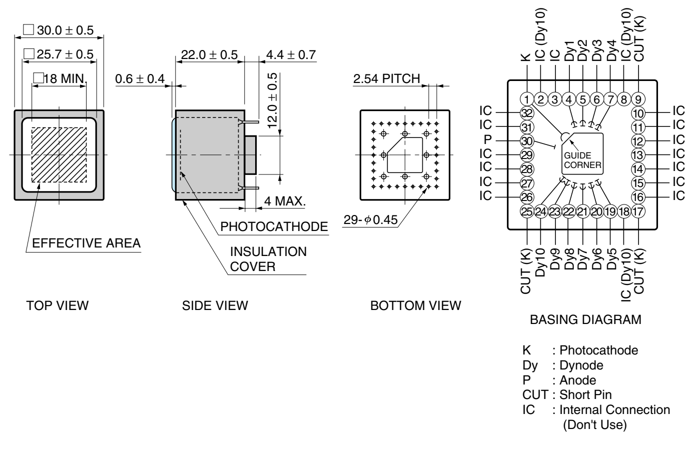
54 R8520-406, -506



TPMHA0575EA

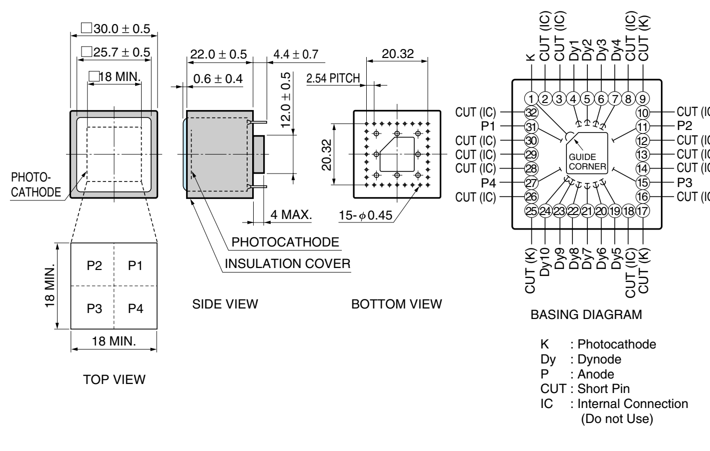
(Unit: mm)

55 R7600U, R7600U-100/-200/-300



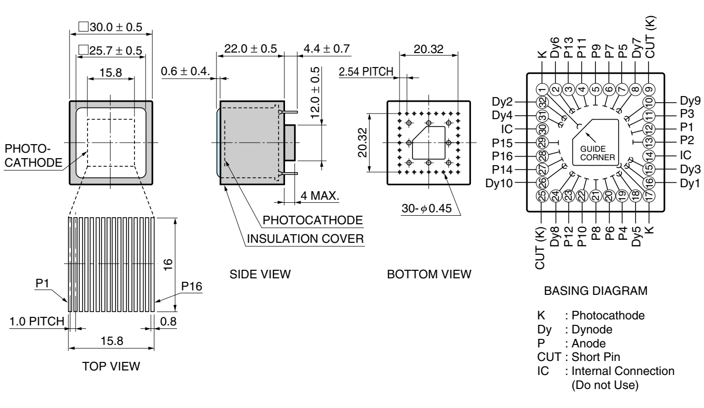
TPMHA0278EJ

56 R7600U-00-M4, R7600U-100-M4/-200-M4/-300-M4



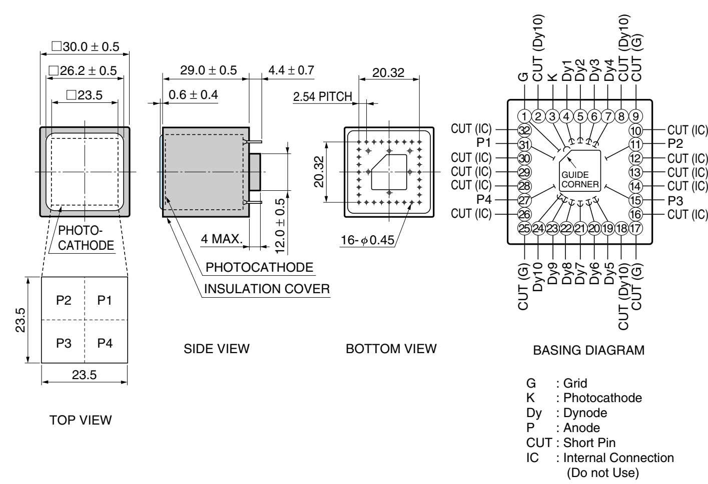
TPMHA0297EJ

57 R5900U-00-L16, R5900U-100-L16/-200-L16



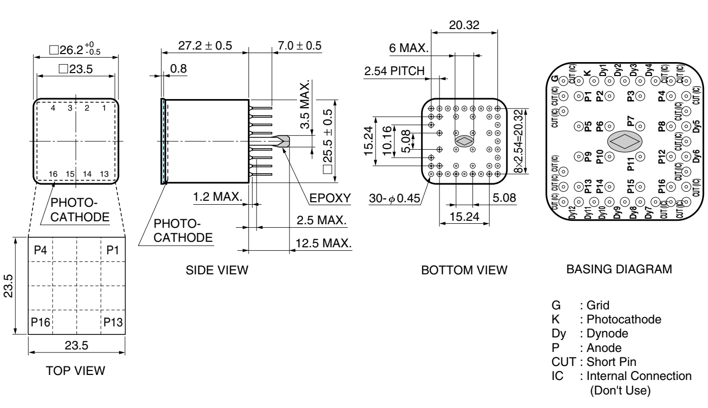
TPMHA0298EH

58 R8900U-00-M4, R8900U-100-M4



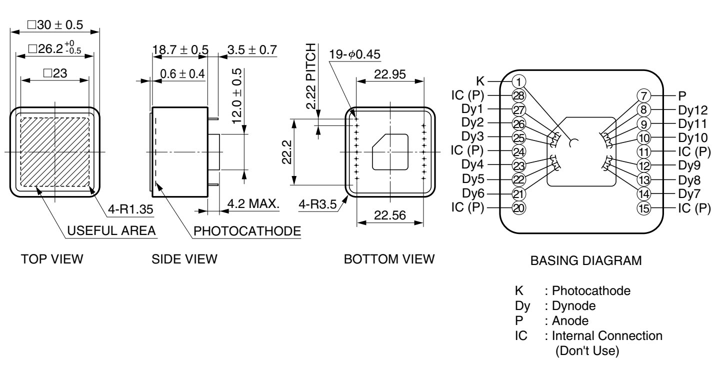
TPMHA0530EA

59 R8900-00-M16, R8900-100-M16



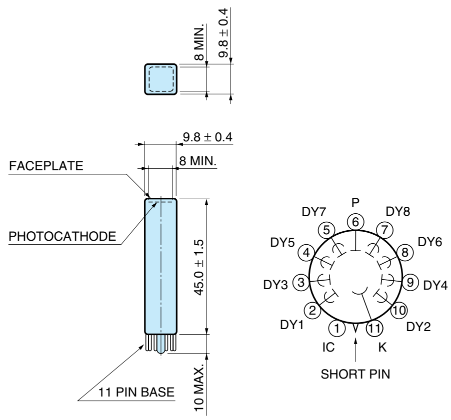
TPMHA0531EB

60 R11265U, R11265U-100, R11265U-200



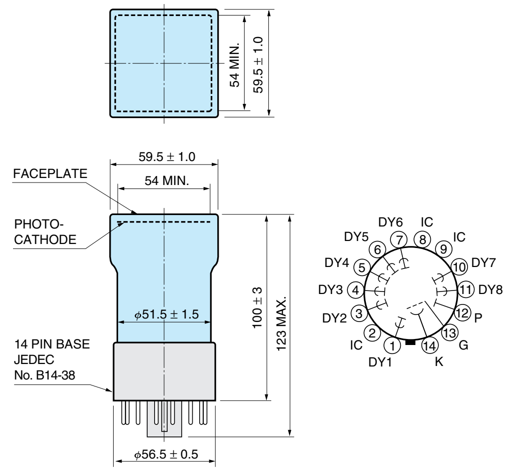
TPMHA0577EB

61 R2248



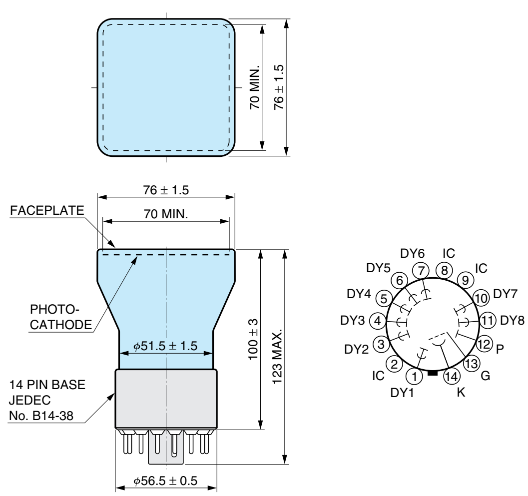
TPMHA0098EC

62 R6236



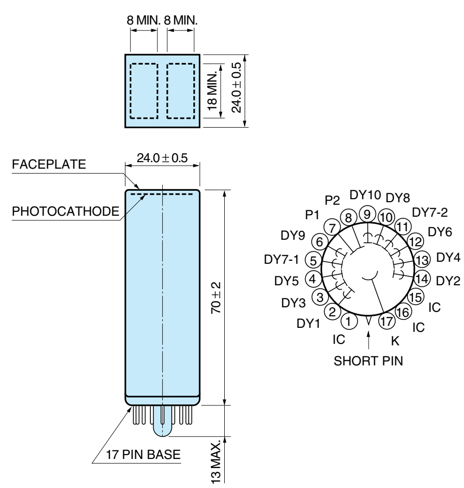
TPMHA0392EB

63 R6237



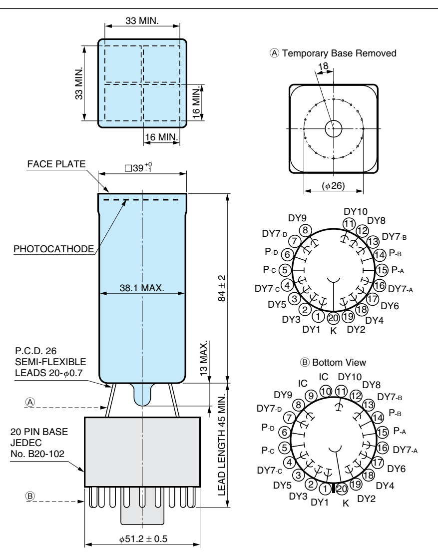
TPMHA0393EC

64 R1548-07



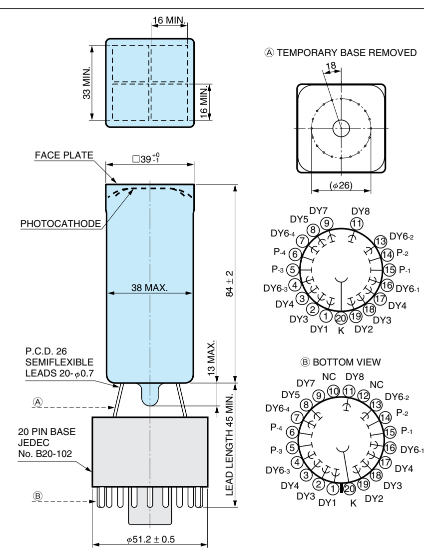
TPMHA0511EA

65 R8997



TPMHA0552EC

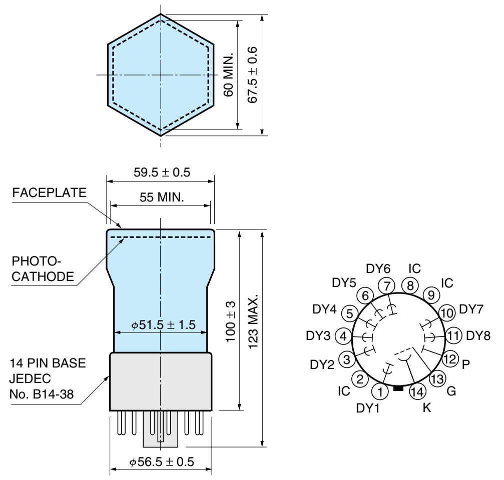
66 R10550



TPMHA0576EC

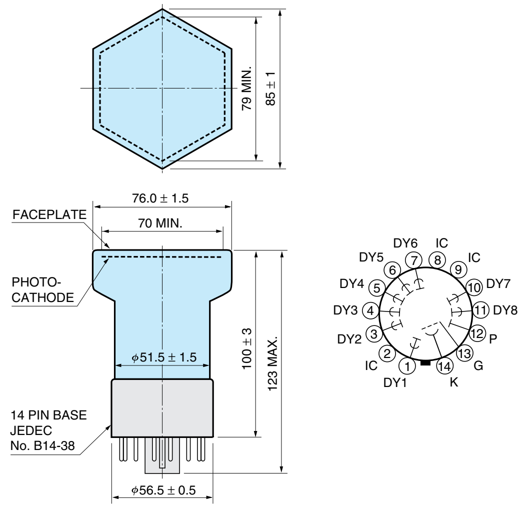
(Unit: mm)

67 R6234



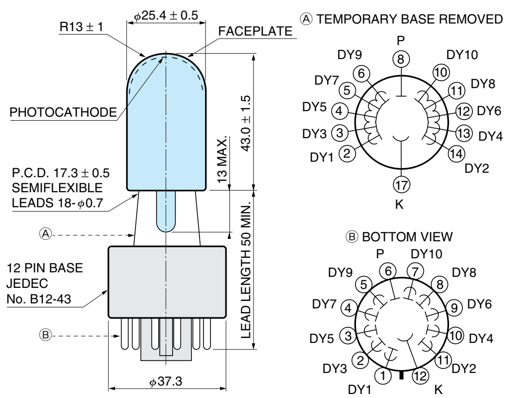
TPMHA0390EB

68 R6235



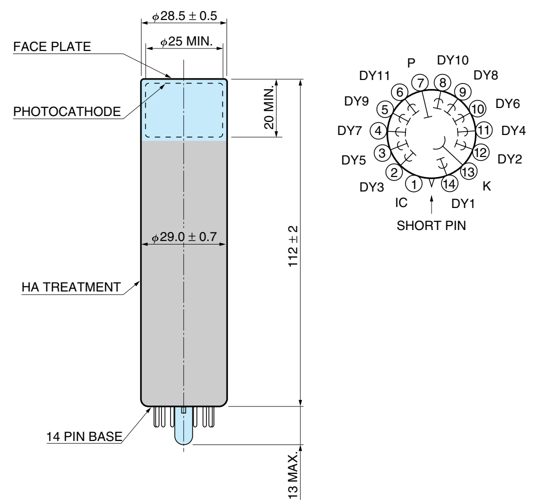
TPMHA0391EB

69 R7373A-01



TPMHA0460EB

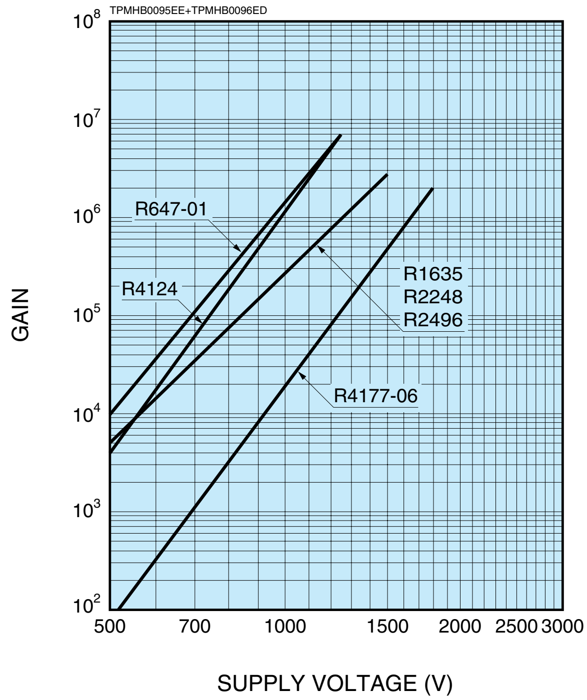
70 R8143



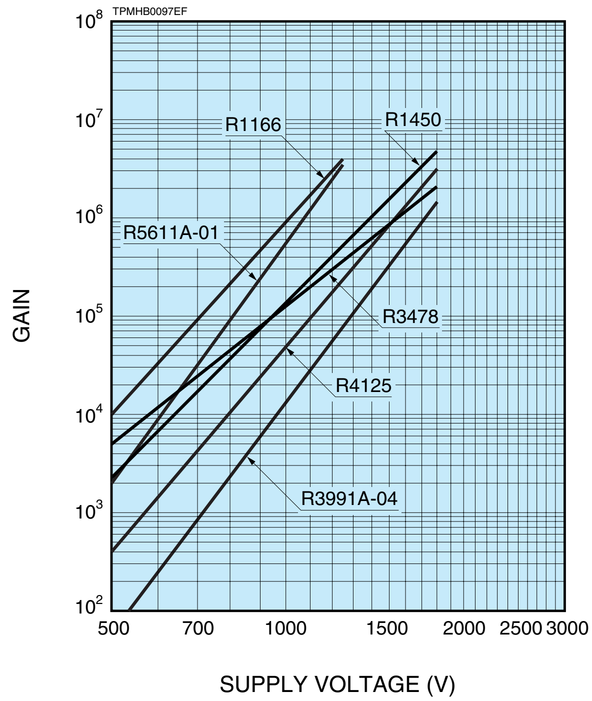
TPMHA0507EA

Typical Gain Characteristics

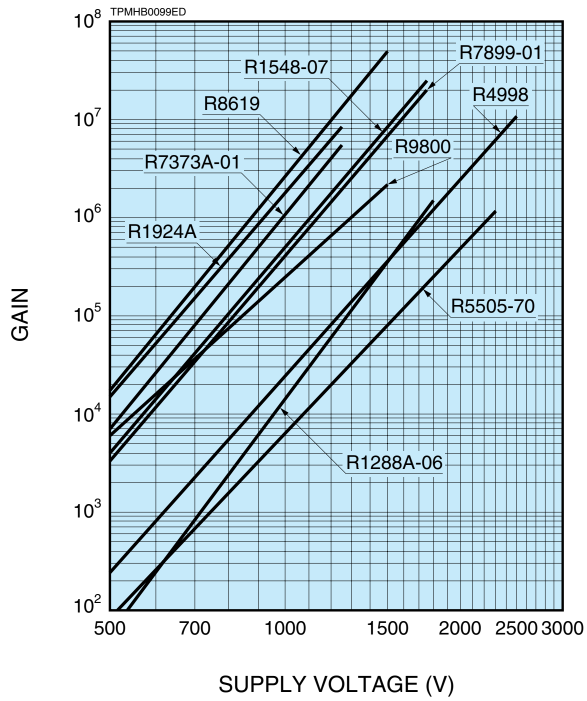
● 10 mm (3/8") Dia. and TO-8 Types
● 13 mm (1/2") Dia. Types



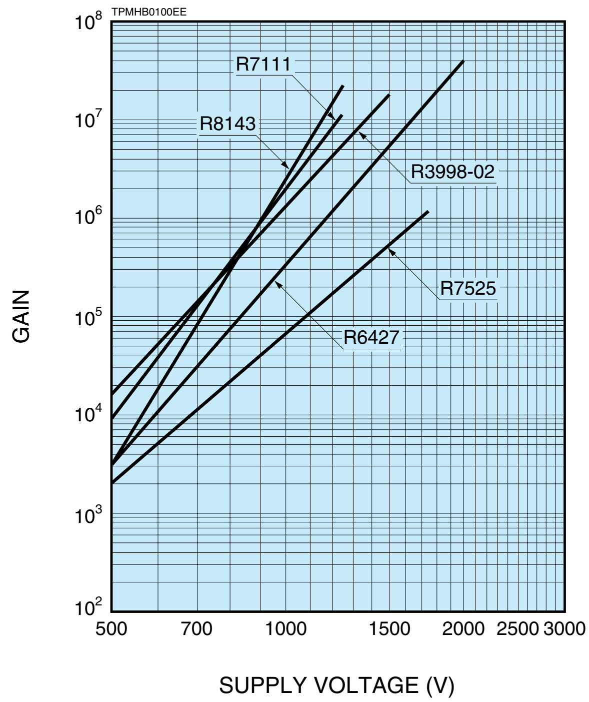
● 19 mm (3/4") Dia. Types



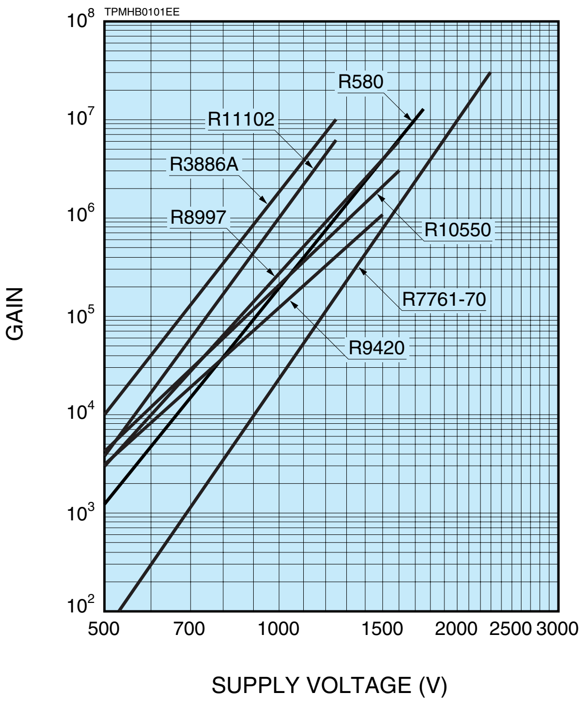
● 25 mm (1") Dia. Types



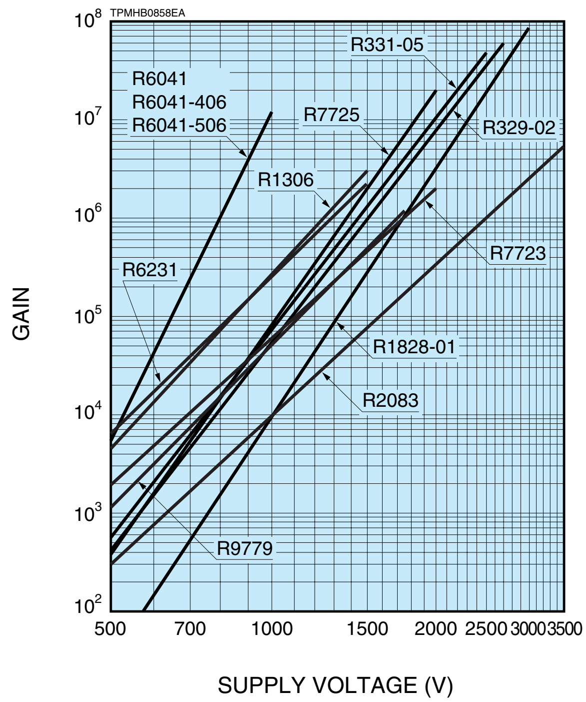
● 28 mm (1-1/8") Dia. Types



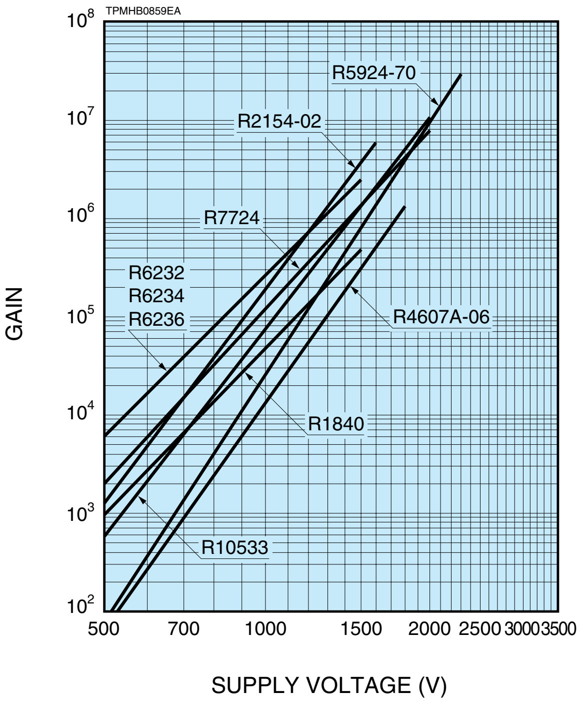
● 38 mm (1-1/2") Dia. Types



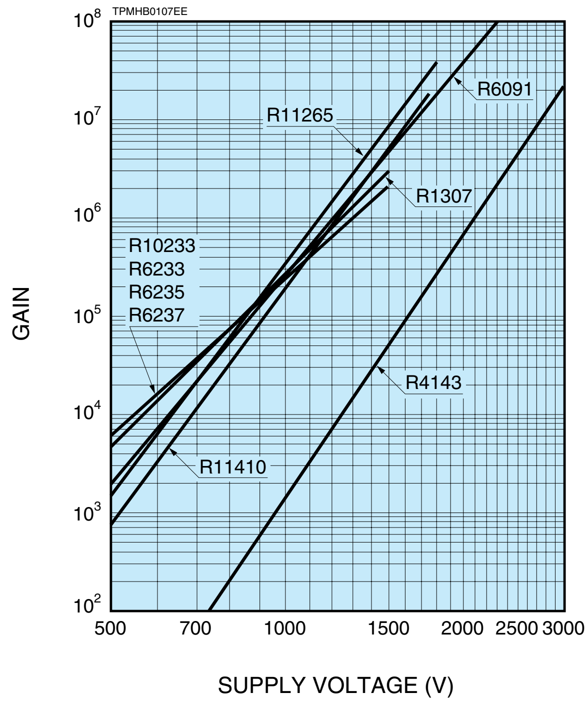
● 51 mm (2") Dia. Types



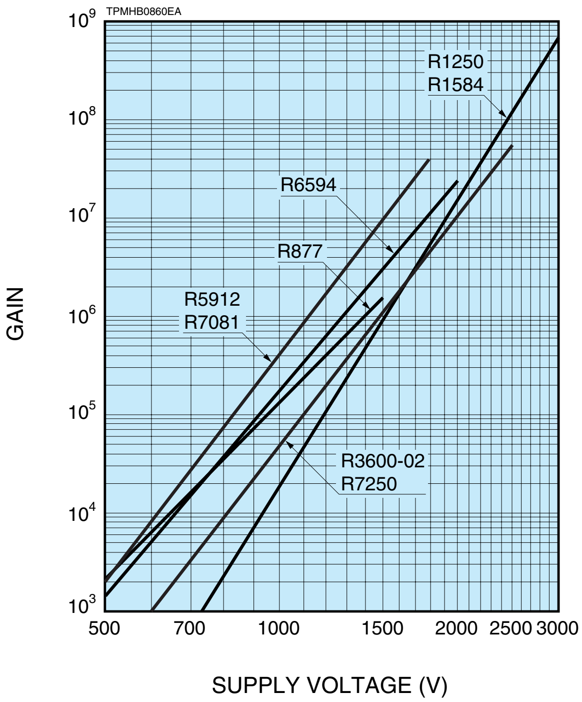
● 51 mm (2") Dia. Types
● 60 mm (2.5") Dia. Types

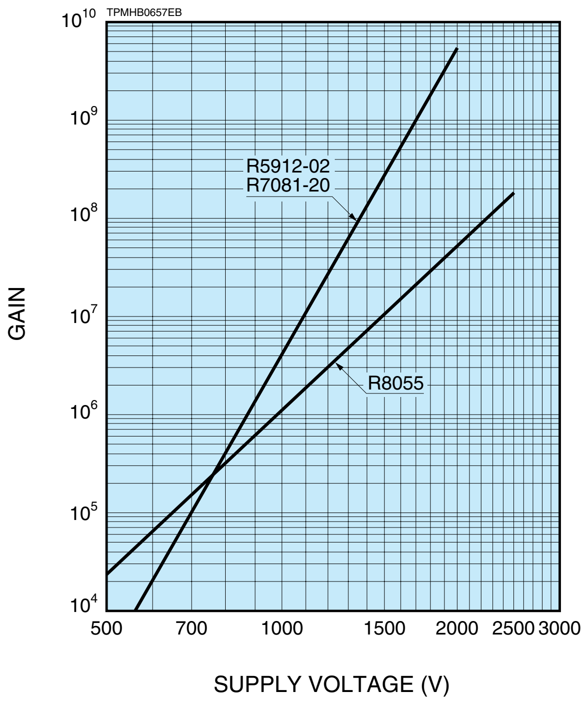


● 76 mm (3") Dia. Types and 90 mm (3.5") Dia. Types

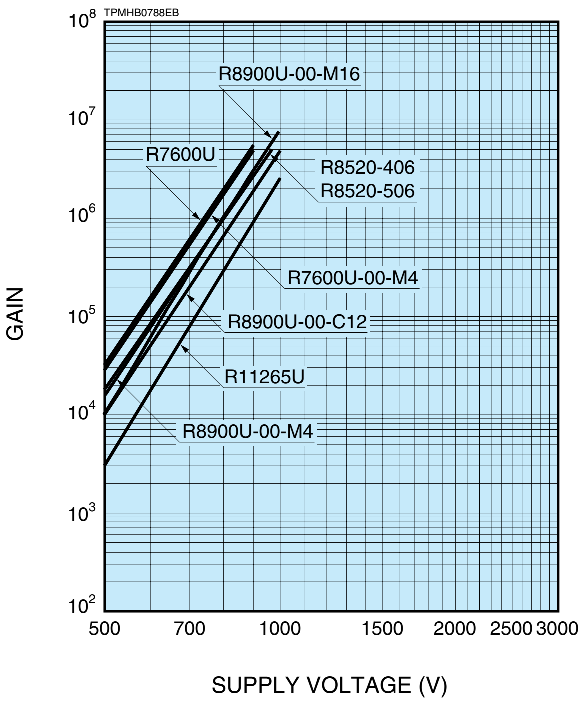


● 127 mm (5"), 204 mm (8"), 254 mm (10"), 332 mm (13") and 508 mm (20") Dia. Types

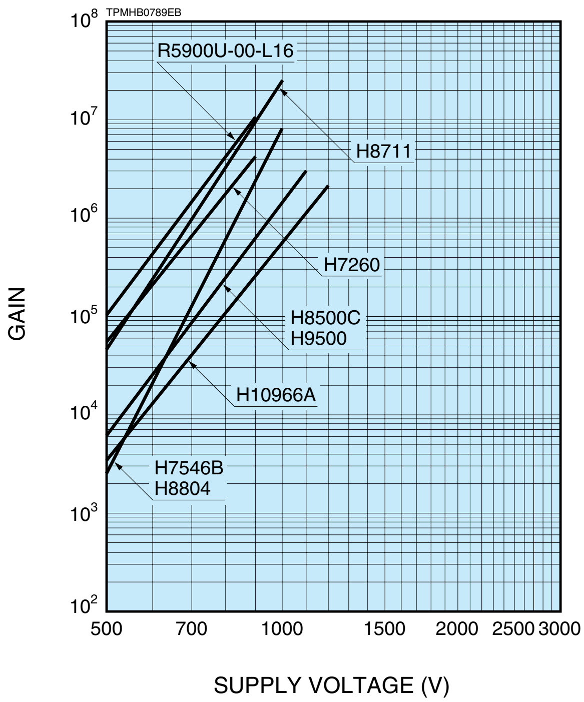




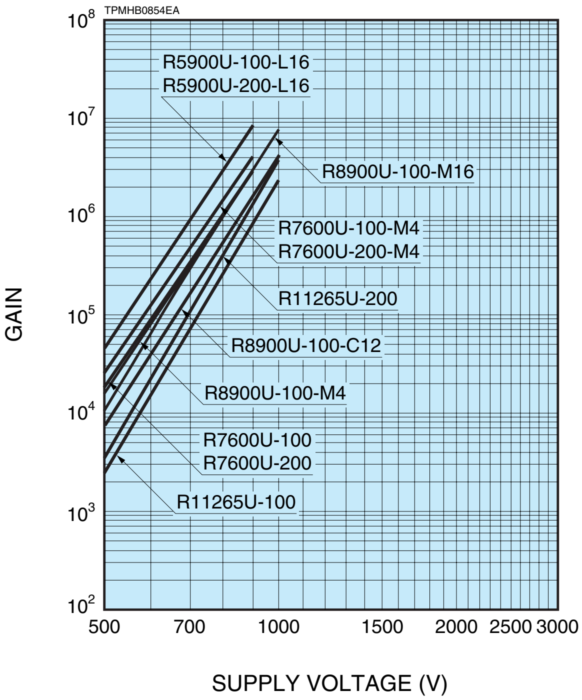
● Metal Package Types



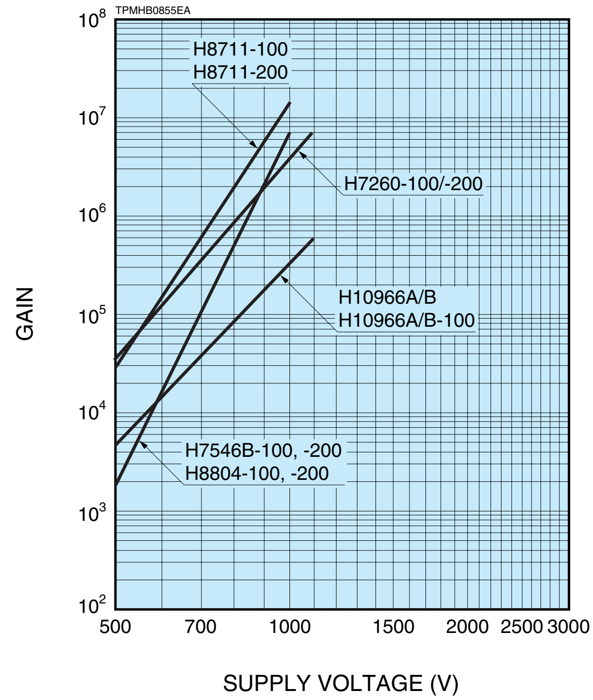
● Metal Package Types and Assembly Type



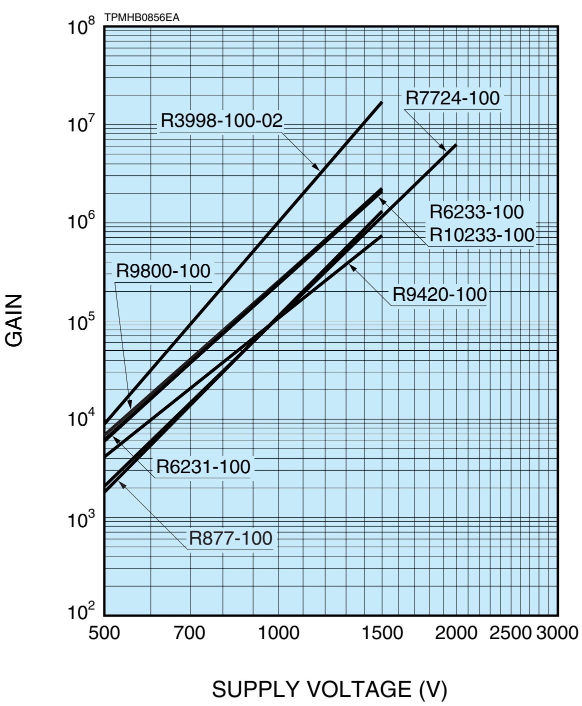
● UBA / SBA Metal Package Types



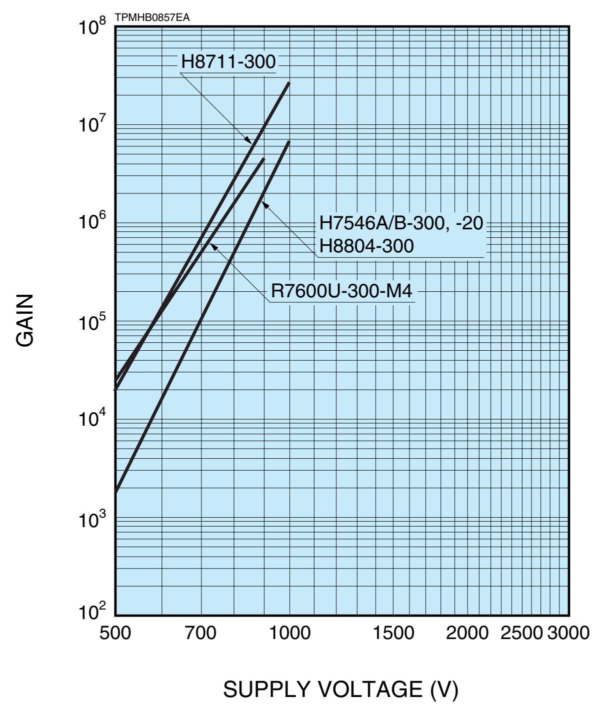
● UBA / SBA Metal Package Types and Assembly Types



● SBA PMT Series



● Extended Green Metal Package Types and Assembly Types

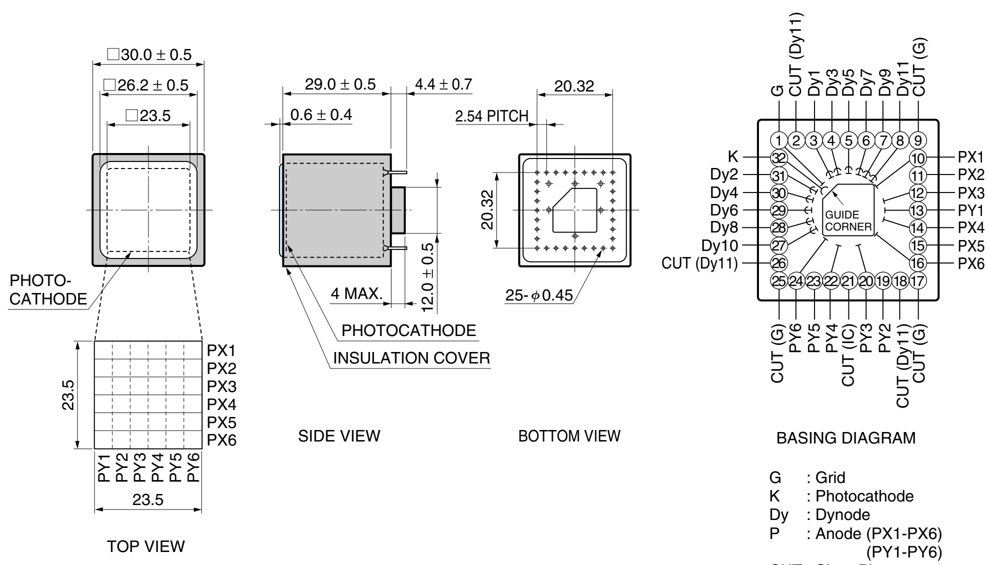


Position Sensitive Photomultiplier Tubes

Tube Diameter	Type No.	❶ Spectral Response Range (nm) / Curve Code	❷ Outline No.	Anode Sensitivity			❸ Socket & Socket Assembly	❹ Dynode Structure / No. of Stages	Cathode Sensitivity		
				Effective Area (mm)	Number of Plates or wires	Anode Pitch (mm)			❺ Luminous Typ. (µA/lm)	❻ Blue Sens. Index (CS 5-58) Typ.	❼ Q.E. at Peak Typ. (%)
Position Sensitive Photomultiplier Tubes with Metal Channel Dynodes											
30 mm Square	R8900U -00-C12	300 to 650/A-D	1	23.5 × 23.5	6(X) + 6(Y) Plates	4.0	E678-32B 28	MC / 11	85	10.0	25
Position Sensitive Photomultiplier Tubes											
5" round	R3292-02	300 to 650/A-D	2	ϕ100	28(X) + 28(Y) Wires	4.0	—	CM / 12	80	9.0	23

Note: Please refer to page 18 and 19 for each item in the above list.

1 R8900U-00-C12, R8900U-100-C12

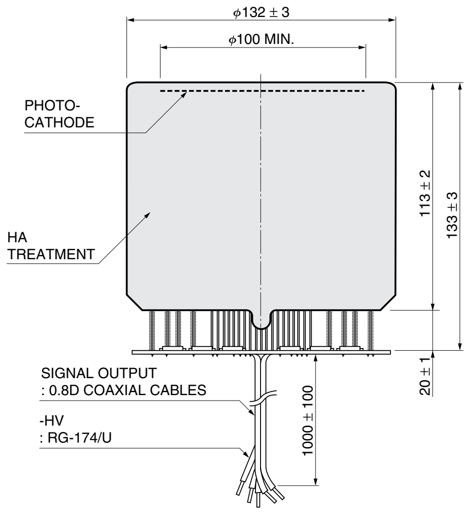


G : Grid
K : Photocathode
Dy : Dynode
P : Anode (PX1-PX6)
(PY1-PY6)
CUT : Short Pin
IC : Internal Connection
(Do not Use)

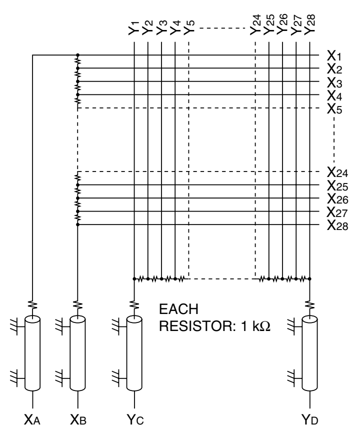
TPMHA0524EB

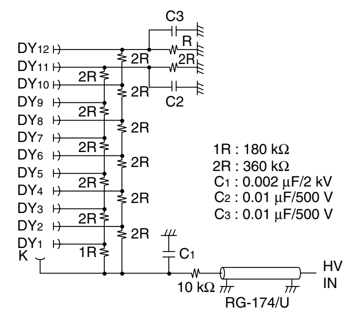
Anode Sensitivity					Maximum Rating ⓬		Typical Time Response ⓭			Note	Type No.
❽ Anode to Cathode Supply Voltage	❾ Gain Typ.	❿ Luminous Typ. (A/lm)	⓫ Dark Current Typ. (nA)	Dark Current Max. (nA)	Anode to Cathode Voltage (V)	Average Anode Current (mA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)	T.T.S. Typ. (FWHM) (ns)		
800 ㊳	7.0×10^5	60	2	10	1000	0.1	2.2	11.9	0.75	R8900-00-C12, without cover type, is available.	R8900U-00-C12
1250 ㊷	1.3×10^5	10	40	150	1300	0.06	6.0	20	—	No suffix number: PMT + HA -01: PMT + HA +Voltage Divider -02: -01 + Resistor Chain	R3292-02

② R3292-02



TPMHA0162EE





TPMHC0088EE

Voltage Distribution Ratios

Interstages for the dynodes of a PMT are supplied by a voltage divider network consisting of series resistors, as shown on the right page. The cathode ground scheme (1) is usually used in scintillation counting because it reduces noise resulting from glass scintillation. In fast-pulse light applications, use of the anode ground scheme (2) is suggested. Either scheme requires decoupling (charge-storage) capacitors connected to the last few stages of dynodes in order to maintain the dynode voltage at a constant value during pulse duration. refer to section 11 and 12 on page 8 to 13 for further details.

To free the user from the necessity of designing voltage divider and performing troublesome parts selection, Hamamatsu provides a variety of socket assemblies which enable sufficient performance to be derived from PMT's by making simple connections only.

Voltage Distribution Ratio

<Symbols>
K: Photocathode G: Grid F: Focusing Electrode
Dy: Dynode GR: Guard Ring P: Anode
Acc: Accelerating Electrode

Voltage Distribution No.	Number of stages	Voltage Distribution Ratios							
		K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	P
①	6	2	1	1	1	2	4	2	

No.	stages	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	P
②	8	1	1	1	1	1	1	1	1	1	1	
③		1.3	4.8	1.5	1.5	1	1	1	1	1	1	
④		2	—	2	1	1	1	1	1	1	1	
⑤		2	2	1	1	1	1	1	1	1	1	
⑥		3	—	1.5	1.5	1	1	1	1	1	1	
⑦		4	—	1	1.5	1	1	1	1	1	1	
⑧		4	—	1	1.5	1	1.2	1.5	2	3.3	3	
⑨		4	—	1	2	1	1	1	1	2	1	
⑩		4	—	1.5	1.5	1	1	1	1	1	1	
⑪		7	—	1	1.5	1	1	1	1	1	1	

No.	stages	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Acc	Dy7	Dy8	P
⑫	8	1.3	4.8	1.2	1.8	1	1	1	1	0.5	3	2.5	

Acc: Grid (Accelerating Electrode)

No.	stages	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	GR	P
⑬	8	1	1	1	1	1	1	1	1	1	0.5	

No.	stages	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	P
⑭	9	3	—	1	1	1	1	1.5	1	1	1	1	
⑮		3	1	1	1	1	1	1.5	1	1	1	1	

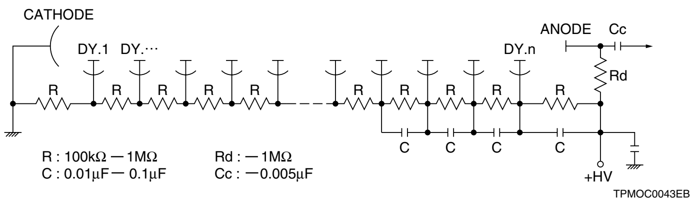
No.	stages	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P	
⑯	10	0.5	1.5	2	1	1	1	1	1	1	1	1	0.5		
⑰		1	—	1	1	1	1	1	1	1	1	1	1		
⑱		1	1	1	1	1	1	1	1	1	1	1	1		
⑲		1.3	4.8	1.2	1.8	1	1	1	1	1	1.5	3	2.5		(Note 1)
⑳		1.3	4.8	1.5	1.5	1	1	1	1	1	1	1	1		
㉑		1.5	—	1	1	1	1	1	1	1	1	1	1		
㉒		1.5	—	1	1	1	1	1	1	1.2	1.8	3.6	3.3		
㉓		1.5	—	1.5	1.5	1	1	1	1	1	1	1	1		
㉔		2	—	1	1	1	1	1	1	1	1	1	1		
㉕		2	—	1	1	1	1	1	1	1.2	1.5	1.8	2		
㉖		2	—	1	1	1	1	1	1.2	1.5	2.2	3.6	3		
㉗		2	—	1	1.5	1	1	1	1	1	1	1	0.75		
㉘		2	—	2	2	1	1	1	1	1	2	3	2		
㉙		3	—	1	1	1	1	1	1	1	1	1	1		
㉚		3	—	1	1.5	1	1	1	1	1	1	1	1		
㉛		3	—	1	1.5	1	1	1	1	2	3	3.6	3.3		
㉜		3	—	1.5	1	1	1	1	1	1	1	1	1		
㉝		4	—	1	1.5	1	1	1	1	1	1	1	1		
㉞		4	—	1	1.5	1	1	1	1.2	1.5	2	3.3	3		
㉟		4	—	1	2	1	1	1	1	1	1	2	1		

No.	stages	K	Dy1	F1	F3	F2	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P
㊱	10	8	0.18	0	0.17	0.85	1.5	1	1	1	1	1	1	1	1	
㊲		8	0.18	0	0.17	0.85	1.5	1	1	1	1.2	1.5	2.1	3	2.4	

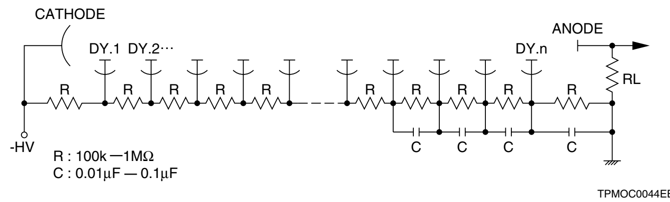
Note 1: Acc should be connected to Dy7 except R4998.

Schematic Diagram of Voltage Divider Networks

(1) Cathode Ground Scheme (+HV)



(2) Anode Ground Scheme (-HV)



Voltage Distribution Ratio

Voltage Distribution No.	Number of stages	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	P
38	11	0.5	1.5	2	1	1	1	1	1	1	1	1	1	0.5	
39		2	—	1	1	1	1	1	1	1	1	1	1	1	

No.	stages	K	F2	F1	F3	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	P
40	11	5	1	2	0.02	3	1	1	1	1	1	1	1	1	1	1	

No.	stages	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	P	
41	12	0.6	—	1.8	2.4	1	1	1	1	1	1	1	1	1	1		
42		1	—	1	1	1	1	1	1	1	1	1	1	1	1		
43		1	3	1.2	1.8	1	1	1	1	1	1	1.5	1.5	3	2.5		
44		1	3	1.2	1.8	1	1	1	1	1.5	2.5	3.6	4.5	8.6	4		
45		1.2	2.8	1.2	1.8	1	1	1	1	1	1	1.5	1.5	3	2.5		
46		1.2	2.8	1.2	1.8	1	1	1.2	1.5	2	2.8	4	5.7	8	5		
47		2	—	2	2	1	1	1	1	1	1	1	1	1	1		
48		2	—	2	2	1	1	1	1	1	1	1	1	1	1.2		
49		2.5	—	1.3	0.8	0.8	1	1	1	1	1	1	1	1	0.5		
50		3	—	2	2	1	1	1	1	1	1	1	1	2	5		
51		3.3	0	1.6	1	1	1	1	1	1	1	1	1	2.7	0.5		
52		4	—	1	1.4	1	1	1	1	1	1	1	1	1	1		(Note 2)
53		4	—	1	2	1	1	1	1	1	1	1	1	2	1		
54		4	—	1.5	2	1	1	1	1	1	1	1	1	2	1		
55		4.3	0	1	1.6	1	1	1	1	1	1	1.6	2	3.3	2		(Note 2)
56		4.3	0	1	1.6	1	1	1	1.2	1.5	2	2.4	3	3.9	3		(Note 2)

No.	stages	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	P	
57	12	4	1.5	2	1	1	1	1	1	1	1	1	2	1		(Note 2)

No.	stages	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	GR	P
58	12	1	1	1	1	1	1	1	1	1	1	1	1	1	0.5	
59		1	1	1	1	1	1	1	1	1	1	1	1	0.9	0.1	

No.	stages	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	Dy13	Dy14	P
60	14	2.5	7.5	1.2	1.8	1	1	1	1	1	1	1	1	1.5	1.5	3	2.5	
61		2.5	7.5	1.2	1.8	1	1	1	1	1.2	1.5	2	2.8	4	5.7	8	5	

No.	stages	K	Dy1	F2	F1	F3	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	Dy13	Dy14	P
62	10	16.8	0	0.6	0	3.4	5	3.33	1.67	1	1.2	1.5	2.2	1	—	—	—	—	2.4	
63		18.5	0	0.6	0	3.4	5	3.3	1.7	1	1	1	2	3	—	—	—	—	4	
64	14	11.3	0	0.6	0	3.4	5	3.33	1.67	1	1	1	1	1	1.2	1.5	2.2	3	2.4	

No.	stages	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	Dy13	Dy14	Dy15	Dy16	Dy17	Dy18	Dy19	P
65	15	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	—	—	—	—	1	
66	19	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	

Note 2: Shield should be connected to Dy5.

Quick Reference for PMT Hybrid Assemblies

Assembly Type No.	PMT Characteristics: Tube Diameter	Tube Type No. / Voltage Distribution Ratio		Reference Page for PMT Feature	Assembly Characteristics: Outline No.	H.V Input Terminal	Signal Output Terminal	Standard Rating: Overall Voltage ① (V)	Standard Rating: Divider Current ② (mA)	Maximum Rating: Overall Voltage (V)	Gain Typ.	Notes
H3164-10	10 mm (3/8")	R1635	④	20	1	SHIELD CABLE*	RG-174/U	-1250	0.34	-1500	1.0×10^6	
H3695-10		R2496	⑥	20	2	SHIELD CABLE*	RG-174/U	-1250	0.31	-1500	1.0×10^6	
H3165-10	13 mm (1/2")	R647-01	⑰	20	3	SHIELD CABLE*	RG-174/U	-1000	0.27	-1250	1.4×10^6	
H6520	19 mm (3/4")	R1166	㉑	20	4	SHIELD CABLE*	RG-174/U	-1000	0.26	-1250	1.0×10^6	
H6524		R1450	㉗	20	5	SHIELD CABLE*	RG-174/U	-1500	0.36	-1800	1.7×10^6	
H6613		R2076	⑪	21	6	SHIELD CABLE*	RG-174/U	-1700	0.33	-1800	1.0×10^6	
H6612		R3478	⑪	20	7	SHIELD CABLE*	RG-174/U	-1700	0.33	-1800	1.7×10^6	
H8135		R5611A	㉙	21	8	SHIELD CABLE*	RG-174/U	-1000	0.23	-1250	5.5×10^5	
H6533	25 mm (1")	R4998	⑲	20	9	SHIELD CABLE*	RG-174/U	-2250	0.32	-2500	5.7×10^6	H6610 (R5320)
H6152-70		R5505-70	㊿65	20	10	SHIELD CABLE*	RG-174/U	+2000	0.36	+2300	5.0×10^5	+HV
H8643		R7899-01	㉛	20	11	SHIELD CABLE*	RG-174/U	-1500	0.35	-1800	1.7×10^6	
H10580		R9800	⑩	20	12	SHIELD CABLE*	RG-174/U	-1300	0.33	-1500	1.1×10^6	
H7415	28 mm (1-1/8")	R6427	㉝	20	13	SHIELD CABLE*	RG-174/U	-1500	0.31	-2000	5.0×10^6	H7416 (R7056)
H3178-51	38 mm (1-1/2")	R580	㉔	20	14	SHV	BNC	-1500	0.54	-1750	7.9×10^5	
H8409-70		R7761-70	66	20	15	SHIELD CABLE*	RG-174/U	+2000	0.29	+2300	1.0×10^7	+HV

Note :
①: When overall voltage is negative (-HV), DC and pulse signals are obtained. When it's positive (+HV), pulse signal is obtained.
②: The maximum average anode current is defined as 5 % of divider current.
* mark: It's possible to attach an SHV connector to the shield cable.

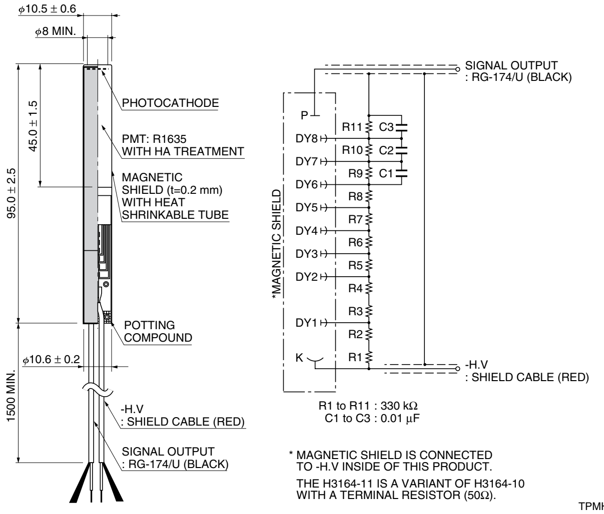
Assembly Type No.	PMT Characteristics: Tube Diameter	PMT Characteristics: Tube Type No.	PMT Characteristics: Voltage Distribution Ratio	PMT Characteristics: Reference Page for PMT Feature	Assembly Characteristics: Outline No.	H.V Input Terminal	Signal Output Terminal	Standard Rating: Overall Voltage ① (V)	Standard Rating: Divider Current ② (mA)	Maximum Rating: Overall Voltage (V)	Gain Typ.	Notes
H6410	51 mm (2")	R329-02	56	22	16	SHV	BNC	-2000	0.49	-2700	3.0×10^6	H6521 (R2256-02) H6522 (R5113-02)
H7195		R329-02	55	22	17	SHV	BNC × 3**	-2000	0.91	-2700	3.0×10^6	
H1949-50		R1828-01	45	22	18	SHV	BNC × 3**	-2500	1.15	-3000	1.0×10^7	H3177-50 (R2059) H4022-50 (R4004)
H1949-51		R1828-01	45	22	19	SHV	BNC	-2500	0.58	-3000	1.0×10^7	H3177-51 (R2059) H4022-51 (R4004)
H2431-50		R2083	12	22	20	SHV	BNC	-3000	0.52	-3500	2.5×10^6	H3378-50 (R3377)
H6614-70		R5924-70	66	22	21	SHIELD CABLE*	RG-174/U	+2000	0.29	+2300	1.0×10^7	+HV
H10570		R9779	3	22	22	SHV	BNC	-1500	0.33	-1750	5.0×10^5	
H6525	76 mm (3")	R4143	43	22	23	SHV	BNC	-2500	0.58	-3000	5.0×10^6	H6526 (R4885)
H6559		R6091	56	22	24	SHV	BNC	-2000	0.49	-2500	1.0×10^7	
H6527	127 mm (5")	R1250	60	22	25	SHV	BNC	-2000	0.68	-3000	1.4×10^7	
H6528		R1584	60	22	25	SHV	BNC	-2000	0.68	-3000	1.4×10^7	
R3600-06	508 mm (20")	R3600-02	40	22	26	HYBRID CABLE (H.V=SINGLE WIRE, SIGNAL=RG-58C/U)		+2000	0.35	+2500	1.0×10^7	
H8711	Metal Package PMT	16 ch (4 × 4)	47	24	27	TERMINAL PIN	TERMINAL PIN	-800	0.28	-1000	3.5×10^6	(14 µA is total anode current of 16 ch.)
H7546B		64 ch (8 × 8)	50	24	28	TERMINAL PIN	TERMINAL PIN	-800	0.36	-1000	6.0×10^5	(18 µA is total anode current of 64 ch.)
H8804		64 ch (8 × 8)	50	24	29	TERMINAL PIN	TERMINAL PIN	-800	0.36	-1000	6.0×10^5	(18 µA is total anode current of 64 ch.)
H7260		32 ch (1 × 32)	17	24	30	TERMINAL PIN	TERMINAL PIN	-800	0.33	-900	2.0×10^6	(100 µA is total anode current of 32 ch.)
H8500C		64 ch (8 × 8)	58	24	31	SHV	TERMINAL PIN	-1000	0.16	-1100	1.5×10^6	(100 µA is total anode current of 64 ch.)
H10966A		64 ch (8 × 8)	13	24	31	SHV	TERMINAL PIN	-1100	0.25	-1100	3.3×10^5	(100 µA is total anode current of 64 ch.)
H10966B		64 ch (8 × 8)	13	—	32	TERMINAL PIN	TERMINAL PIN	-1000	0.25	-1100	3.3×10^5	(100 µA is total anode current of 64 ch.)
H9500		256 ch (16 × 16)	59	24	33	SHV	TERMINAL PIN	-1000	0.16	-1100	1.5×10^6	(100 µA is total anode current of 256 ch.)

Note :
①: When overall voltage is negative (-HV), DC and pulse signals are obtained. When it's positive (+HV), pulse signal is obtained.
②: The maximum average anode current is defined as 5 % of divider current.
* mark: It's possible to attach an SHV connector to the shield cable.
** mark: It has 2 anode outputs and 1 dynode output.

Dimensional Outlines and Circuit Diagrams

For PMT Hybrid Assemblies

1 H3164-10

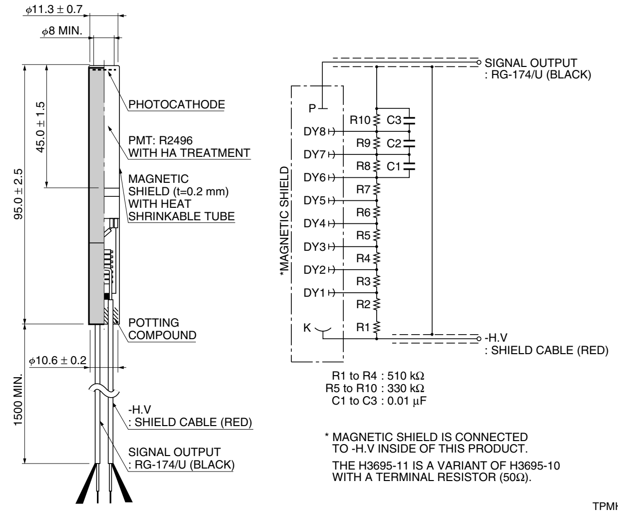


* MAGNETIC SHIELD IS CONNECTED TO -H.V INSIDE OF THIS PRODUCT.

THE H3164-11 IS A VARIANT OF H3164-10 WITH A TERMINAL RESISTOR (50Ω).

TPMHA0309EC

2 H3695-10

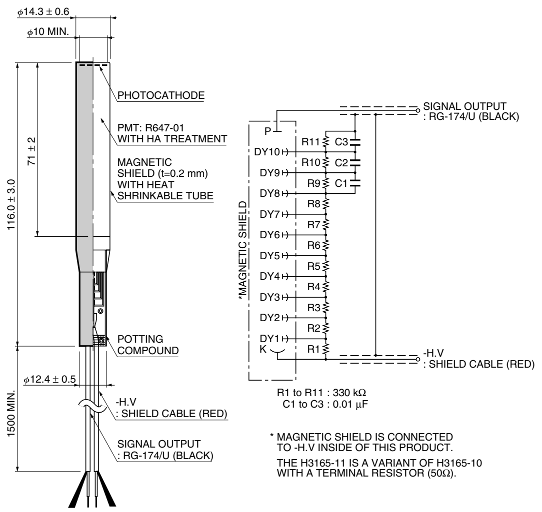


* MAGNETIC SHIELD IS CONNECTED TO -H.V INSIDE OF THIS PRODUCT.

THE H3695-11 IS A VARIANT OF H3695-10 WITH A TERMINAL RESISTOR (50Ω).

TPMHA0310EB

3 H3165-10

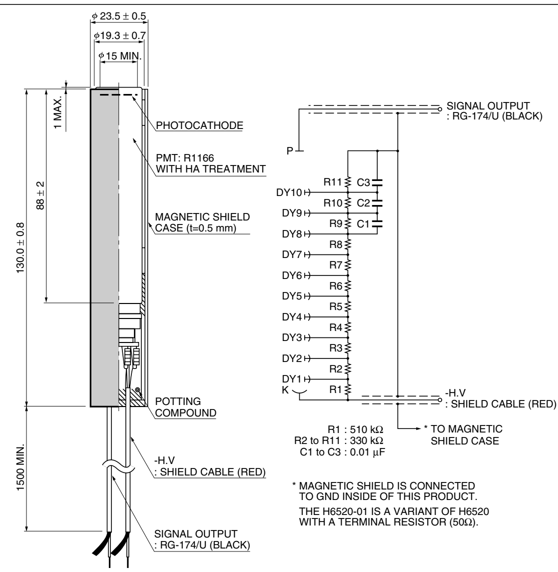


* MAGNETIC SHIELD IS CONNECTED TO -H.V INSIDE OF THIS PRODUCT.

THE H3165-11 IS A VARIANT OF H3165-10 WITH A TERMINAL RESISTOR (50Ω).

TPMHA0311EC

4 H6520

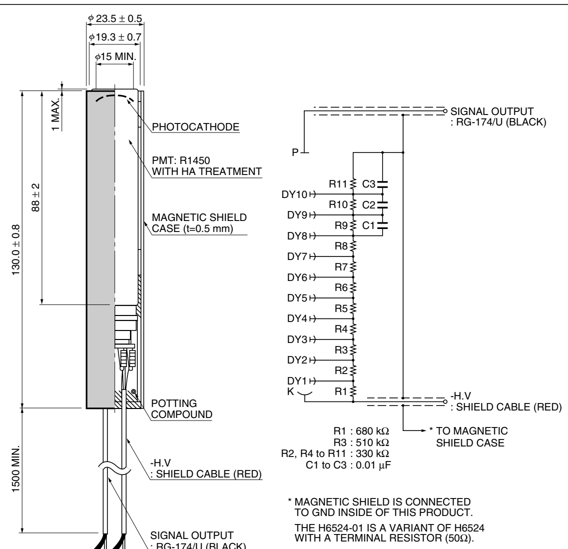


* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

THE H6520-01 IS A VARIANT OF H6520 WITH A TERMINAL RESISTOR (50Ω).

TPMHA0312EB

5 H6524

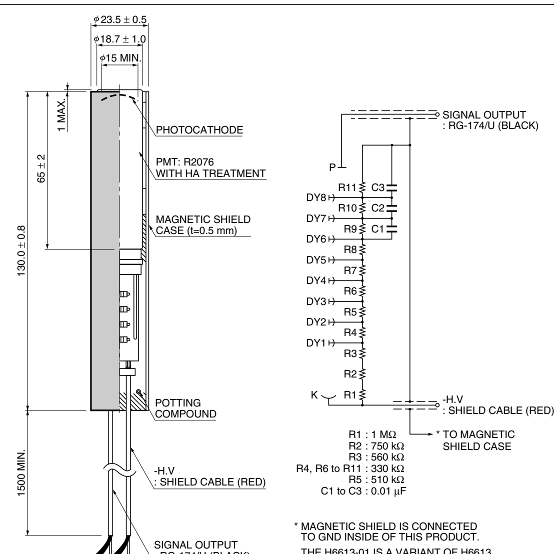


* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

THE H6524-01 IS A VARIANT OF H6524 WITH A TERMINAL RESISTOR (50Ω).

TPMHA0313EB

6 H6613



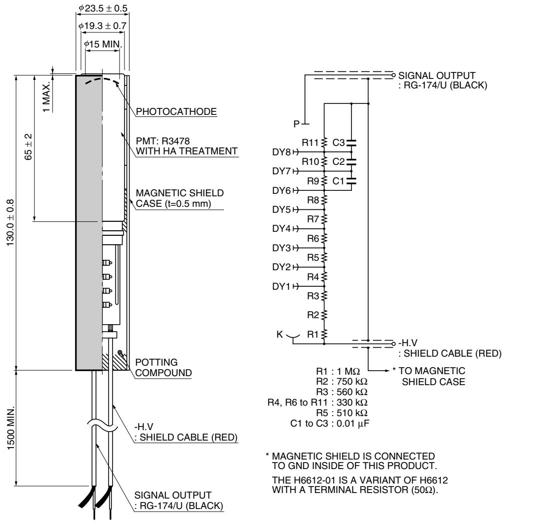
* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

THE H6613-01 IS A VARIANT OF H6613 WITH A TERMINAL RESISTOR (50Ω).

TPMHA0314EA

(Unit: mm)

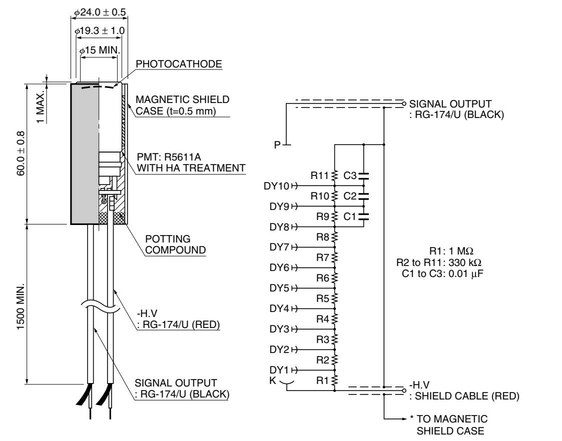
7 H6612



* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.
THE H6612-01 IS A VARIANT OF H6612 WITH A TERMINAL RESISTOR (50Ω).

TPMHA0315EA

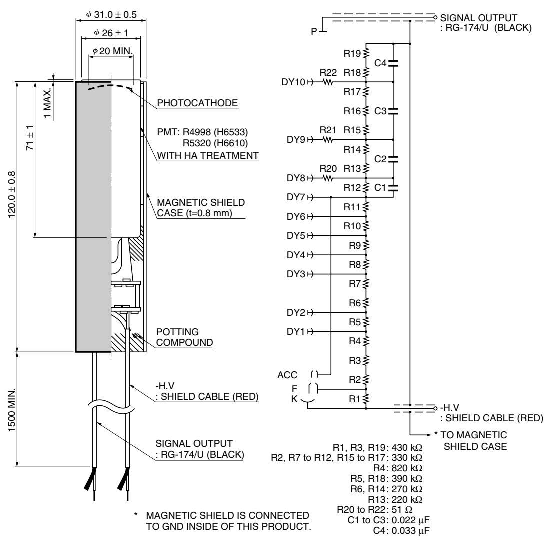
8 H8135



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

TPMHA0513EB

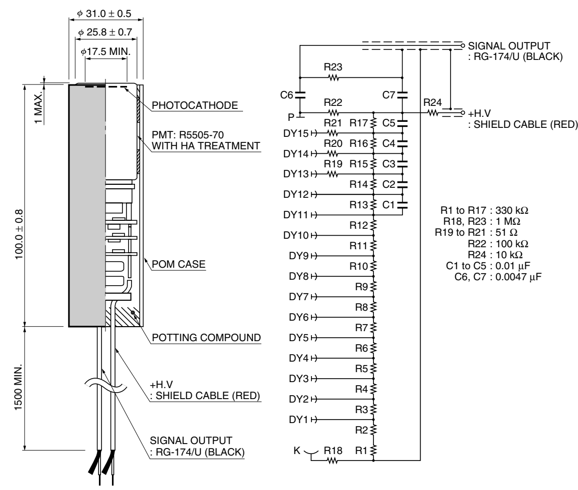
9 H6533



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

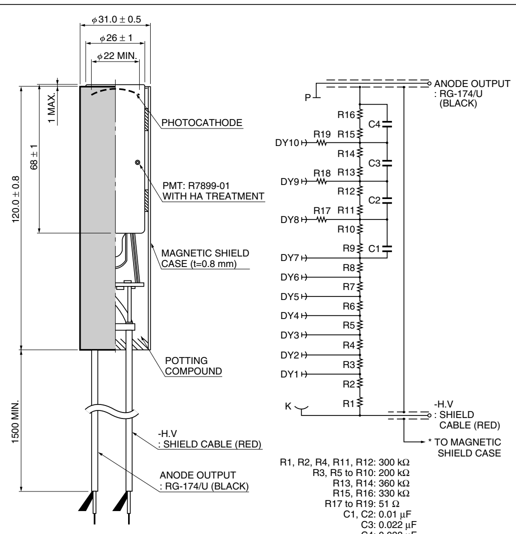
TPMHA0317EB

10 H6152-70



TPMHA0470EB

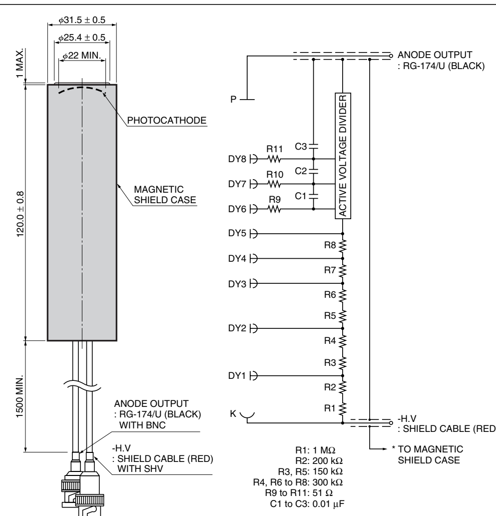
11 H8643



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

TPMHA0514EA

12 H10580

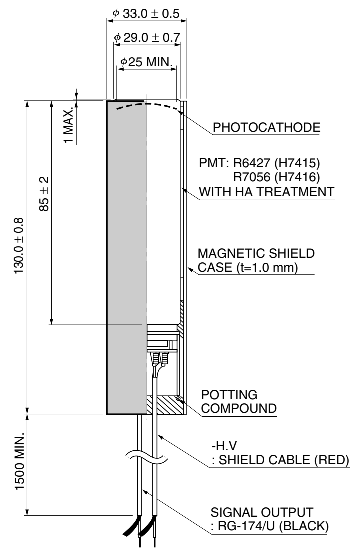


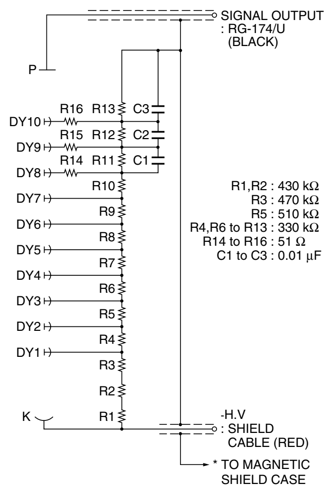
VOLTAGE DIVIDER CURRENT =383 μA / 1500 V INPUT

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

TPMHA0554EA

13 H7415





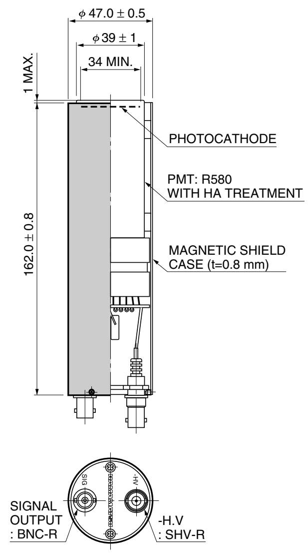
R1,R2 : 430 kΩ
R3 : 470 kΩ
R5 : 510 kΩ
R4,R6 to R13 : 330 kΩ
R14 to R16 : 51 Ω
C1 to C3 : 0.01 μF

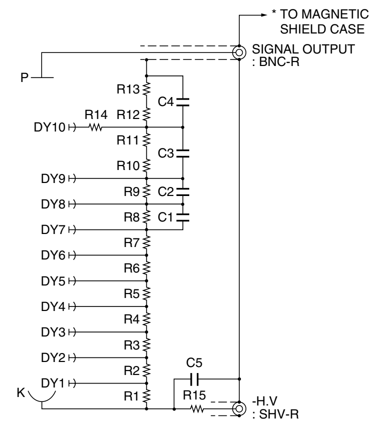
* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

THE H7415-01 IS A VARIANT OF H7415 WITH A TERMINAL RESISTOR (50Ω).

TPMHA0318EC

14 H3178-51



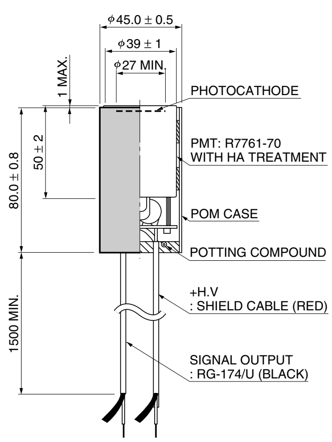


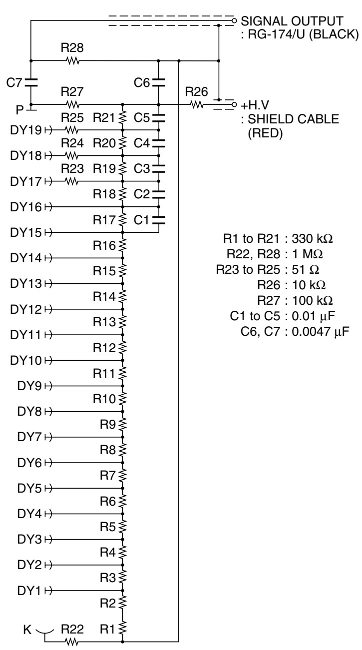
R1, R10, R12 : 300 kΩ
R2 to R6, R13 : 150 kΩ
R7 : 180 kΩ
R8 : 220 kΩ
R9 : 330 kΩ
R11 : 240 kΩ
R14 : 51 Ω
R15 : 10 kΩ
C1 : 0.01 μF
C2 : 0.022 μF
C3 : 0.047 μF
C4 : 0.1 μF
C5 : 4700 pF

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

TPMHA0320EB

15 H8409-70

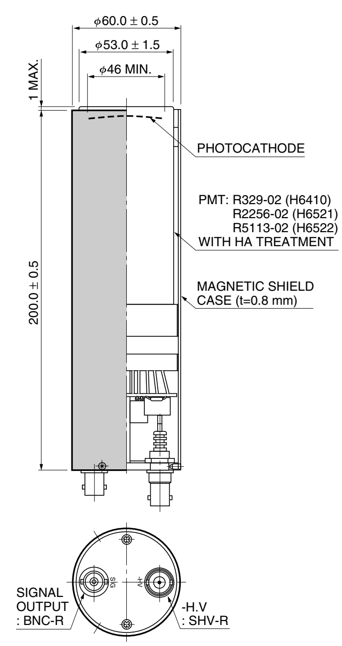


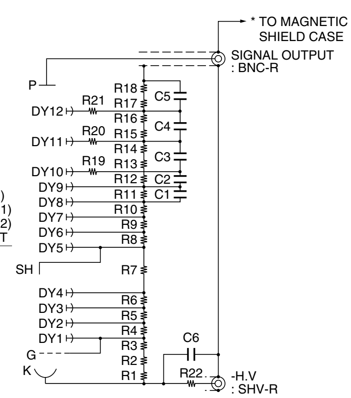


R1 to R21 : 330 kΩ
R22, R28 : 1 MΩ
R23 to R25 : 51 Ω
R26 : 10 kΩ
R27 : 100 kΩ
C1 to C5 : 0.01 μF
C6, C7 : 0.0047 μF

TPMHA0476EB

16 H6410





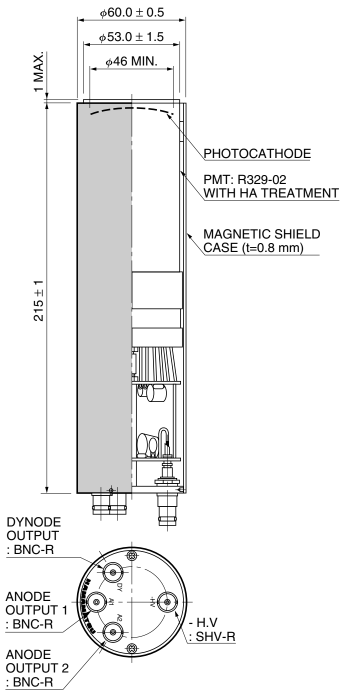
R1, R5 : 240 kΩ
R2, R10, R16 : 220 kΩ
R3, R9 : 180 kΩ
R4, R6 to R8, R14, R18 : 150 kΩ
R11, R13, R17 : 300 kΩ
R12, R15 : 360 kΩ
R19 : 51 Ω
R20, R21 : 100 Ω
R22 : 10 kΩ
C1 : 0.022 μF
C2 : 0.047 μF
C3 : 0.1 μF
C4 : 0.22 μF
C5 : 0.47 μF
C6 : 470 pF

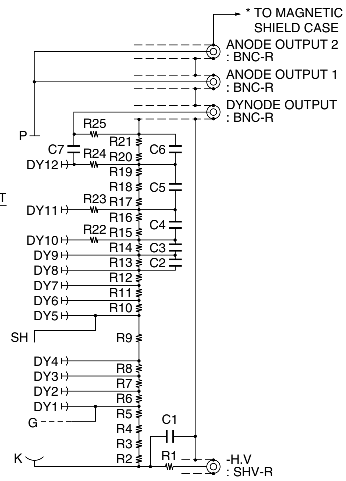
* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

TPMHA0324EC

(Unit: mm)

⑰ H7195



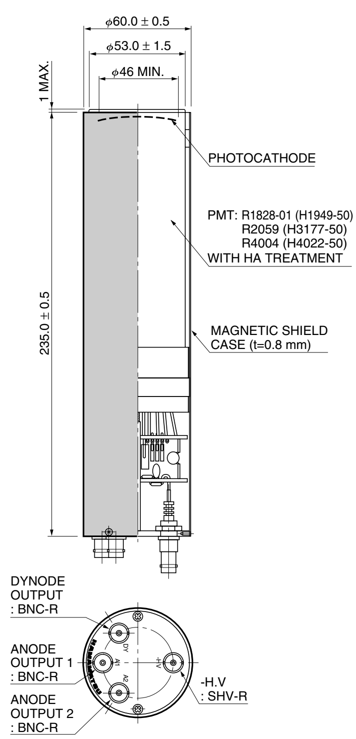


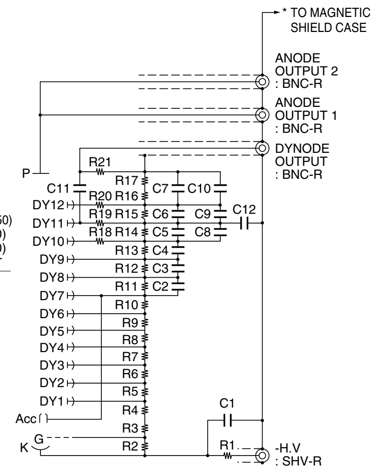
R1, R25 : 10 kΩ
R2 to R4, R17 to R19 : 110 kΩ
R5, R6, R8 to R13, R15
R16, R20, R21 : 100 kΩ
R7, R14 : 160 kΩ
R22 : 51 Ω
R23, R24 : 100 Ω
C1 : 470 pF
C2 : 0.022 µF
C3 : 0.047 µF
C4 : 0.1 µF
C5 : 0.22 µF
C6 : 0.47 µF
C7 : 0.01 µF

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

TPMHA0323EC

⑱ H1949-50



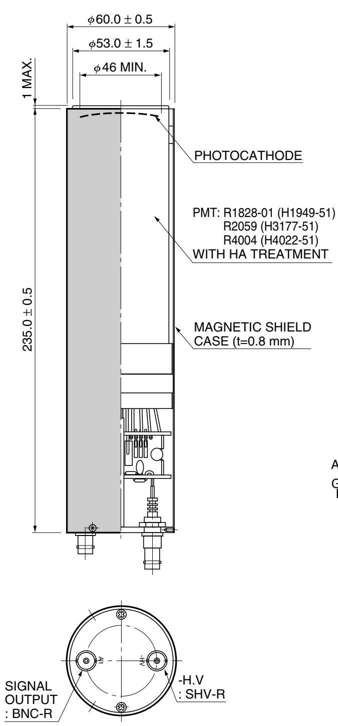


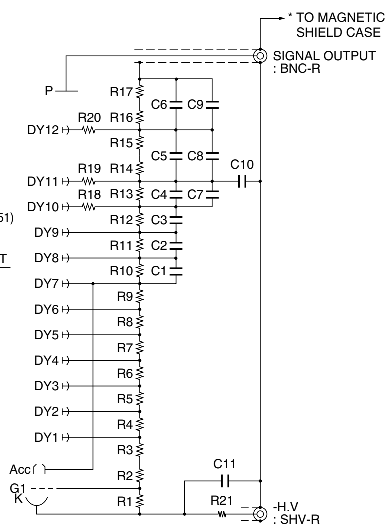
R1, R21 : 10 kΩ
R2, R5 : 120 kΩ
R3, R7 to R12, R16 : 100 kΩ
R4, R6 : 180 kΩ
R13, R14, R17 : 150 kΩ
R15 : 300 kΩ
R18 to R20 : 51 Ω
C1 : 470 pF
C2 to C4, C10 : 0.01 µF
C5, C6 : 0.022 µF
C7 : 0.033 µF
C8, C9 : 4700 pF
C11, C12 : 0.01 µF

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

TPMHA0325EC

⑲ H1949-51



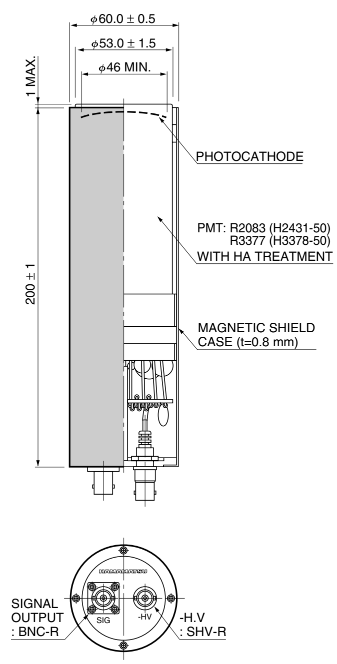


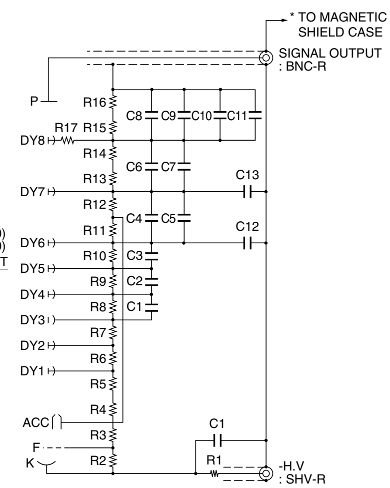
R1, R4 : 240 kΩ
R2, R5 : 360 kΩ
R3, R6 to R11, R17 : 200 kΩ
R12 to R16 : 300 kΩ
R18 to R20 : 51 Ω
R21 : 10 kΩ
C1 to C7 : 0.01 µF
C8 : 0.022 µF
C9 : 0.033 µF
C10 : 0.01 µF
C11 : 470 pF

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

TPMHA0326EC

⑳ H2431-50

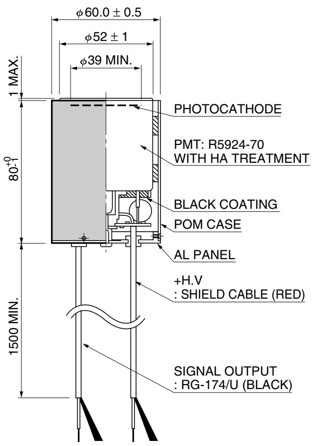


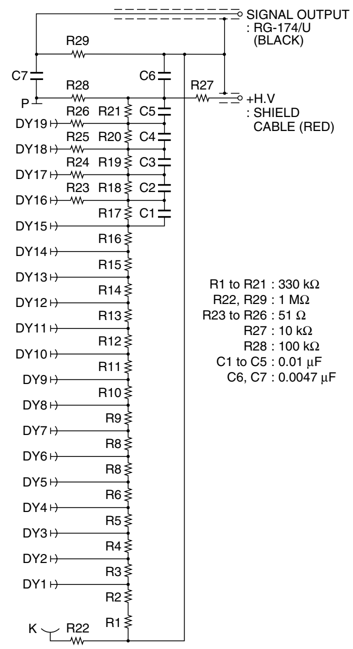


R1: 33 kΩ
R2, R15: 390 kΩ
R3, R4, R13: 470 kΩ
R5: 499 kΩ
R6, R16: 360 kΩ
R7: 536 kΩ
R8 to R11: 300 kΩ
R12: 150 kΩ
R14: 430 kΩ
R17: 51 Ω
C1, C2: 4700 pF
C3 to C11: 0.01 µF
C12, C13: 1000 pF
C14: 2200 pF

TPMHA0327EB

21 H6614-70

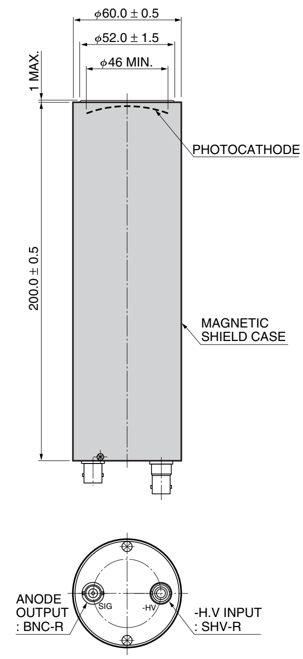


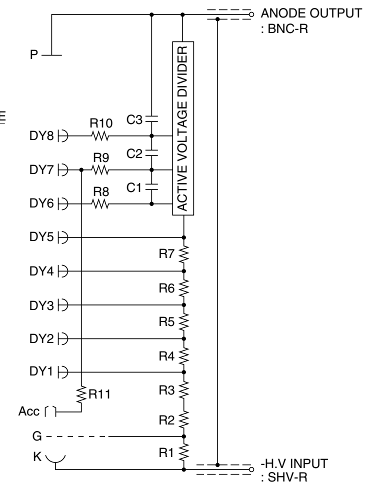


R1 to R21 : 330 kΩ
R22, R29 : 1 MΩ
R23 to R26 : 51 Ω
R27 : 10 kΩ
R28 : 100 kΩ
C1 to C5 : 0.01 μF
C6, C7 : 0.0047 μF

TPMHA0472EB

22 H10570



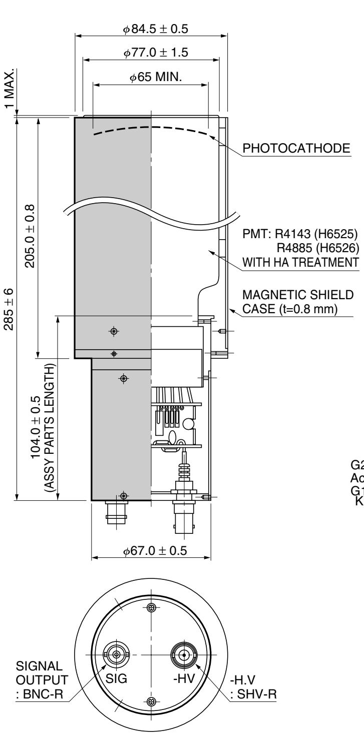


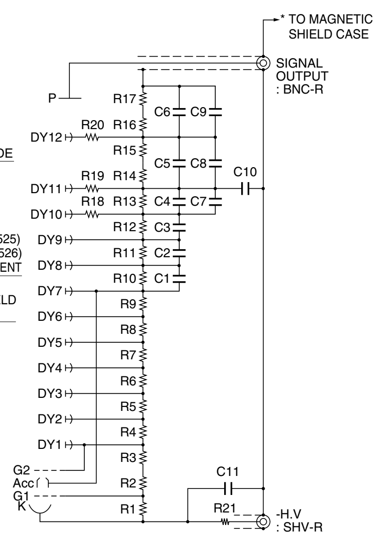
R1 to R7: 300 kΩ
R8 to R10: 51 Ω
R11: 1 MΩ
C1 to C3: : 0.022 μF

VOLTAGE DIVIDER CURRENT
=383 μA / 1750 V (MAX.) INPUT

TPMHA0555EA

23 H6525, H6526



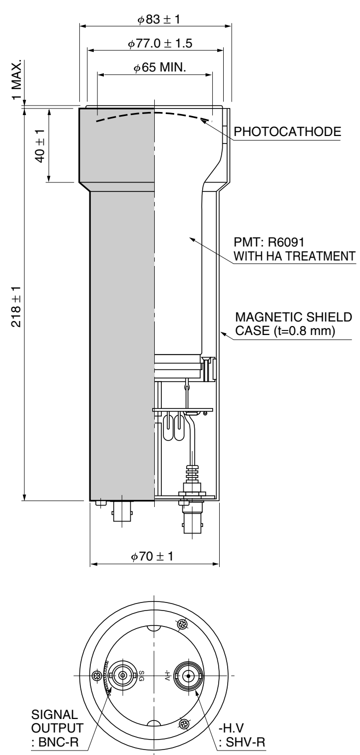


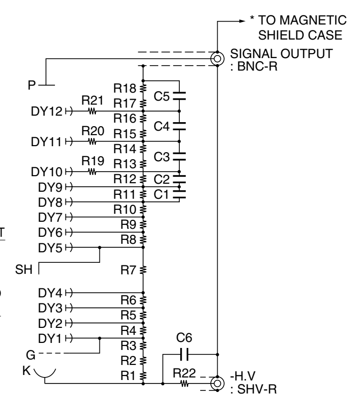
R3, R4 : 240 kΩ
R2, R5 : 360 kΩ
R1, R6 to R11, R17 : 200 kΩ
R12 to R16 : 300 kΩ
R18 to R20 : 51 Ω
R21 : 10 kΩ
C1 to C7 : 0.01 μF
C8 : 0.022 μF
C9 : 0.033 μF
C10 : 0.01 μF
C11 : 470 pF

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

TPMHA0330EB

24 H6559





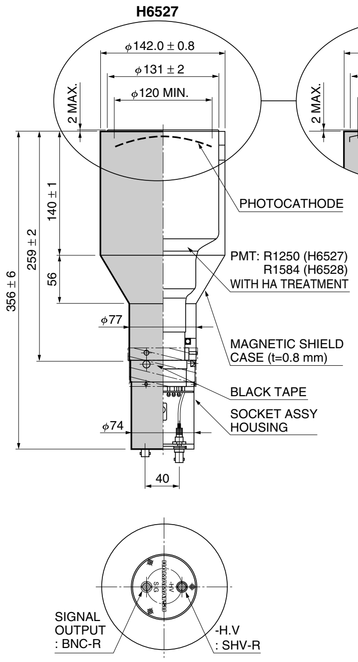
R1, R5 : 240 kΩ
R2, R10, R16 : 220 kΩ
R3, R9 : 180 kΩ
R4, R6 to R8, R14, R18 : 150 kΩ
R11, R13, R17 : 300 kΩ
R12, R15 : 360 kΩ
R19 : 51 Ω
R20, R21 : 100 Ω
R22 : 10 kΩ
C1 : 0.022 μF
C2 : 0.047 μF
C3 : 0.1 μF
C4 : 0.22 μF
C5 : 0.47 μF
C6 : 470 pF

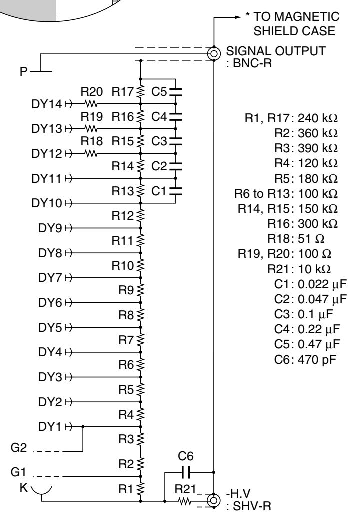
* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

TPMHA0331EB

(Unit: mm)

25 H6527, H6528

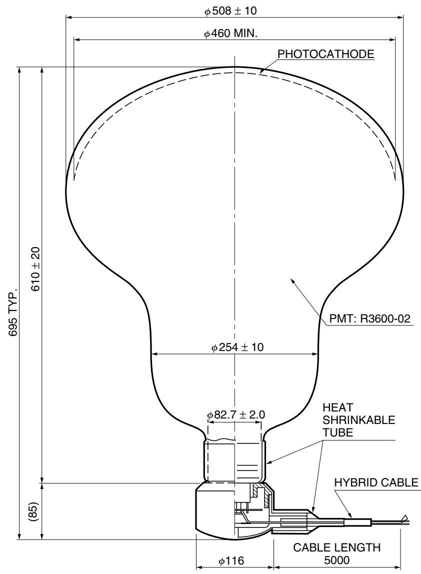


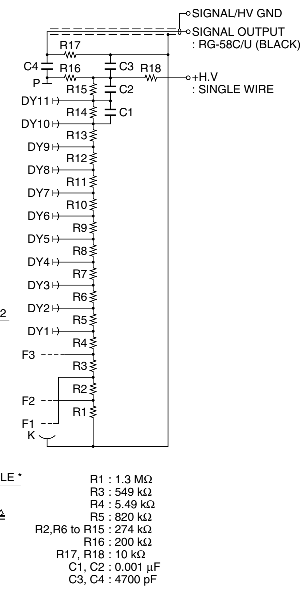


* MAGNETIC SHIELD IS CONNECTED TO GND INSIDE OF THIS PRODUCT.

TPMHA0332EE

26 R3600-06

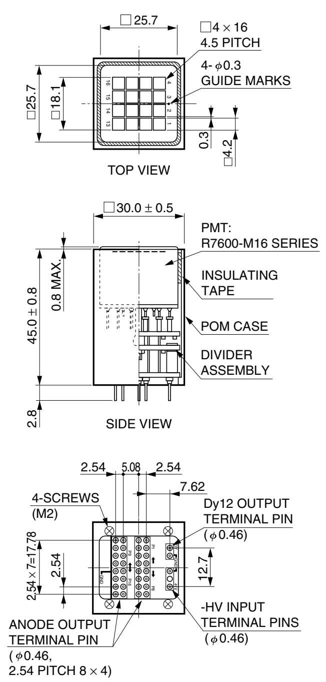


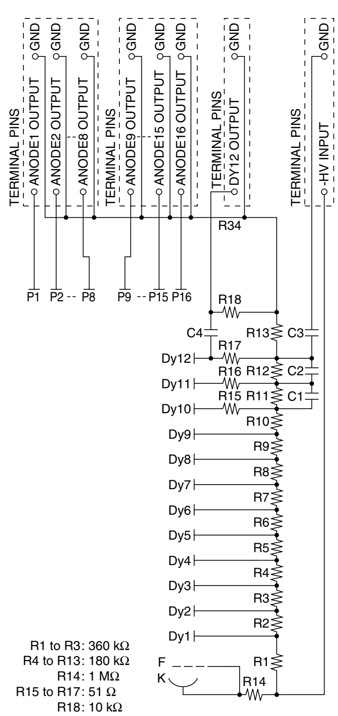


* HYBRID CABLE CONTAINS A SIGNAL CABLE AND HV WIRE WITH ADDITIONAL COVER.

TPMHA0156EC

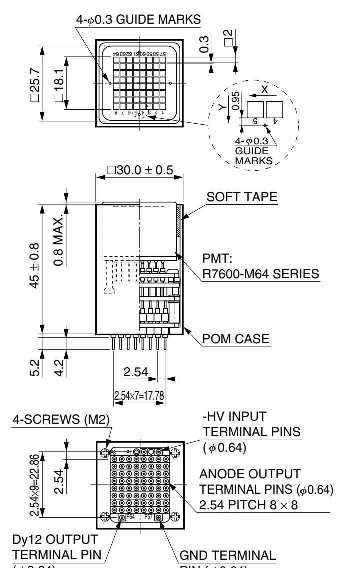
27 H8711, H8711-100, H8711-200, H8711-300

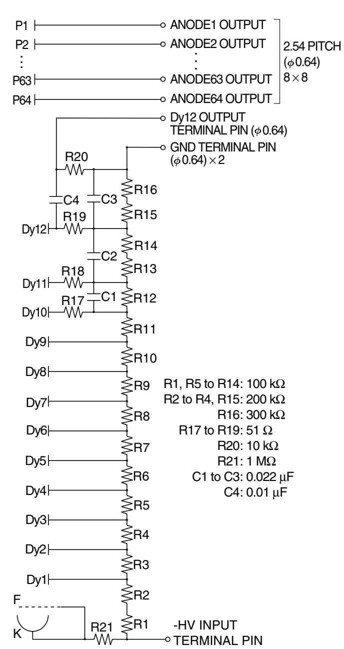




TPMHA0487ED

28 H7546B, H7546B-100, H7546B-200, H7546B-300

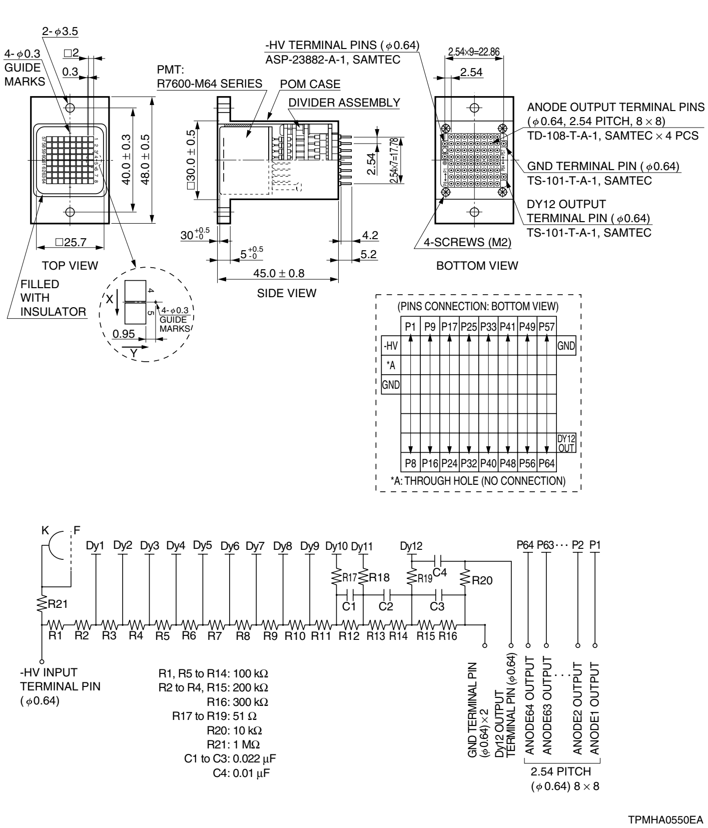




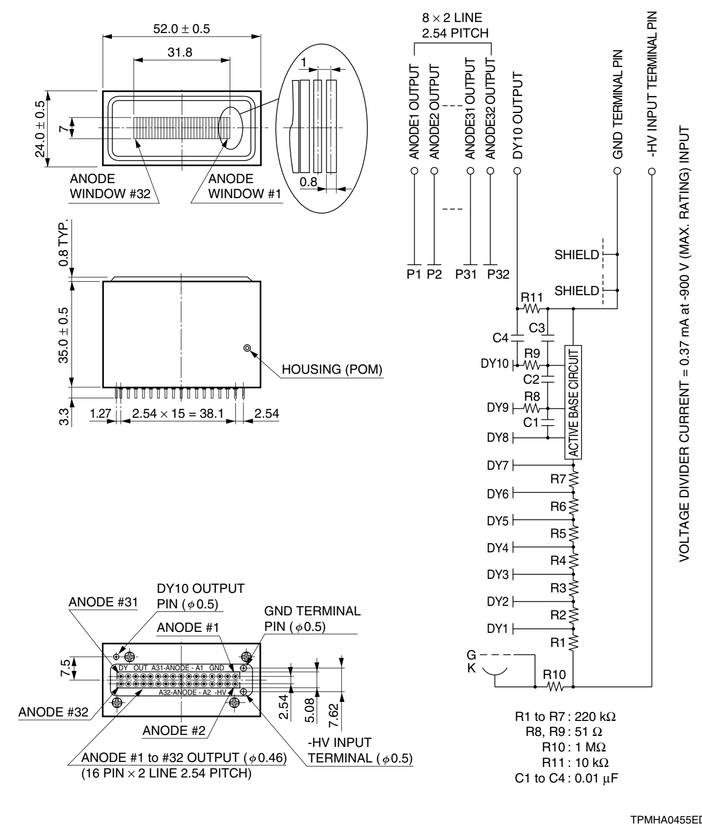
TPMHA0506EC

TPMHC0223EB

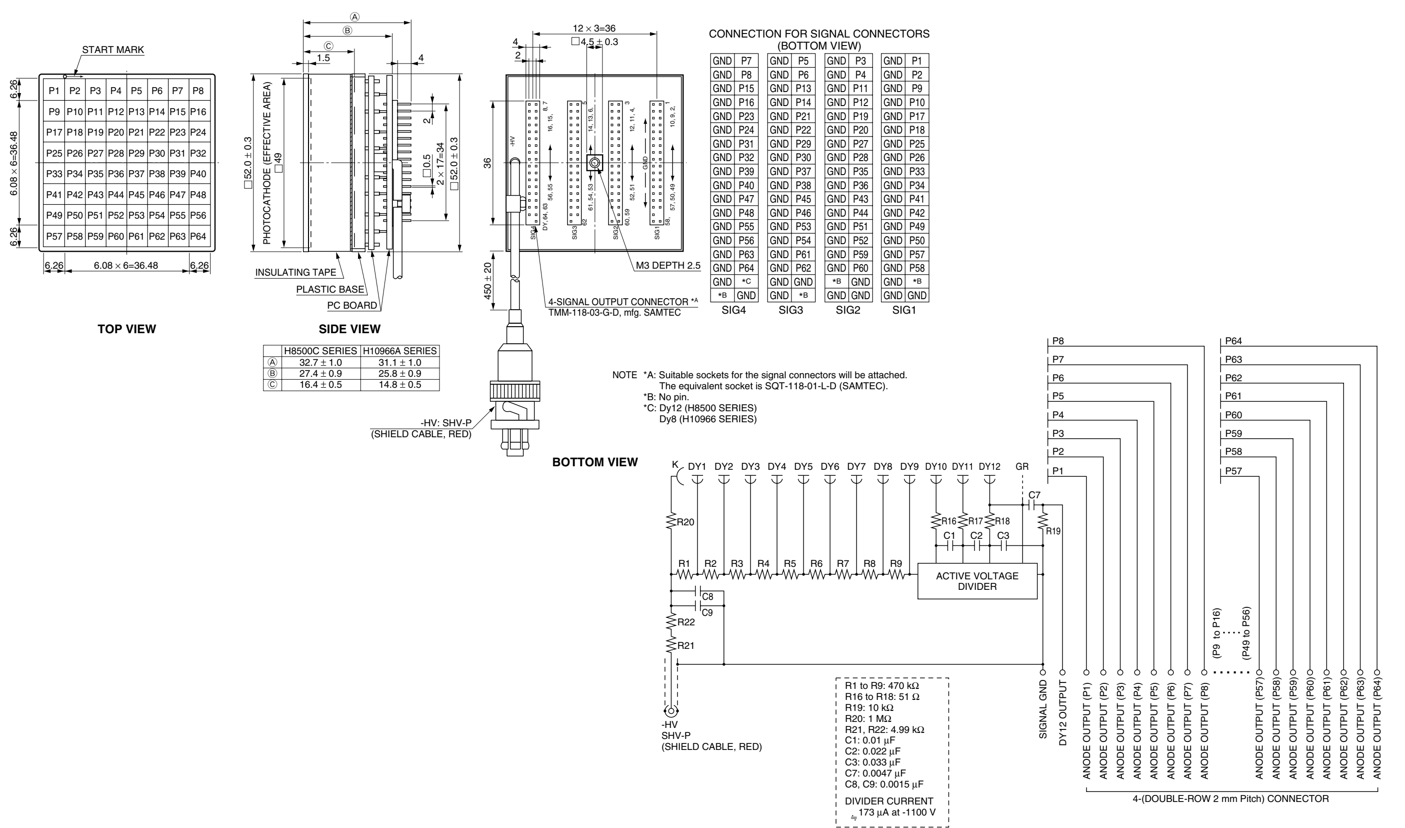
㉙ H8804, H8804-100, H8804-200, H8804-300



㉚ H7260, H7260-100, H7260-200



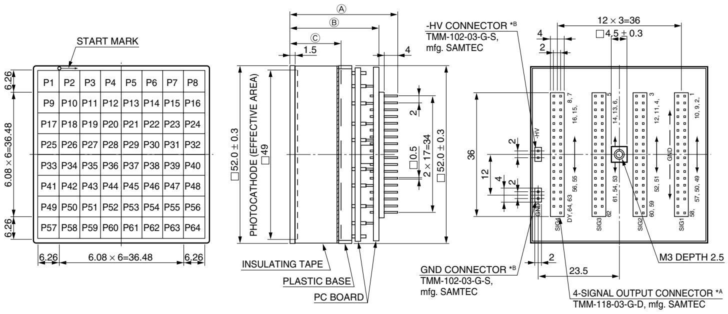
㉛ H8500C, H10966A, H10966A-100



	H8500C SERIES	H10966A SERIES
Ⓐ	32.7 ± 1.0	31.1 ± 1.0
Ⓑ	27.4 ± 0.9	25.8 ± 0.9
Ⓒ	16.4 ± 0.5	14.8 ± 0.5

(Unit: mm)

32 H8500D, H10966B, H10966B-100



TOP VIEW — SIDE VIEW — BOTTOM VIEW

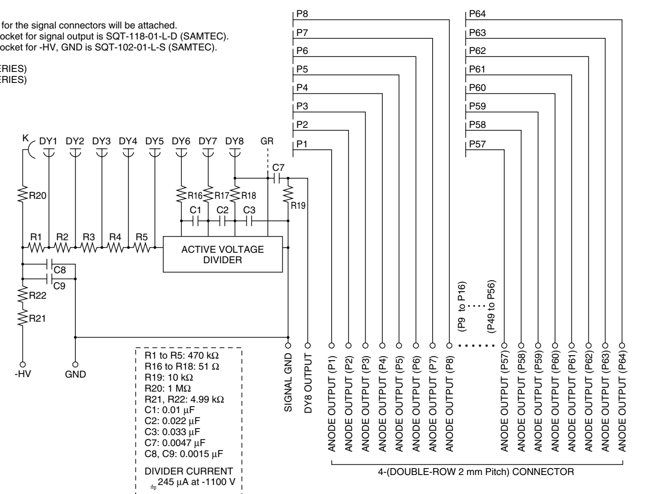
	H8500D SERIES	H10966B SERIES
Ⓐ	32.7 ± 1.0	31.1 ± 1.0
Ⓑ	27.4 ± 0.9	25.8 ± 0.9
Ⓒ	16.4 ± 0.5	14.8 ± 0.5

CONNECTION FOR SIGNAL CONNECTORS
(BOTTOM VIEW)

SIG4		SIG3		SIG2		SIG1	
GND	P7	GND	P5	GND	P3	GND	P1
GND	P8	GND	P6	GND	P4	GND	P2
GND	P15	GND	P13	GND	P11	GND	P9
GND	P16	GND	P14	GND	P12	GND	P10
GND	P23	GND	P21	GND	P19	GND	P17
GND	P24	GND	P22	GND	P20	GND	P18
GND	P31	GND	P29	GND	P27	GND	P25
GND	P32	GND	P30	GND	P28	GND	P26
GND	P39	GND	P37	GND	P35	GND	P33
GND	P40	GND	P38	GND	P36	GND	P34
GND	P47	GND	P45	GND	P43	GND	P41
GND	P48	GND	P46	GND	P44	GND	P42
GND	P55	GND	P53	GND	P51	GND	P49
GND	P56	GND	P54	GND	P52	GND	P50
GND	P63	GND	P61	GND	P59	GND	P57
GND	P64	GND	P62	GND	P60	GND	P58
GND	*C	GND	GND	*B	GND	GND	*B
*B	GND	GND	*B	GND	GND	GND	GND

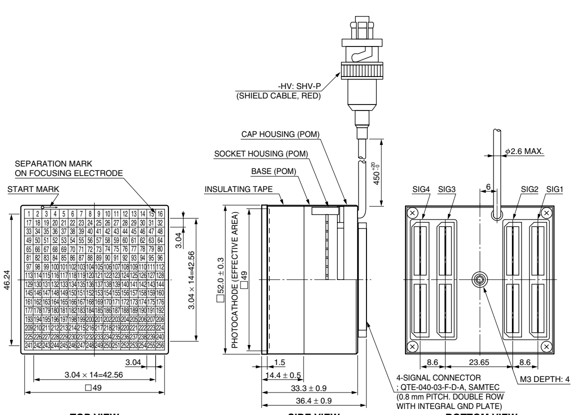
-HV
-HV
GND
GND

NOTE *A: Suitable sockets for the signal connectors will be attached.
The equivalent socket for signal output is SQT-118-01-L-D (SAMTEC).
The equivalent socket for -HV, GND is SQT-102-01-L-S (SAMTEC).
*B: No pin.
*C: Dy12 (H8500 SERIES)
Dy8 (H10966 SERIES)

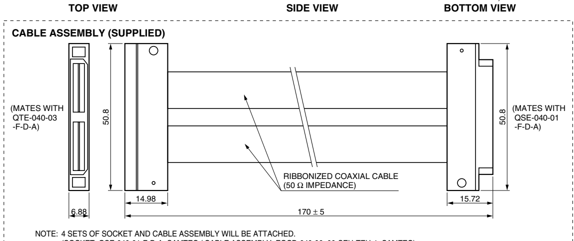


TPMHA0572EA

33 H9500



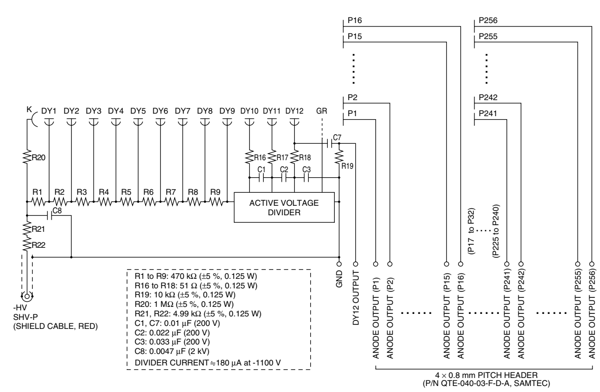
TOP VIEW — SIDE VIEW — BOTTOM VIEW



CONNECTION FOR SIGNAL CONNECTORS
(BOTTOM VIEW)

SIG4		SIG3		SIG2		SIG1	
GND	GND	GND	GND	GND	GND	GND	GND
GND	GND	GND	GND	GND	GND	GND	GND
GND	GND	GND	GND	GND	GND	GND	GND
GND	GND	GND	GND	GND	GND	GND	GND
P15	P13	P11	P9	P7	P5	P3	P1
P16	P14	P12	P10	P8	P6	P4	P2
P31	P29	P27	P25	P23	P21	P19	P17
P32	P30	P28	P26	P24	P22	P20	P18
P47	P45	P43	P41	P39	P37	P35	P33
P48	P46	P44	P42	P40	P38	P36	P34
P63	P61	P59	P57	P55	P53	P51	P49
P64	P62	P60	P58	P56	P54	P52	P50
P79	P77	P75	P73	P71	P69	P67	P65
P80	P78	P76	P74	P72	P70	P68	P66
P95	P93	P91	P89	P87	P85	P83	P81
P96	P94	P92	P90	P88	P86	P84	P82
P111	P109	P107	P105	P103	P101	P99	P97
P112	P110	P108	P106	P104	P102	P100	P98
P127	P125	P123	P121	P119	P117	P115	P113
P128	P126	P124	P122	P120	P118	P116	P114
P143	P141	P139	P137	P135	P133	P131	P129
P144	P142	P140	P138	P136	P134	P132	P130
P159	P157	P155	P153	P151	P149	P147	P145
P160	P158	P156	P154	P152	P150	P148	P146
P175	P173	P171	P169	P167	P165	P163	P161
P176	P174	P172	P170	P168	P166	P164	P162
P191	P189	P187	P185	P183	P181	P179	P177
P192	P190	P188	P186	P184	P182	P180	P178
P207	P205	P203	P201	P199	P197	P195	P193
P208	P206	P204	P202	P200	P198	P196	P194
P223	P221	P219	P217	P215	P213	P211	P209
P224	P222	P220	P218	P216	P214	P212	P210
P239	P237	P235	P233	P231	P229	P227	P225
P240	P238	P236	P234	P232	P230	P228	P226
P255	P253	P251	P249	P247	P245	P243	P241
P256	P254	P252	P250	P248	P246	P244	P242
GND	GND	GND	GND	GND	GND	GND	GND
GND	GND	GND	GND	GND	GND	GND	GND
GND	GND	GND	GND	GND	GND	GND	GND
DY12 OUTPUT	GND	GND	GND	GND	GND	GND	GND

METAL PLATE (GND)



TPMHA0504EB

Quick Reference for PMT Socket Assemblies

Assembly Type No.	PMT Characteristics: Tube Diameter	Tube Type No.	/ Voltage Distribution Ratio	Reference Page for PMT Feature	Assembly Characteristics: Outline No.	H.V Input Terminal	Signal Output Terminal	Standard Rating: Overall① Voltage (V)	Standard Rating: Divider② Current (mA)	Maximum Rating: Overall Voltage (V)	Notes
E1761-21	10 mm (3/8")	R1635 R2248	④	20 24	1	SHV	BNC	-1250	0.35	-1500	
E1761-22		R2496	⑥	20	1	SHV	BNC	-1250	0.32	-1500	
E849-90	13 mm (1/2")	R647-01	⑰	20	2	SHV	BNC	-1000	0.28	-1250	
E849-68		R4124	㉚	20	3	AWG22	RG-174/U	-1000	0.23	-1250	
E974-17	19 mm (3/4")	R1166	㉑	20	4	SHV	BNC	-1000	0.27	-1800	
E974-22		R1450	㉗	20	4	SHV	BNC	-1500	0.37	-1800	
E2253-05		R3478	⑪	20	5	SHV	BNC	-1700	0.34	-1800	
E974-19		R4125	㉒	20	6	AWG22	RG-174/U	-1500	0.27	-1800	
E2037-02	25 mm (1")	R1548-07	㉝	24	7	AWG24	AWG24	-1250	0.13	-1750	6 µA is for total of 2 anodes.
E6133-04		R5505-70	(65)	20	8	SHV	BNC	+2000	0.36	+2300	E6133-03 (-HV) is available.
E2924-11		R7899	㉚	21	9	AWG22	RG-174/U	-1250	0.28	-1800	For R7899 (Glass Base Type)
E990-29		R3998-02 R3998-100-02	⑭	20 26	10	AWG22	RG-174/U	-1000	0.23	-1500	
E2924-500	25 mm (1") 28 mm (1-1/8")	R1924A R7111	㉙	20 20	11	SHV	BNC	-1000	0.24	-1250	
E2624-14	28 mm (1-1/8")	R6427	㉝	20	12	SHV	BNC	-1500	0.32	-2000	
E2624-04			㉞	20	13	AWG22	RG-174/U	-1500	0.37	-2000	
E2183-500	38 mm (1-1/2")	R580 R11102 R3886A	㉔	20 20 20	14	SHV	BNC	-1250 -1000 -1000	0.32 0.26 0.26	-1750 -1250 -1250	
E2183-501			㉖	20 20 20	14	SHV	BNC	-1500 -1000 -1000	0.54 0.36 0.36	-1750 -1250 -1250	
E1198-07	51 mm (2")	R2154-02	㉔	22	15	AWG22	RG-174/U	-1250	0.32	-1750	
E2979-500		R1828-01	㊺	22	16	SHV	BNC	-2500	0.58	-3000	with shield case
E1198-05	51 mm (2") 60 mm (2.4") 76 mm (3") 90 mm (3.5")	R1306 R1307	②	22 22	17	AWG22	RG-174/U	-1000	0.31	-1500	
E1198-20			②	22 22	18	SHIELD CABLE	RG-174/U	+1000	0.28	+1500	
E1198-26		R6231 R6231-100 R6232 R6233 R6233-100	⑤	22 26 22 22 26	19	SHIELD CABLE	RG-174/U	-1000	0.25	-1500	
E1198-27		R6234 R6235 R6236 R6237 R10233 R10233-100		24 24 24 24 22 26	19	SHIELD CABLE	RG-174/U	+1000	0.25	+1500	
E5859	51 mm (2") 76 mm (3")	R329-02 R6091	(56)	22 22	20	SHV	BNC	-2000	0.5	-2700 -2500	shield case is available. +HV type (E5859-02) is available.
E5859-01		R329-02 R331-05 R6091	(52)	22 22 22	20	SHV	BNC	-1500	0.42	-2700 -2500	shield case is available. +HV type (E5859-03) is available.

Note:
①: When overall voltage is negative (-HV), DC and pulse signals are obtained. When it's positive (+HV), pulse signal is obtained.
②: The maximum average anode current is defined as 5 % of divider current.

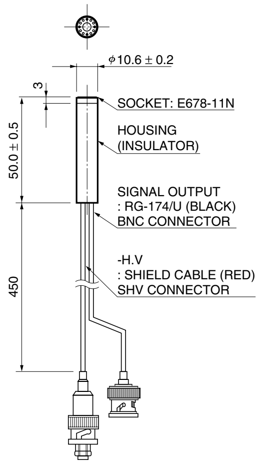
Assembly Type No.	PMT Characteristics: Tube Diameter	PMT Characteristics: Tube Type No. / Voltage Distribution Ratio		PMT Characteristics: Reference Page for PMT Feature	Assembly Characteristics: Outline No.	Assembly Characteristics: H.V Input Terminal	Assembly Characteristics: Signal Output Terminal	Standard Rating: Overall① Voltage (V)	Standard Rating: Divider② Current (mA)	Maximum Rating: Overall Voltage (V)	Notes
E1198-22	127 mm (5")	R877 R877-100	⑱	22 26	21	SHIELD CABLE	RG-174/U	-1250 -1250 -1500	0.32 0.32 0.38	-1500 -1500 -2000	
E1198-23					21	SHIELD CABLE	RG-174/U	+1250 +1250 +1500	0.32 0.32 0.38	+1500 +1500 +2000	shield case is available.
E6316-01					22	SHV	BNC	-1250 -1250 -1500	0.32 0.32 0.38	-1500 -1500 -2000	
E7693		R1250 R1584	⑥⓪	22 22	23	SHV	BNC	-2000	0.68	-3000	
E7694	204 mm (8") 254 mm (10")	R5912 R7081	⑥②	22 22	24	SHV	BNC	-1500	0.32	-1800	+HV type (E7694-01) is available.
E5996	30 mm Square Type	R7600U R7600U-03 R7600U-100 R7600U-200 R7600U-300	㉓	24 24 26 26 26	25	SHIELD CABLE	RG-174/U	-800	0.3	-900	
E7083		R7600U-00-M4 R7600U-100-M4 R7600U-200-M4 R7600U-300-M4	㉓	24 26 26 26	26	SHIELD CABLE	0.8D-QEV	-800	0.3	-900	
E6736		R5900U-00-L16 R5900U-100-L16 R5900U-200-L16	⑰	24 26 26	27	SHIELD CABLE	0.8D-QEV	-800	0.34	-900	Active base type (E6572) is available.
E7514		R8900U-00-C12	㊳	44	28	SHIELD CABLE	0.8D-QEV	-800	0.27	-1000	
E10411		R8900U-100	⑯	26	29	SHIELD CABLE	RG-174/U	-800	0.3	-1000	
E9349		R8900-00-M16 R8900-100-M16	㊶	24 26	30	PIN	PIN	-800	0.28	-1000	
E11807		R11265U R11265U-100 R11265U-200	㊾ (51)	24 26 26	31	RG-174/U	RG-174/U	900	0.32	1000	
E11807-01		R11265U R11265U-100 R11265U-200	㊾ (51)	24 26 26	31	RG-174/U	RG-174/U	900	0.32	1000	

Note:
①: When overall voltage is negative (-HV), DC and pulse signals are obtained. When it's positive (+HV), pulse signal is obtained.
②: The maximum average anode current is defined as 5 % of divider current.

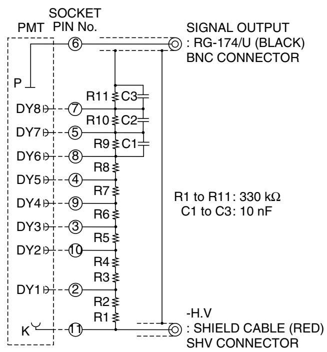
Dimensional Outline and Circuit Diagrams

For PMT Socket Assemblies

1 E1761-21, E1761-22

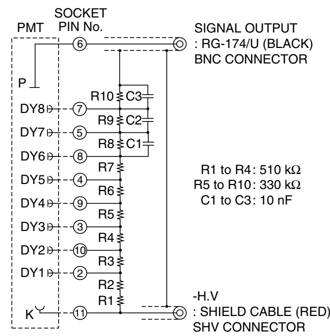


E1761-21



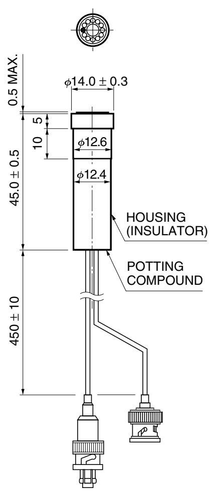
TACCA0075EB

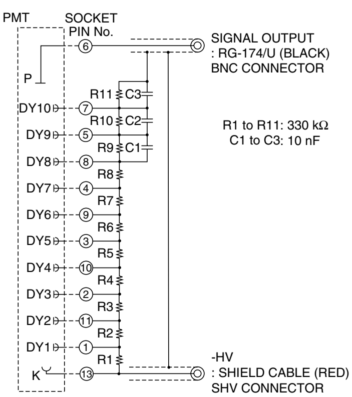
E1761-22



TACCA0076EC

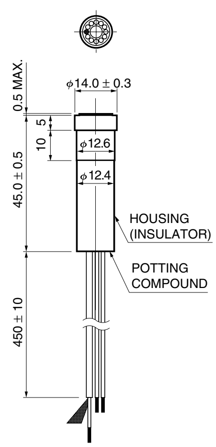
2 E849-90

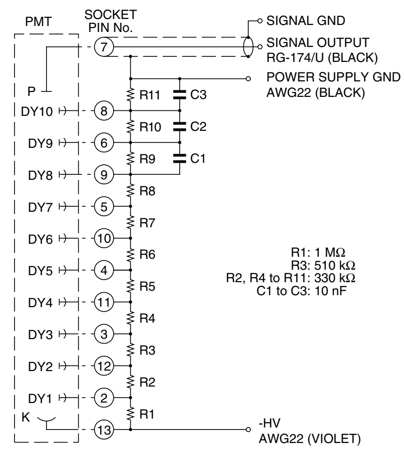




TACCA0077ED

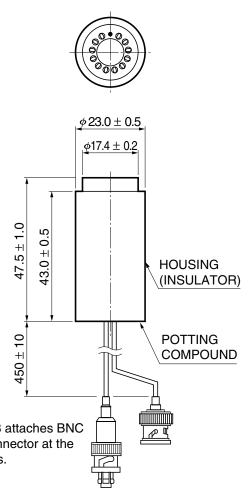
3 E849-68





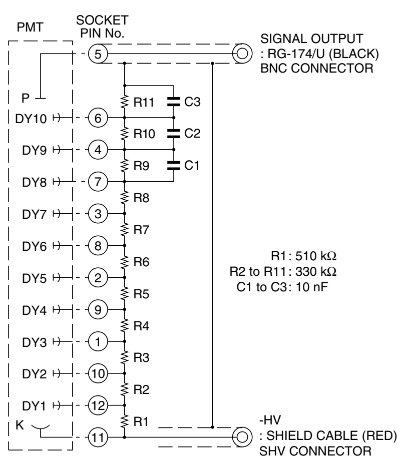
TACCA0210EB

4 E974-17, E974-22



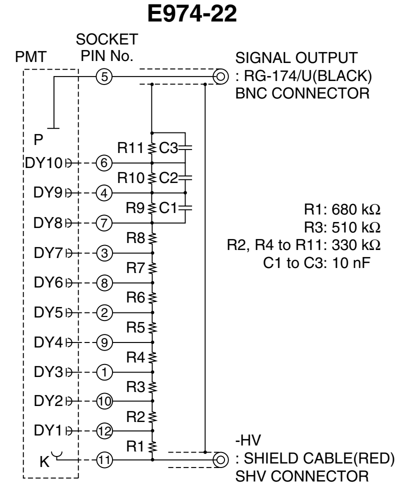
E974-17, -18 attaches BNC and SHV connector at the end of cables.

E974-17



TACCA0212EB

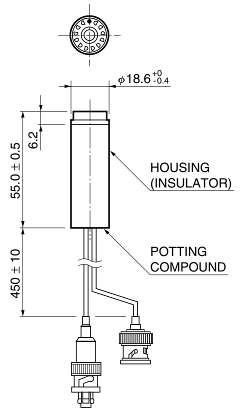
E974-22

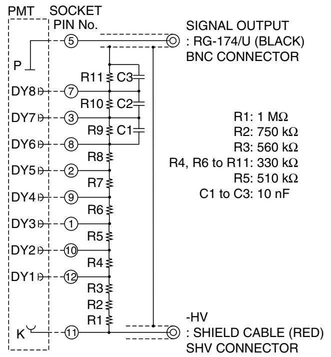


TACCA0078EC

(Unit: mm)

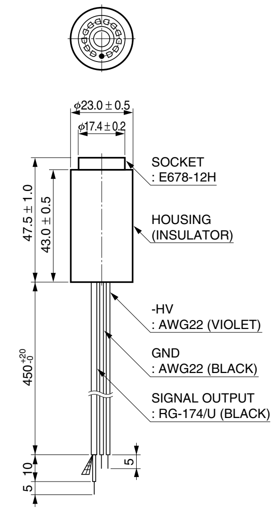
5 E2253-05

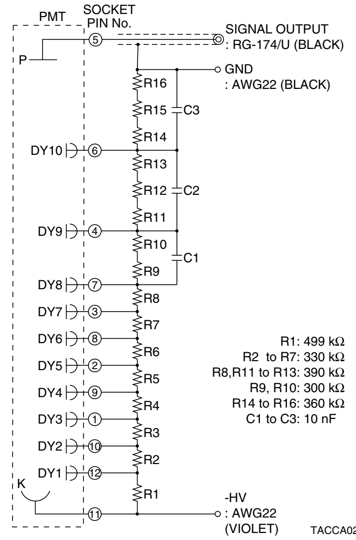




TACCA0079EB

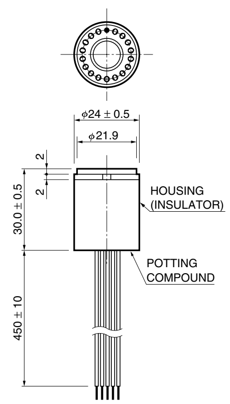
6 E974-19

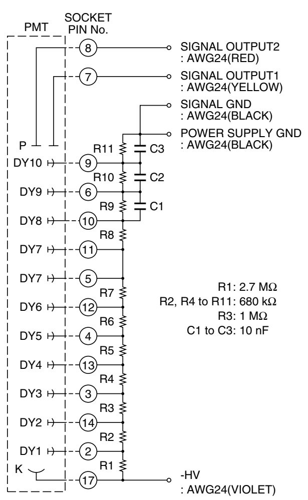




TACCA0230EB

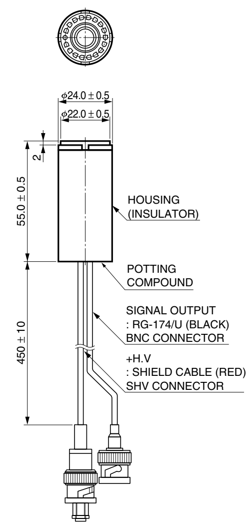
7 E2037-02

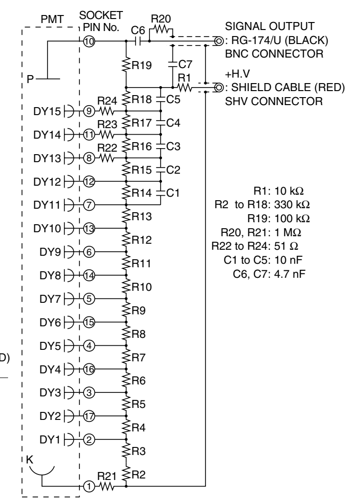




TACCA0028EC

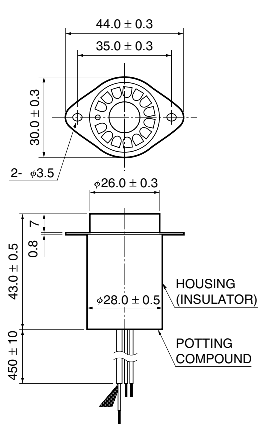
8 E6133-04

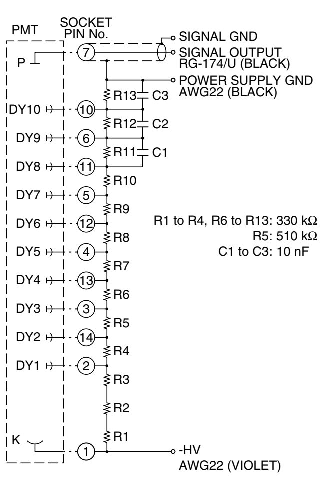




TACCA0231EB

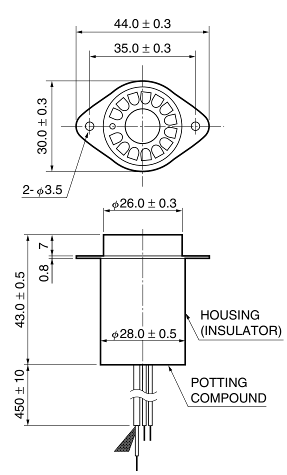
9 E2924-11

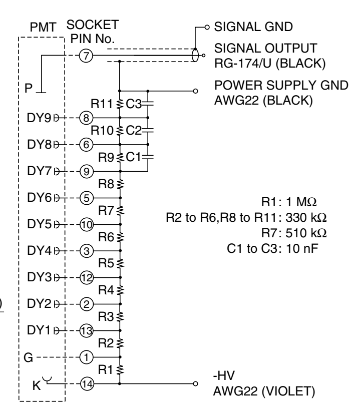




TACCA0032EC

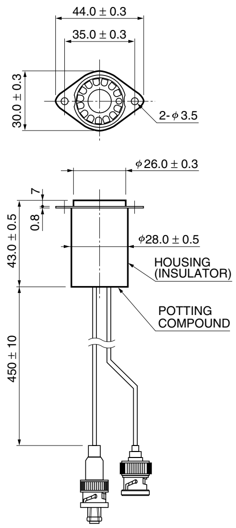
10 E990-29

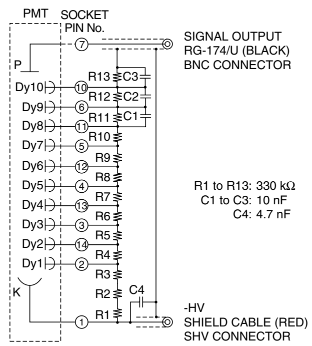




TACCA0215EC

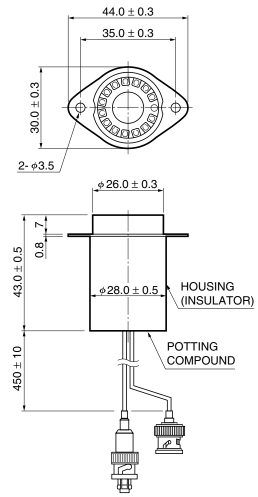
11 E2924-500

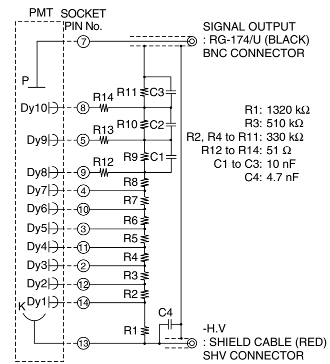




TACCA0081EC

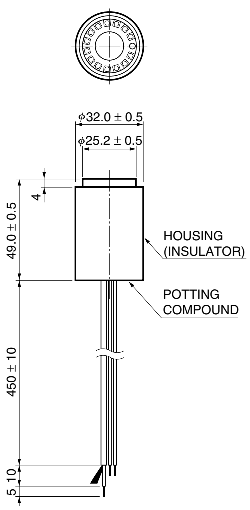
12 E2624-14

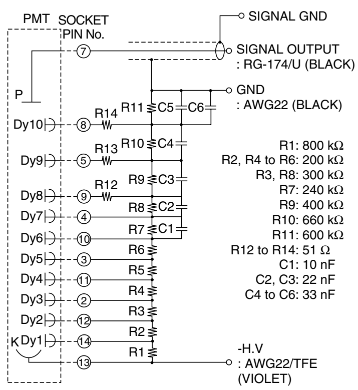




TACCA0082EC

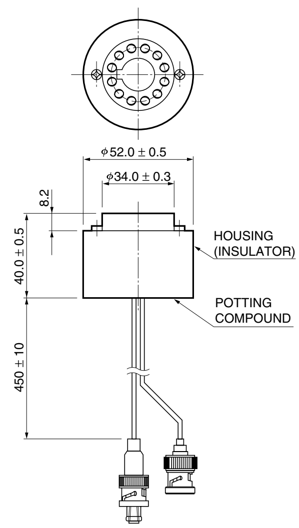
13 E2624-04



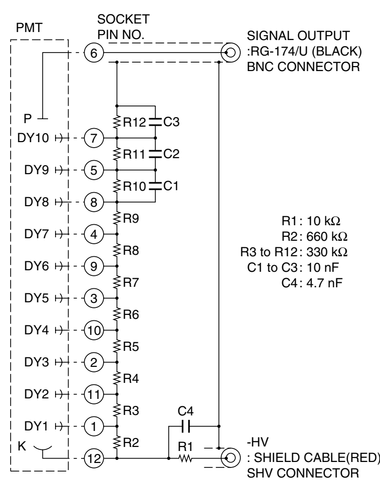


TACCA0084ED

14 E2183-500, E2183-501

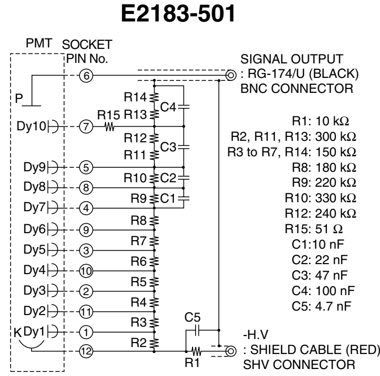


E2183-500



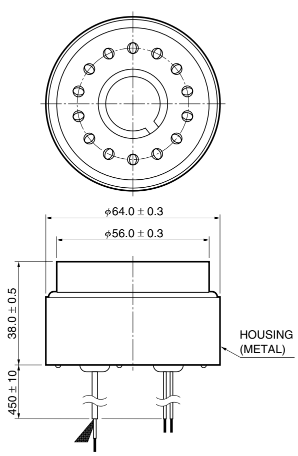
TACCA0166EC

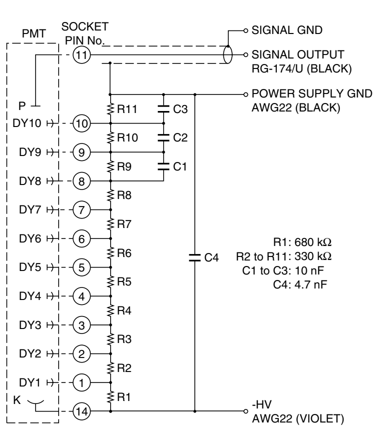
E2183-501



TACCA0086EC

15 E1198-07



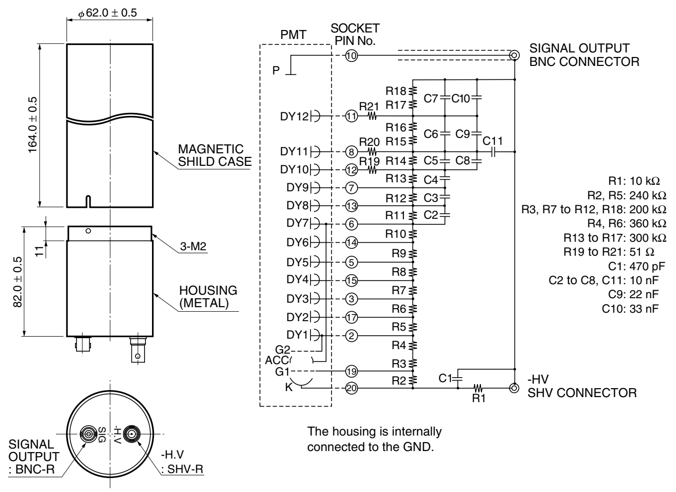


The housing is internally connected to the GND.

TACCA0220EB

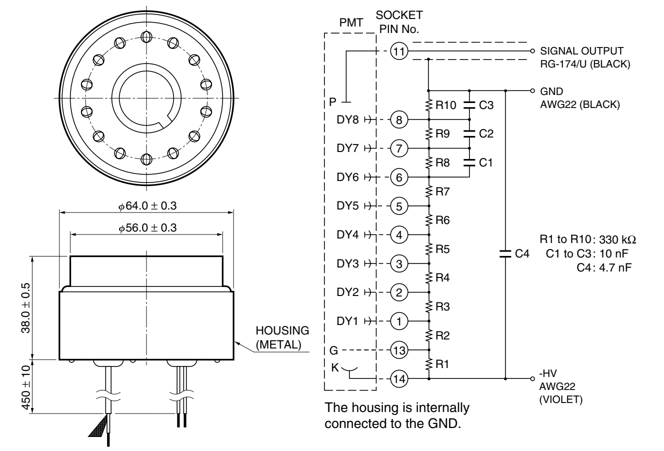
(Unit: mm)

16 E2979-500



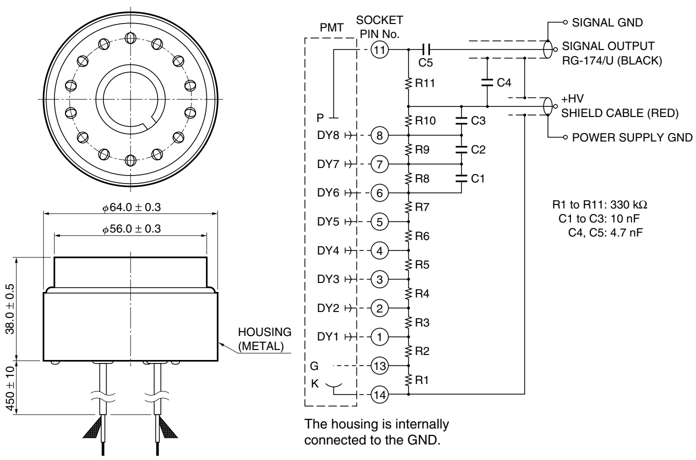
TACCA0093EB

17 E1198-05



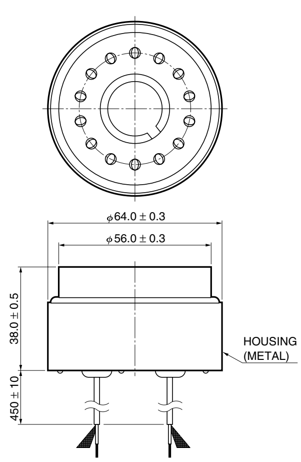
TACCA0221EB

18 E1198-20

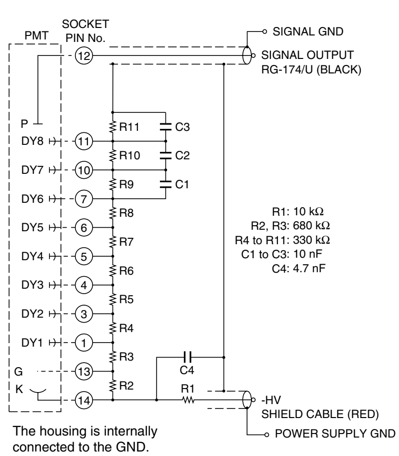


TACCA0223EC

19 E1198-26, E1198-27

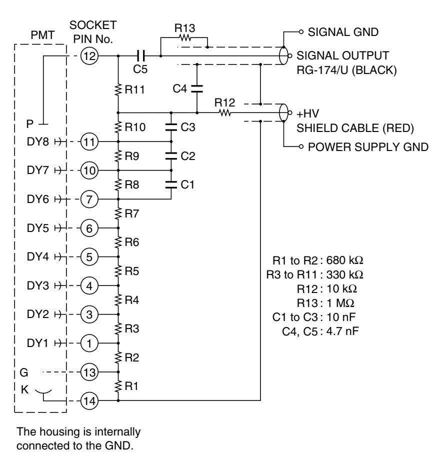


E1198-26



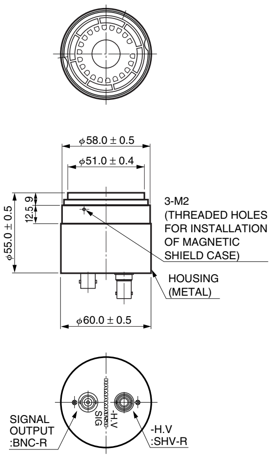
TACCA0224EB

E1198-27

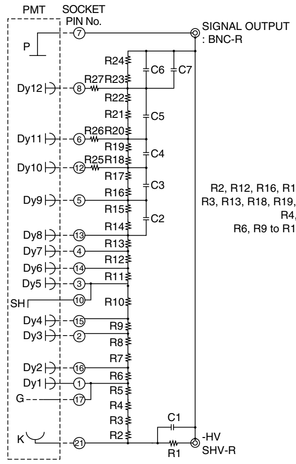


TACCA0225EB

20 E5859, E5859-01



E5859

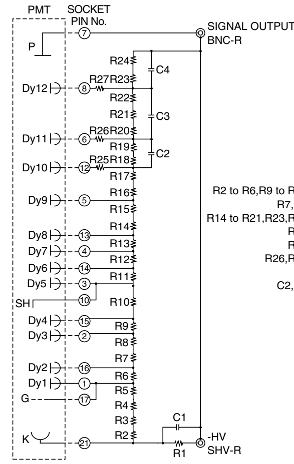


R1: 10 kΩ
R2, R12, R16, R17, R20, R21: 180 kΩ
R3, R13, R18, R19, R22 to R24: 226 kΩ
R4, R5, R7, R8: 121 kΩ
R6, R9 to R11, R14, R15: 150 kΩ
R25: 51 kΩ
R26, R27: 100 Ω
C1: 470 pF
C2: 22 nF
C3: 47 nF
C4: 100 nF
C5 to C7: 220 nF

The housing is internally connected to the GND.

TACCA0176EC

E5859-01

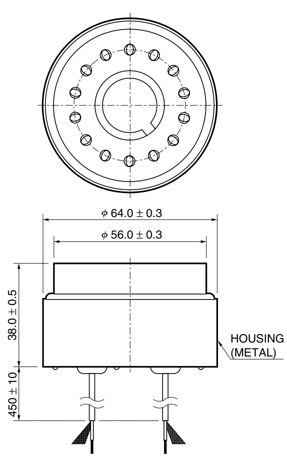


R1: 10 kΩ
R2 to R6,R9 to R13: 220 kΩ
R7,R8: 154 kΩ
R14 to R21,R23,R24: 110 kΩ
R22: 0 Ω
R25: 51 Ω
R26,R27: 100 Ω
C1: 470 pF
C2,C3: 10 nF
C4: 22 nF

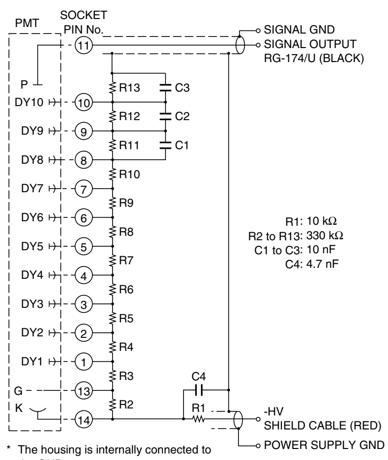
The housing is internally connected to the GND.

TACCA0178EC

21 E1198-22, E1198-23



E1198-22

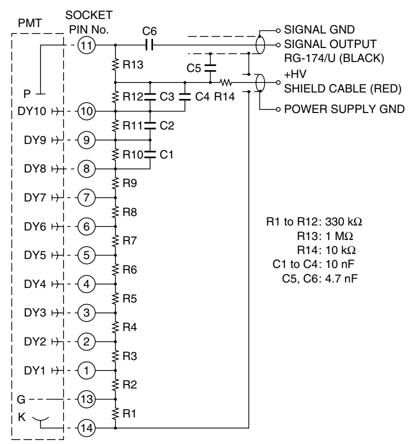


R1: 10 kΩ
R2 to R13: 330 kΩ
C1 to C3: 10 nF
C4: 4.7 nF

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

TACCA0168EB

E1198-23

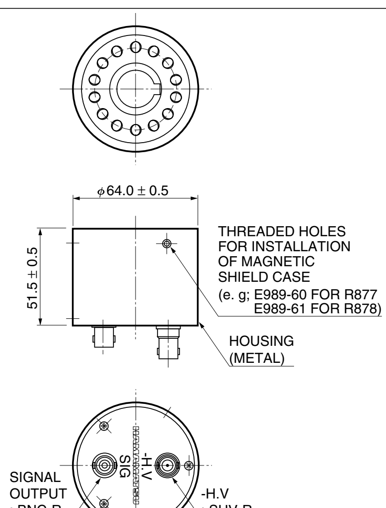


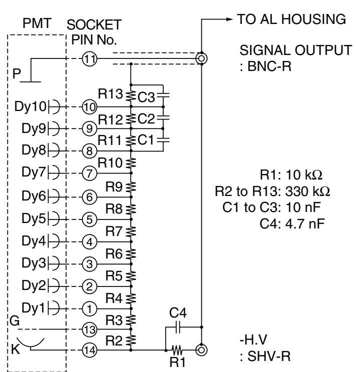
R1 to R12: 330 kΩ
R13: 1 MΩ
R14: 10 kΩ
C1 to C4: 10 nF
C5, C6: 4.7 nF

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

TACCA0169EC

22 E6316-01





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

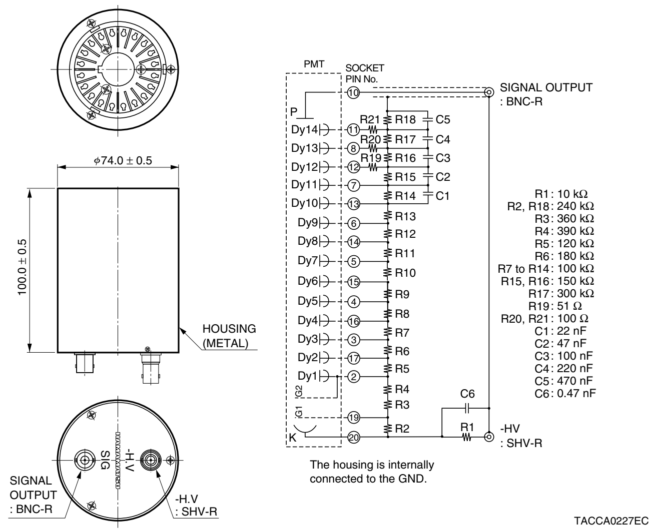
The housing is internally connected to the GND.

Note: Magnetic shield case is available to order separately.

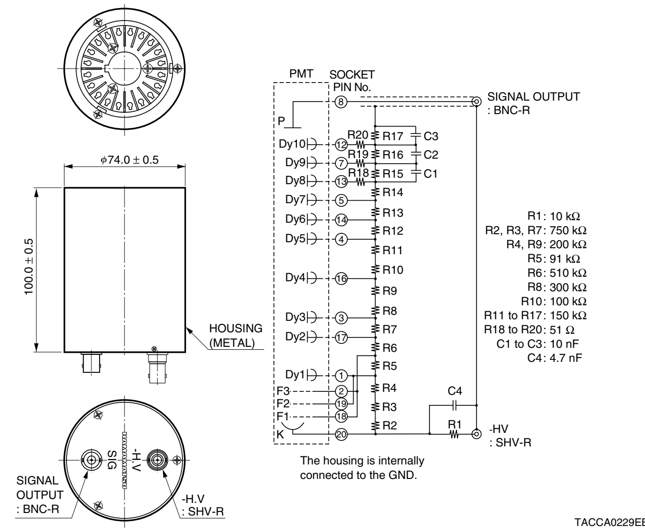
TACCA0089EB

(Unit: mm)

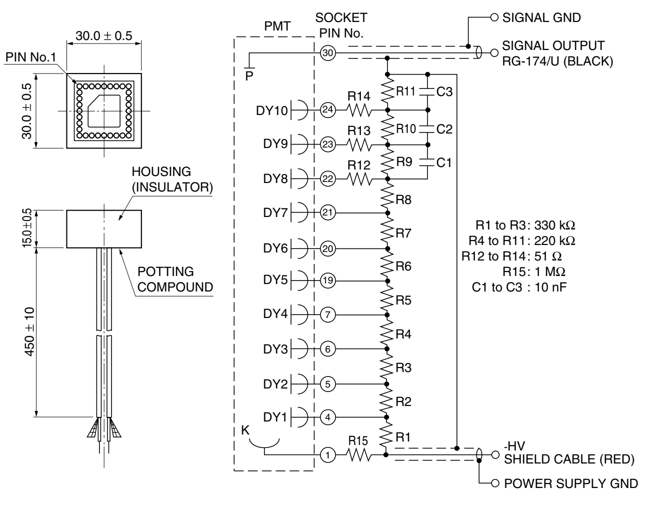
23 E7693



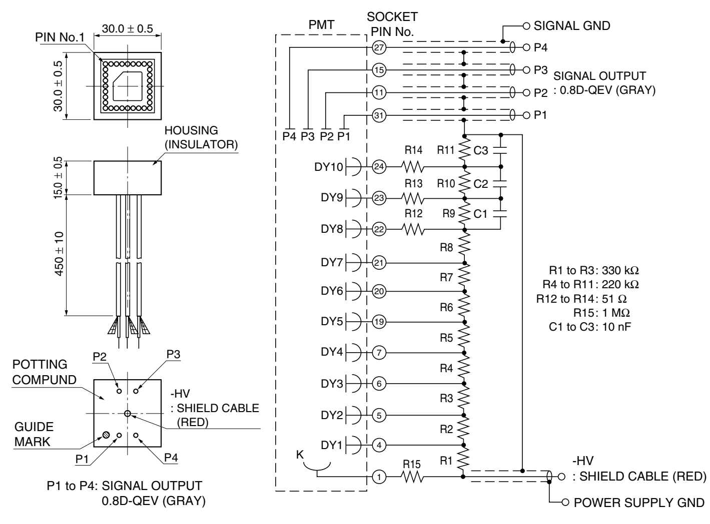
24 E7694



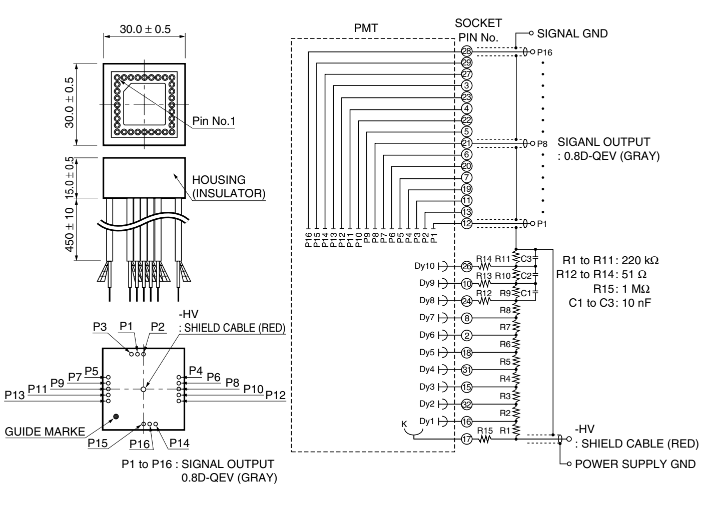
25 E5996



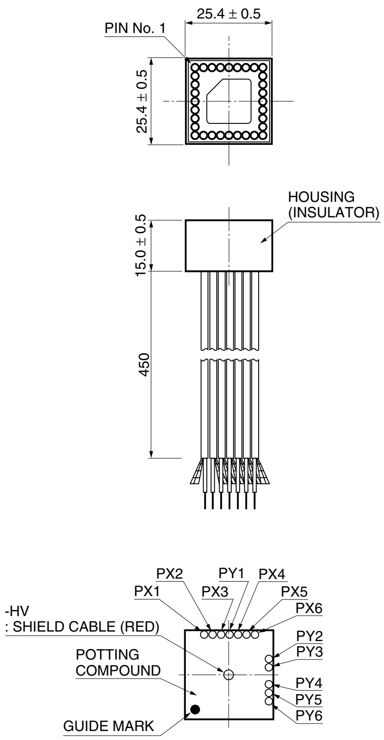
26 E7083



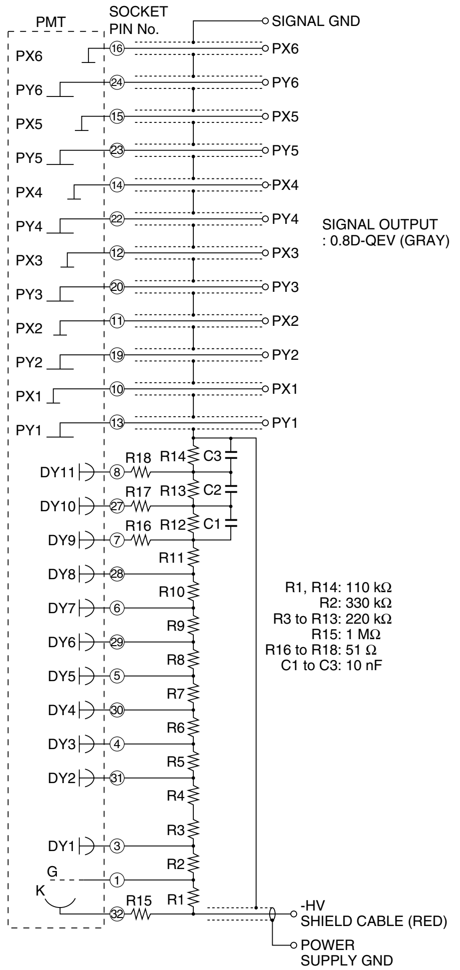
27 E6736



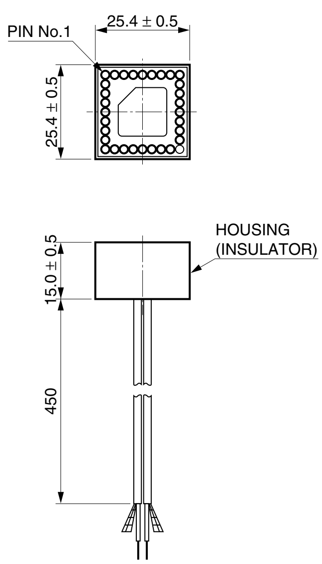
28 E7514

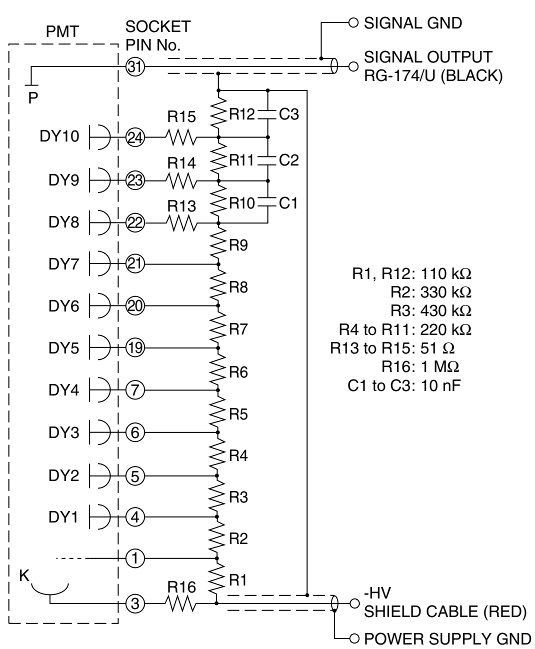


PX1 to PX6
PY1 to PY6: SIGNAL OUTPUT
0.8D-QEV (GRAY)



29 E10411

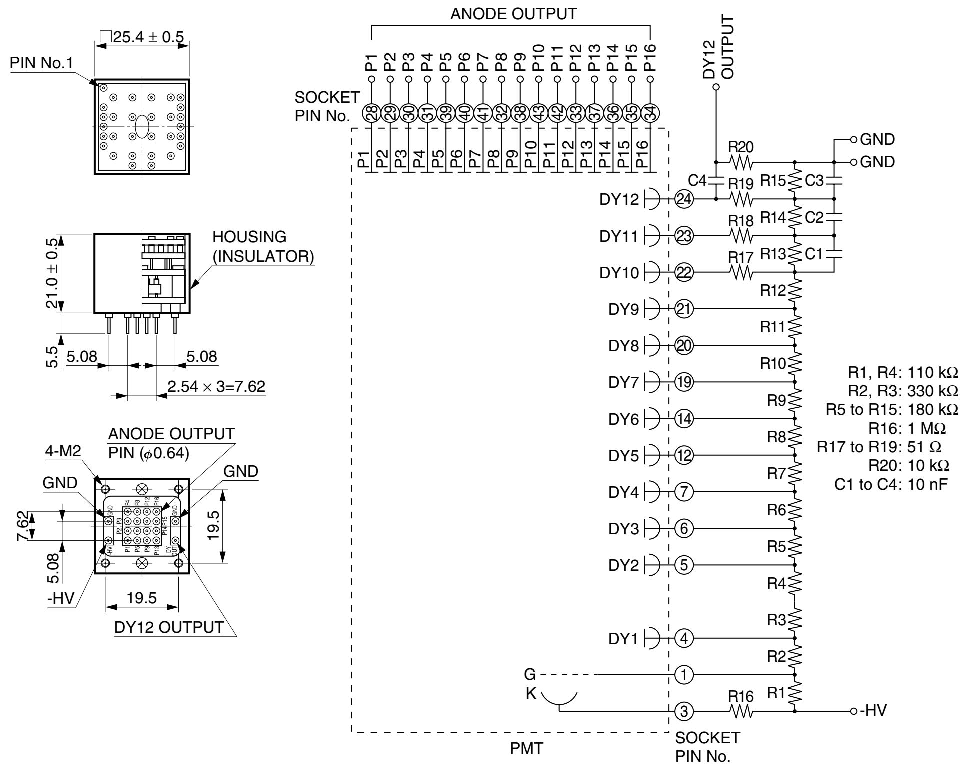




TACCA0298EA

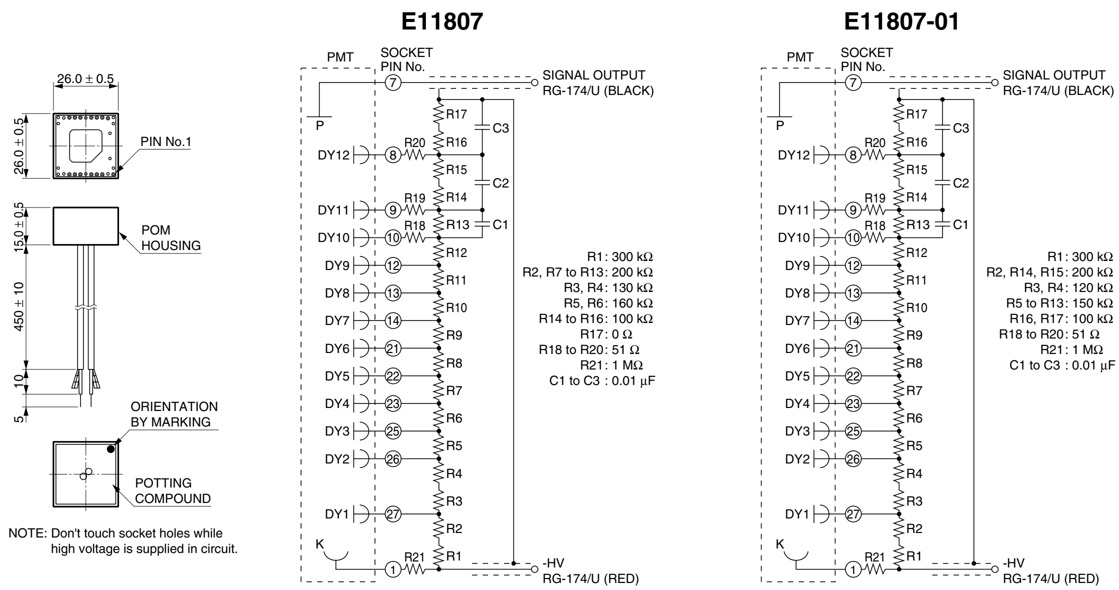
(Unit: mm)

30 E9349



TACCA0297EB

31 E11807, E11807-01

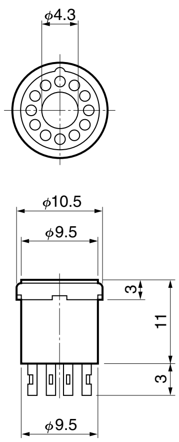


TACCA0314EA

Dimensional Outline

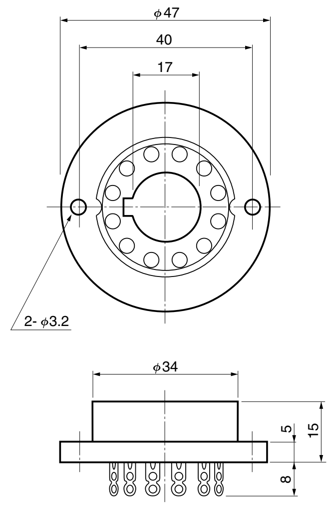
For E678 Series Sockets

E678-11N



TACCA0043EA

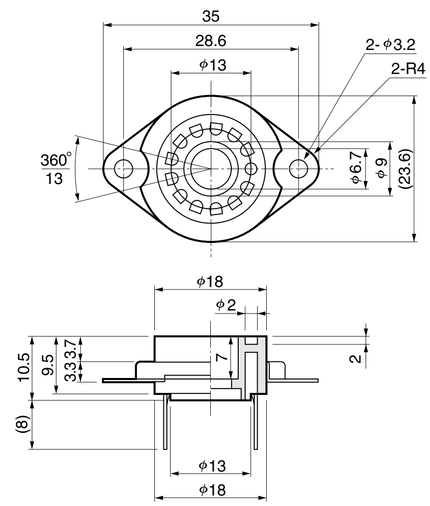
E678-12A, E678-12R*



* Gold plating type

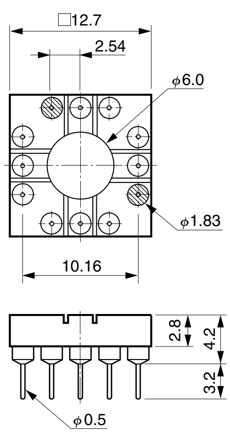
TACCA0009EB

E678-12L



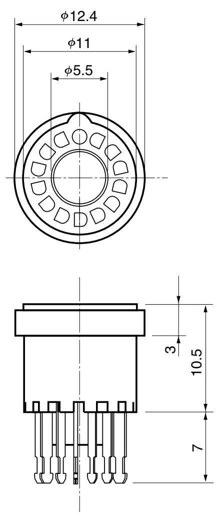
TACCA0047EA

E678-12V



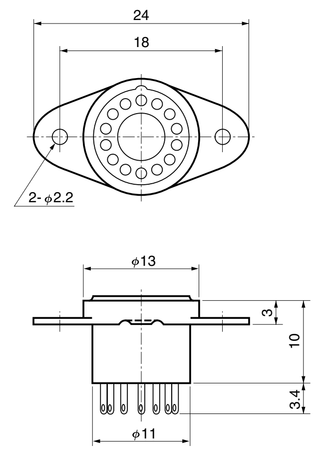
TACCA0164EC

E678-13E



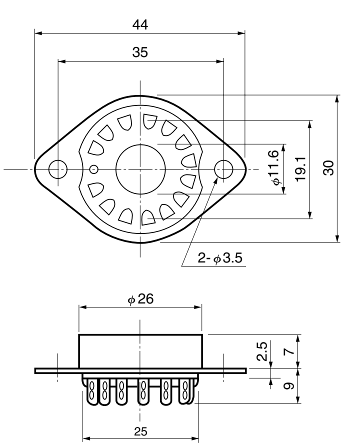
TACCA0013EB

E678-13F



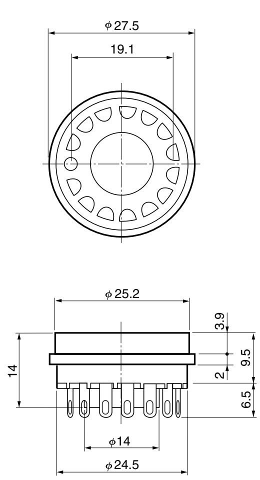
TACCA0005EA

E678-14C



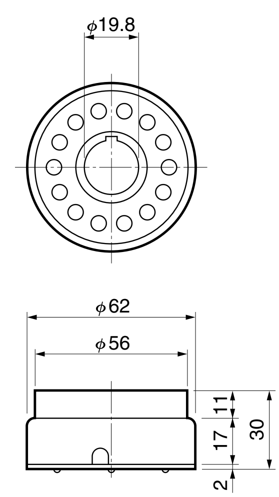
TACCA0004EA

E678-14-03



TACCA0184EA

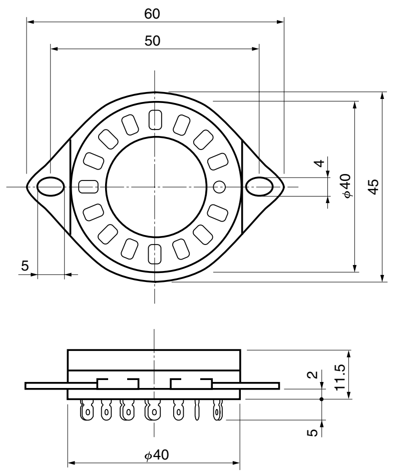
E678-14W



TACCA0200EA

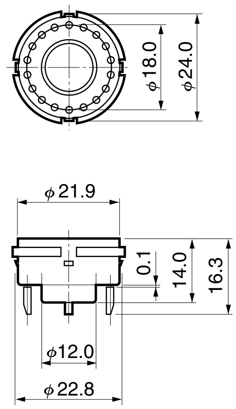
(Unit: mm)

E678-15C



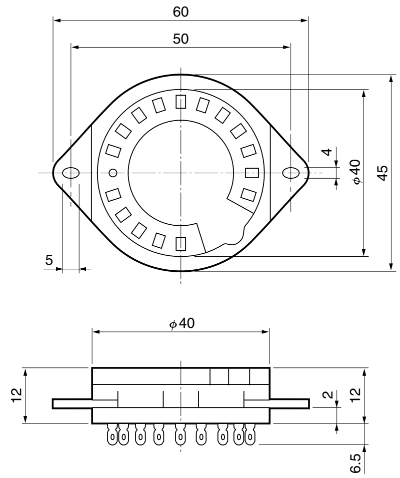
TACCA0201EA

E678-17A



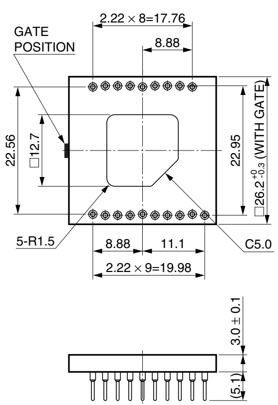
TACCA0046EB

E678-19J



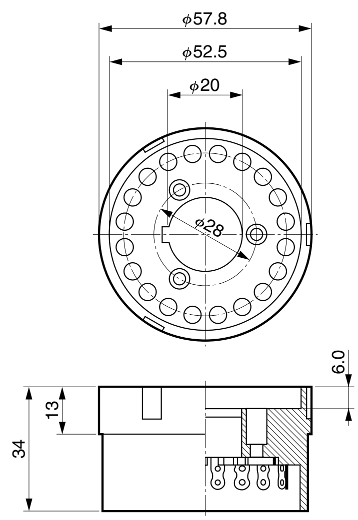
TACCA0203EA

E678-19K



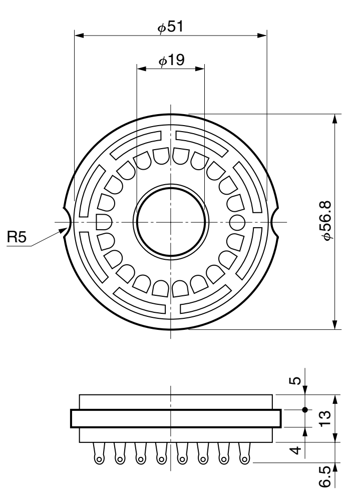
TACCA0313EA

E678-20B



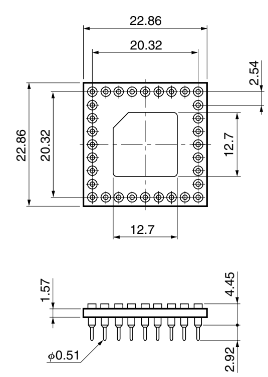
TACCA0309EA

E678-21C



TACCA0066EC

E678-32B



MATERIAL: Glass Epoxy

TACCA0094ED

Index by Type No.

CAUTIONS AND WARRANTY

⚠ WARNING

HIGH VOLTAGE

Take sufficient care to avoid an electric shock hazard

A high voltage used in photomultiplier tube operation may present a shock hazard. Photomultiplier tubes should be installed and handled only by qualified personnel that have been instructed in handling of high voltages. Designs of equipment utilizing these devices should incorporate appropriate interlocks to protect the operator and service personnel. The metal housing of the Metal Package PMT R7400 series, R5900 series and R7600 series are connected to the photocathode (potential) so that it becomes a high voltage potential when the product is operated at a negative high voltage (anode grounded).

PRECAUTIONS FOR USE

● Handle tubes with extreme care

Photomultiplier tubes have evacuated glass envelopes. Allowing the glass to be scratched or to be subjected to shock can cause cracks. Extreme care should be taken in handling, especially for tubes with graded sealing of synthetic silica.

● Keep faceplate and base clean

Do not touch the faceplate and base with bare hands. Dirt and fingerprints on the faceplate cause loss of transmittance and dirt the base may cause ohmic leakage. Should they become soiled, wipe it clean using alcohol.

● Do not expose to strong light

Direct sunlight and other strong illumination may cause damage the Photocathode. They must not be allowed to strike the photocathode, even when the tube is not operated.

● Handling of tubes with a glass base

A glass base (also called button stem) is less rugged than a plastic base, so care should be taken in handling this type of tube. For example, when fabricating the voltage-divider circuit, solder the divider resistors to socket lugs while the tube is inserted in the socket.

● Cooling of tubes

When cooling a photomultiplier tube, the photocathode section is usually cooled. However, if you suppose that the base is also cooled down to -30 °C or below, please consult our sales office in advance.

● Helium permeation through silica bulb

Helium will permeate through the silica bulb, leading to an increase in noise. Avoid operating or storing tubes in an environment where helium is present.

Data and specifications listed in this catalog are subject to change due to product improvement and other factors. before specifying any of the types in your production equipment, please consult our sales office.

WARRANTY

All Hamamatsu photomultiplier tubes and related products are warranted to the original purchaser for a period of 12 months following the date of shipment. The warranty is limited to repair or replacement of any defective material due to defects in workmanship or materials used in manufacture.

A: Any claim for damage of shipment must be made directly to the delivering carrier within five days.

B: Customers must inspect and test all detectors within 30 days after shipment. Failure to accomplish said incoming inspection shall limit all claims to 75 % of invoice value.

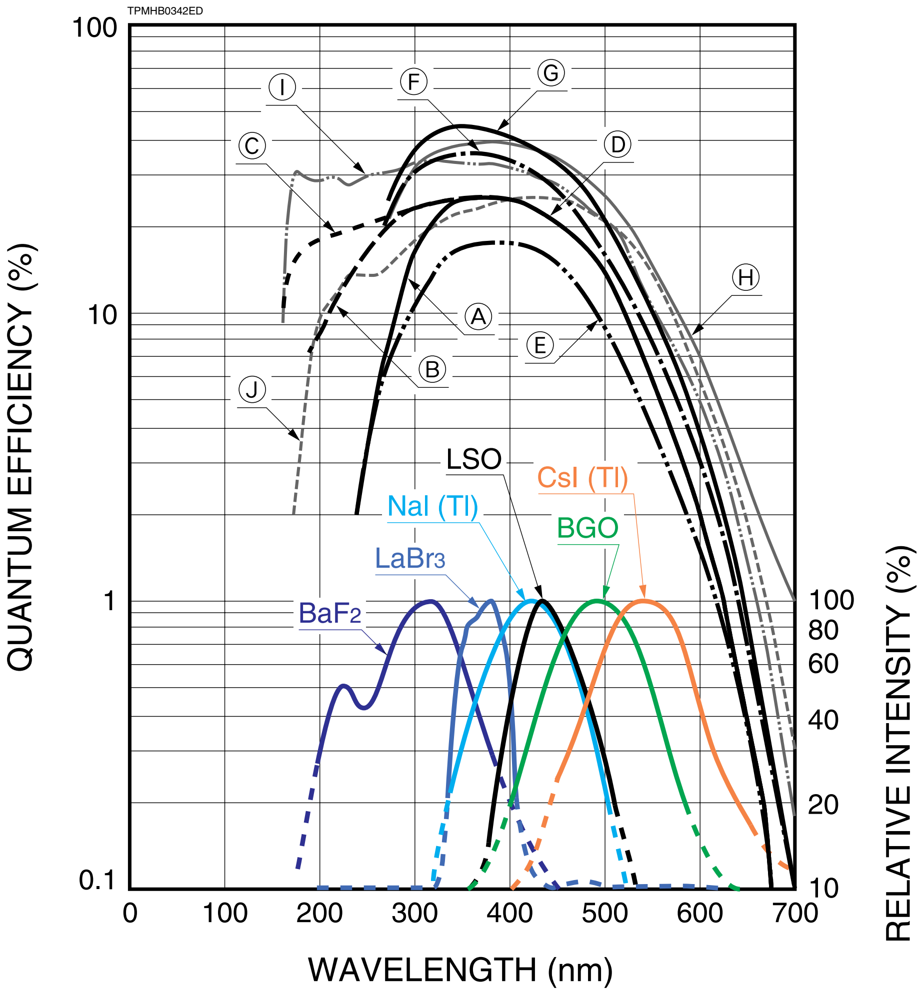
C: No credit will be issued for broken detectors unless in the opinion of Hamamatsu the damage is due to a bulb crack or a crack in a graded seal traceable to a manufacturing defect.

D: No credit will be issued for any detector which in the judgment of Hamamatsu has been damaged, abused, modified or whose serial number or type number have been obliterated or defaced.

E: No detectors will be accepted for return unless permission has been obtained from Hamamatsu in writing, the shipment has been returned prepaid and insured, the detectors are packed in their original box and accompanied by the original data sheet furnished to the customer with the tube, and a full written explanation of the reason for rejection of each detector.

F: When products are used at a condition which exceeds the specified maximum ratings or which could hardly be anticipated, Hamamatsu will not be the guarantor of the products.

Typical Photocathode Spectral Response and Emission Spectrum of Scintillators



Ⓐ: Bialkali Photocathode (Borosilicate Glass)
Ⓑ: Bialkali Photocathode (UV Glass)
Ⓒ: Bialkali Photocathode (Synthetic Silica)
Ⓓ: Bialkali Photocathode
Ⓔ: High Temp. Bialkali Photocathode
Ⓕ: Super Bialkali
Ⓖ: Ultra Bialkali
Ⓗ: Extended Green Bialkali
Ⓘ: Low Temp. (down to -110 °C) Bialkali Photocathode
Ⓙ: Low Temp. (down to -186 °C) Bialkali Photocathode

HAMAMATSU

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

Main Products

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

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

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

Laser Products
Semiconductor lasers
Applied products of semiconductor lasers
Solid state lasers

REVISED SEPT. 2012

Sales Offices

Japan:
HAMAMATSU PHOTONICS K.K.
325-6, Sunayama-cho, Naka-ku,
Hamamatsu City, 430-8587, Japan
Telephone: (81)53-452-2141, Fax: (81)53-456-7889
E-mail: intl-div@hq.hpk.co.jp

China:
HAMAMATSU PHOTONICS (CHINA) Co., Ltd.
1201 Tower B, Jiaming Center,
No.27 Dongsanhuan Beilu,
Chaoyang District, Beijing 100020, China
Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866
E-mail: hpc@hamamatsu.com.cn

U.S.A.:
HAMAMATSU CORPORATION
Main Office
360 Foothill Road, P.O. BOX 6910,
Bridgewater, N.J. 08807-0910, U.S.A.
Telephone: (1)908-231-0960, Fax: (1)908-231-1218
E-mail: usa@hamamatsu.com

Western U.S.A. Office:
Suite 200, 2875 Moorpark Avenue
San Jose, CA 95128, U.S.A.
Telephone: (1)408-261-2022, Fax: (1)408-261-2522
E-mail: usa@hamamatsu.com

United Kingdom:
HAMAMATSU PHOTONICS UK LIMITED
Main Office
2 Howard Court, 10 Tewin Road, Welwyn Garden City,
Hertfordshire AL7 1BW, United Kingdom
Telephone: 44-(0)1707-294888, Fax: 44-(0)1707-325777
E-mail: info@hamamatsu.co.uk

South Africa Office:
PO Box 1112, Buccleuch 2066,
Johannesburg, Repubic of South Africa
Telephone/Fax: (27)11-802-5505

France, Portugal, Belgium, Switzerland, Spain:
HAMAMATSU PHOTONICS FRANCE S.A.R.L.
Main Office
19, Rue du Saule Trapu Parc du Moulin de Massy
91882 Massy CEDEX, France
Telephone: (33)1 69 53 71 00
Fax: (33)1 69 53 71 10
E-mail: infos@hamamatsu.fr

Swiss Office:
Dornacherplatz 7
4500 Solothurn, Switzerland
Telephone: (41)32/625 60 60,
Fax: (41)32/625 60 61
E-mail: swiss@hamamatsu.ch

Belgian Office:
Scientic Park, 7, Rue du Bosquet
B-1348 Louvain-La-Neuve, Belgium
Telephone: (32)10 45 63 34
Fax: (32)10 45 63 67
E-mail: epirson@hamamatsu.com

Spanish Office:
C. Argenters, 4 edif 2
Parque Tecnológico del Vallés
E-08290 Cerdanyola, (Barcelona) Spain
Telephone: +34 93 582 44 30
Fax: +34 93 582 44 31
E-mail: infospain@hamamatsu.es

Germany, Denmark, The Netherlands, Poland:
HAMAMATSU PHOTONICS DEUTSCHLAND GmbH
Main Office
Arzbergerstr. 10,
D-82211 Herrsching am Ammersee, Germany
Telephone: (49)8152-375-0, Fax: (49)8152-2658
E-mail: info@hamamatsu.de

Denmark Office:
Lautruphoj 1-3
DK-2750 Ballerup, Denmark
Telephone: (45)70-20-93-69, Fax: (45)44-20-99-10
Email: info@hamamatsu.de

The Netherlands Office:
Televisieweg 2
NL-1322 AC Almere Netherlands
Telephone: (31)36-5382-123, Fax: (31)36-5382-124
E-mail: info@hamamatsu.nl

Poland Office:
ul. sw. A. Boboli 8,
02-525 Warszawa, Poland
Telephone: (48)22-646-00-16, Fax: (48)22-646-00-18
E-mail: info@hamamatsu.de

North Europe and CIS:
HAMAMATSU PHOTONICS NORDEN AB
Main Office
Thorshamnsgatan 35 16440 Kista, Sweden
Telephone: (46)8-509-031-00, Fax: (46)8-509-031-01
E-mail: info@hamamatsu.se

Russian Office:
Vyatskaya St. 27, bld. 15
RU-127015, Moscow, Russia
Telephone: +7-(495)-258-85-18, Fax: +7-(495)-258-85-19
E-mail: info@hamamatsu.ru

Italy:
HAMAMATSU PHOTONICS ITALIA S.R.L.
Main Office
Strada della Moia, 1/E
20020 Arese (Milano), Italy
Telephone: (39)02-93 58 1733, Fax: (39)02-93 58 1741
E-mail: info@hamamatsu.it

Rome Office:
Viale Cesare Pavese, 435, 00144 Roma, Italy
Telephone: (39)06-50513454, Fax: (39)06-50513460
E-mail: inforoma@hamamatsu.it

Quality, technology and service are part of every product.

TPMO0007E03
SEPT. 2012 IP
Printed in Japan (4000)