

**HAMAMATSU**

PHOTON IS OUR BUSINESS

# PHOTOMULTIPLIER TUBES

PHOTOMULTIPLIER TUBES AND RELATED PRODUCTS



HAMAMATSU PHOTONICS K.K.

# Opening the future with photonics



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

Since its founding over 60 years ago, Hamamatsu Photonics has been investigating not only light seen by the human eye but also light that far exceeds this level. As a leading manufacturer specializing in the field of photonics, Hamamatsu Photonics has marketed dozens of photosensitive devices, light sources and related products. Through these state-of-the-art products, Hamamatsu Photonics has committed itself to pioneering industrial and academic research work in still unexplored areas in many fields.

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

# CONTENTS

Index by type number .....	2
----------------------------	---

## **About photomultiplier tube**

Construction and operating characteristics .....	4
Connections to external circuits .....	14
Selection guide by applications .....	16

## **Side-on type photomultiplier tubes**

13 mm Dia. types .....	22
28 mm Dia. types with UV to visible sensitivity .....	24
28 mm Dia. types with UV to near IR sensitivity .....	26
13 mm Dia. types, 28 mm Dia. types with solar blind response .....	30

## **Head-on type photomultiplier tubes**

10 mm Dia. types, 13 mm Dia. types .....	32
19 mm Dia. types .....	34
25 mm Dia. types .....	36
28 mm Dia. types .....	38
38 mm Dia. types .....	42
51 mm Dia. types with plastic base .....	44
51 mm Dia. types with glass base .....	46
76 mm Dia. types .....	50
127 mm Dia. types .....	52

## **Special purpose photomultiplier tubes**

Hexagonal types, Rectangular types .....	54
Metal package photomultiplier tubes .....	56
UBA (Ultra Bialkali), SBA (Super Bialkali), EGBA (Extended Green Bialkali) types .....	60
Microchannel plate-Photomultiplier tubes (MCP-PMTs) .....	64
Micro PMT / Micro PMT assemblies .....	66

## **Gain characteristics** 68

## **Voltage distribution ratio** 70

## **Lens for side-on type photomultiplier tubes** 71

## **Photomultiplier tube sockets** 72

## **Photomultiplier tube assemblies** 74

## **Accessories for photomultiplier tubes**

Socket assemblies .....	82
Amplifier units / Amplifier modules .....	108
High voltage power supplies .....	110
Thermoelectric coolers .....	116
Magnetic shield cases .....	120
Housings, Flange .....	121
Power and signal cables, Connector adapters .....	122
Related products for photon counting .....	123

## **Cautions and warranty** 126

## **Typical photocathode spectral response** 127

# Index by type number

Type No.	Product	Page	Type No.	Product	Page
R329-02	Head-on PMT	46	R4220	Side-on PMT	24
R331-05	Head-on PMT	46	R4607A-01	Head-on PMT	46
R374	Head-on PMT	38	R4632	Side-on PMT	26
R375	Head-on PMT	48	C4900 Series	High voltage power supply unit	111
R464	Head-on PMT	46	R4998	Head-on PMT	36
R550	Head-on PMT	44	A5026 Series	Cable with connector	122
R580	Head-on PMT	42	A5059 Series	Connector adapter	122
R636-10	Side-on PMT	28	R5070A	Head-on PMT	36
R647	Head-on PMT	32	A5074	Relay adapter	122
R649	Head-on PMT	46	R5108	Side-on PMT	28
R669	Head-on PMT	48	C5594 Series	Amplifier unit	108
E717 Series	Socket assembly	88	R5610A	Head-on PMT	34
R759	Head-on PMT	32	R5611A-01	Head-on PMT	34
R821	Head-on PMT	34	E5859 Series	Socket assembly	89
E849 Series	Socket assembly	88	R5900U-L16 Series	Metal package PMT	58
E850 Series	Socket assembly	88	R5900U-100-L16	SBA metal package PMT	62
R877	Head-on PMT	52	R5900U-200-L16	UBA metal package PMT	62
R877-100	SBA Head-on PMT	60	R5916U Series	MCP-PMT	64
R878	Head-on PMT	44	R5929	Head-on PMT	40
R928	Side-on PMT	26	R5983	Side-on PMT	24
R943-02	Head-on PMT	48	R5984	Side-on PMT	26
R972	Head-on PMT	34	E5996	Socket assembly	89
E974 Series	Socket assembly	88	R6091	Head-on PMT	50
E989 Series	Magnetic shield case	120	R6094	Head-on PMT	38
E990 Series	Socket assembly	88, 89	R6095	Head-on PMT	38
R1080	Head-on PMT	32	R6231	Head-on PMT	44
R1081	Head-on PMT	32	R6231-100	SBA Head-on PMT	60
R1166	Head-on PMT	34	R6233	Head-on PMT	50
E1168 Series	Cable with connector	122	R6233-100	SBA Head-on PMT	60
E1198 Series	Socket assembly	89	R6234	Hexagonal PMT	54
R1250	Head-on PMT	52	R6235	Hexagonal PMT	54
R1288A	Head-on PMT	36	R6236	Rectangular PMT	54
R1306	Head-on PMT	44	R6237	Rectangular PMT	54
R1307	Head-on PMT	50	E6316 Series	Socket assembly	89
E1341 Series	Housing	121	R6350	Side-on PMT	22
E1435-02	Socket assembly	89	R6352	Side-on PMT	22
R1450	Head-on PMT	34	R6353	Side-on PMT	22
R1463	Head-on PMT	32	R6354	Side-on PMT	30
R1513	Head-on PMT	52	R6355	Side-on PMT	22
R1527	Side-on PMT	24	R6356-06	Side-on PMT	22
R1617	Head-on PMT	34	R6357	Side-on PMT	22
R1635	Head-on PMT	32	R6358	Side-on PMT	22
E1761 Series	Socket assembly	88	H6410	PMT assembly	74
R1828-01	Head-on PMT	44	R6427	Head-on PMT	38
R1878	Head-on PMT	34	C6438 Series	Amplifier unit	108
R1924A	Head-on PMT	36	H6520	PMT assembly	74
R1924A-100	SBA Head-on PMT	60	H6524	PMT assembly	74
R1925A	Head-on PMT	36	H6527	PMT assembly	74
H1949-51	PMT assembly	74	H6533	PMT assembly	74
R2078	Head-on PMT	36	H6559	PMT assembly	74
R2083	Head-on PMT	46	H6612	PMT assembly	74
E2183 Series	Socket assembly	89	E6736	Socket assembly	89
R2228	Head-on PMT	40	R6834	Head-on PMT	38
R2248	Rectangular PMT	54	R6835	Head-on PMT	38
E2253 Series	Socket assembly	88	R6836	Head-on PMT	38
R2257	Head-on PMT	48	E7083	Socket assembly	89
H2431-50	PMT assembly	74	R7111	Head-on PMT	40
R2496	Head-on PMT	32	R7154	Side-on PMT	30
R2557	Head-on PMT	32	H7195	PMT assembly	74
E2624 Series	Socket assembly	88	R7205-01	Head-on PMT	40
R2658	Side-on PMT	28	R7206-01	Head-on PMT	40
E2924 Series	Socket assembly	88	C7246 Series	Socket assembly	100
R2949	Side-on PMT	26	C7247 Series	Socket assembly	100
E2979-500	Socket assembly	89	H7260-20	PMT assembly	74
H3164-10	PMT assembly	74	H7260-100	SBA PMT assembly	62
H3165-10	PMT assembly	74	H7260-200	UBA PMT assembly	62
H3178-51	PMT assembly	74	M7279	Amplifier unit	108
R3478	Head-on PMT	34	C7319	Amplifier unit	108
R3550A	Head-on PMT	36	H7415	PMT assembly	74
H3695-10	PMT assembly	74	E7514	Socket assembly	89
R3788	Side-on PMT	24	R7518	Side-on PMT	24
R3809U Series	MCP-PMT	64	H7546B	PMT assembly	74
R3886A	Head-on PMT	42	H7546B-20	PMT assembly	74
R3896	Side-on PMT	26	H7546B-100	SBA PMT assembly	62
R3991A	Head-on PMT	34	H7546B-200	UBA PMT assembly	62
R3998-02	Head-on PMT	40	H7546B-300	EGBA PMT assembly	62
R3998-100-02	SBA Head-on PMT	60	R7600U Series	Metal package PMT	58
R4177-01	Head-on PMT	32	R7600U-100	SBA metal package PMT	62

Type No.	Product	Page
R7600U-100-M4	SBA metal package PMT	62
R7600U-200	UBA metal package PMT	62
R7600U-200-M4	UBA metal package PMT	62
R7600U-300	EGBA metal package PMT	62
E7693	Socket assembly	89
A7709	Flange	121
E7718-02	Housing	121
R7724	Head-on PMT	46
R7899	Head-on PMT	36
A7992	Relay adapter	122
R8486	Side-on PMT	30
R8487	Side-on PMT	30
H8711	PMT assembly	74
H8711-20	PMT assembly	74
H8711-100	SBA PMT assembly	62
H8711-200	UBA PMT assembly	62
H8711-300	EGBA PMT assembly	62
C8855-01	Counting unit	124
M8879	Amplifier unit	108
R8900U-00-C12	Metal package PMT	58
C8991 Series	Socket assembly	102
R9110	Side-on PMT	26
R9182-01	Side-on PMT	26
R9220	Side-on PMT	26
R9420	Head-on PMT	42
R9420-100	SBA Head-on PMT	60
H9500	Flat panel PMT assembly	74
C9525 Series	Bench-top type multi-output power supply	115
H9530-20	PMT assembly	74
C9619 Series	High voltage power supply unit	111
C9663	Amplifier unit	108
R9722A	Head-on PMT	42
C9727	Bench-top type multi-output power supply	115
C9744	Photon counting unit	123
R9800	Head-on PMT	36
R9880U Series	Metal package PMT	56
C9999 Series	Amplifier unit	108
R10131	Head-on PMT	44
C10344-03	Socket assembly	104
C10372	Thermoelectric cooler	116
C10373	Thermoelectric cooler	116
R10454	Side-on PMT	30
H10515B-20	PMT assembly	74
R10601	Head-on PMT	42
R10601-100	SBA Head-on PMT	60
E10679 Series	Socket assembly	89
R10699	Side-on PMT	26
R10824	Side-on PMT	30
R10825	Side-on PMT	30
H10828	PMT assembly	74
C10940 Series	High voltage power supply unit	112
R11102	Head-on PMT	42
C11152 Series	High voltage power supply unit	114
C11184	Amplifier unit	108
R11265U-20	Metal package PMT	58
R11265U-100	SBA Head-on PMT	62
R11265U-100-M4	SBA Head-on PMT	62
R11265U-200	UBA Head-on PMT	62
R11265U-200-M4	UBA Head-on PMT	62
R11265U-300	EGBA Head-on PMT	62
R11540	Side-on PMT	24
R11558	Side-on PMT	24
R11568	Side-on PMT	24
R11715-01	Side-on PMT	24
E11807 Series	Socket assembly	89
R11833-03	Head-on PMT	52
R11833-100-03	SBA Head-on PMT	60
H11934-20	PMT assembly	74
H12400 Series	Micro PMT assembly	66
C12419	Amplifier unit	108
R12421	Head-on PMT	32
H12428-100	SBA PMT assembly	62
H12428-200	UBA PMT assembly	62
H12445-100	SBA PMT assembly	62
H12445-200	UBA PMT assembly	62
C12446 Series	High voltage power supply unit	111
C12597-01	Socket assembly	102
H12690	PMT assembly	74

Type No.	Product	Page
H12700A	Flat panel PMT assembly	74
C12766 Series	High voltage power supply unit	111
R12772	Head-on PMT	50
R12829	Side-on PMT	26
C12842 Series	Socket assembly	104
C12843 Series	Socket assembly	106
R12857	Side-on PMT	22
R12900U Series	Micro PMT	66
C13002 Series	Socket assembly	104
C13003-01	Socket assembly	104
C13004-01	Socket assembly	104
R13089	Head-on PMT	44
R13194	Side-on PMT	30
R13408	Head-on PMT	42
R13449	Head-on PMT	38
R13456	Side-on PMT	26
R13478	Head-on PMT	36
C13654-01	Socket assembly	106
H13700	PMT assembly	74
C13887 Series	High voltage power supply unit	111
C13890 Series	High voltage power supply unit	113
H13974-00-1616	PMT assembly	74
C14019 Series	Socket assembly	106
C14210-14	High voltage power supply unit	111
R14550	Head-on PMT	44
R14657	Side-on PMT	22
C14760 Series	Thermoelectric cooler	118
C14761 Series	Thermoelectric cooler	118
H15547-07	MCP-PMT	64

### Type numbers shown in "Notes"

Type No.	Page	Type No.	Page
R585	47	R6234-01	55
R647P	33	R6235-01	55
R750	35	R6236-01	55
R758-10	29	R6237-01	55
R760	33	R6350P	23
R877-01	53	R6351	23
R955	27	R6353P	23
R960	33	R6358-10	23
R976	35	H6533	37
R1104	39	H6610	37
R1166P	35	R7056	39
R1288A-01	37	R7207-01	41
R1307-01	51	H7260-103	63
R1464	35	H7260-106	63
R1527P	25	R7446	25
R1924P	37	R7447	25
R1926A	37	R7518P	25
R2027	35	R7600P	59
R2059	45	R7600U-03	59
R2076	35	R7600U-03-M4	59
R2256-02	47	R7899-01	37
R2295	35	R9110P	27
H2431-50	47	R9722A-01	43
R2557P	33	R10491	25
R2658P	29	R10560	37
R3377	47	R10601-100	43
H3378-50	47	R10601-100-01	61
R3479	35	R11265U-103	63
R3550P	37	R11265U-203	63
R4177	33	H11934-100	63
R4220P	25	H11934-200	63
R4332	25	H11934-300	63
E5038	90	R12421-03	33
R5320	37	R12421P	33
R5610P	35	H12428-103	63
R5611A	35	H12428-203	63
R5900U-04-L16	59	H12445-103	63
R5900U-103-L16	63	H12445-203	63
R5983P	25	R12896	27
R6094P-01	39	R13096	27
R6095P-01	39	R13226A-100	63
R6231-01	45	R13226A-200	63
R6233-01	51		

# Construction and operating characteristics

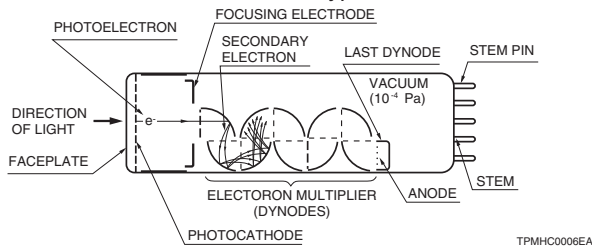
## INTRODUCTION

Among photosensitive devices in use today, the photomultiplier tube (or PMT) is a versatile device providing ultra-fast response and extremely high sensitivity. A typical photomultiplier tube consists of a photoemissive cathode (photocathode) followed by focusing electrodes, an electron multiplier (dynodes) and an electron collector (anode) in a vacuum tube, as shown in Figure 1. When light enters the photocathode, the photocathode emits photoelectrons into the vacuum. These photoelectrons are then directed by the focusing electrode voltages towards the electron multiplier where electrons are multiplied by a secondary emission process. The multiplied electrons then are collected by the anode as an output signal.

Because of secondary-emission multiplication, photomultiplier tubes provide extremely high sensitivity and exceptionally low noise compared to other photosensitive devices currently used to detect radiant energy in the ultraviolet, visible, and near infrared regions. The photomultiplier tube also features fast time response and a choice of large photosensitive areas.

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

Figure 1: Cross-section of head-on type PMT



## CONSTRUCTION

The photomultiplier tube generally has a photocathode in either a side-on or a head-on configuration. The side-on type receives incident light through the side of the glass bulb, while the head-on type receives light through the end of the glass bulb. In general, the side-on type photomultiplier tube is widely used for spectrophotometers and general photometric systems. Most side-on types employ an opaque photocathode (reflection-mode photocathode) and a circular-cage structure electron multiplier (see description of "ELECTRON MULTIPLIER") which has good sensitivity and high amplification at a relatively low supply voltage.

The head-on type (or the end-on type) has a semitransparent photocathode (transmission-mode photocathode) deposited upon the inner surface of the entrance window. The head-on type provides better uniformity (see page 9) than the side-on type having a reflection-mode photocathode. Other features of head-on types include a choice of photosensitive areas ranging from tens to hundreds of square centimeters.

Variants of the head-on type having a large-diameter hemispherical window have been developed for high energy physics experiments where good angular light reception is important.

Figure 2: External appearance

a) Side-on type

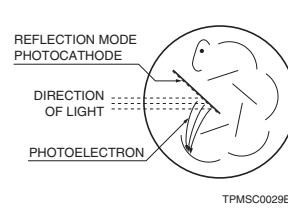


b) Head-on type

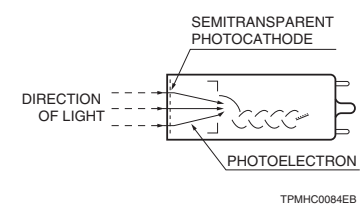


Figure 3: Types of photocathode

a) Reflection Mode



b) Transmission Mode



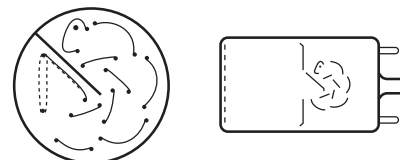
## ELECTRON MULTIPLIER

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

There are several principal types in use today.

### 1) Circular-cage type

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

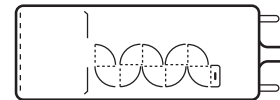


Side-On Type

Head-On Type

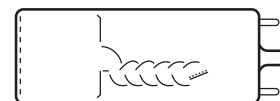
### 2) Box-and-grid type

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



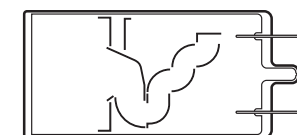
### 3) Linear-focused type

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



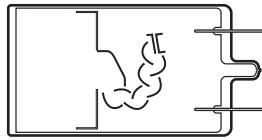
### 4) Box-and-line type

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



**5) Circular and linear-focused type**

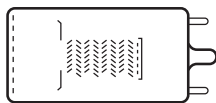
The circular and linear-focused type has a structure that combines a circular-cage type and a linear-focused type. It offers improved pulse linearity while maintaining the compactness of the circular-cage type.



TPMOC0225EA

**6) Venetian blind type**

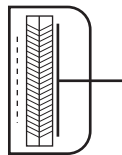
The venetian blind type has a large dynode area and is primarily used for tubes with large photocathode areas. It offers better uniformity and a larger output current. This structure is usually used when time response is not a prime consideration.



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**7) Microchannel plate (MCP) (see page 64)**

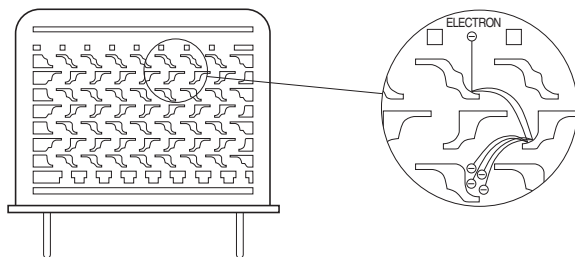
The MCP is a thin disk consisting of millions of microglass tubes (channels) fused in parallel with each other. Each channel acts as an independent electron multiplier. The MCP offers much faster time response than other discrete dynodes. It also features good immunity from magnetic fields and two-dimensional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



TPMOC0082EA

**8) Metal channel type**

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

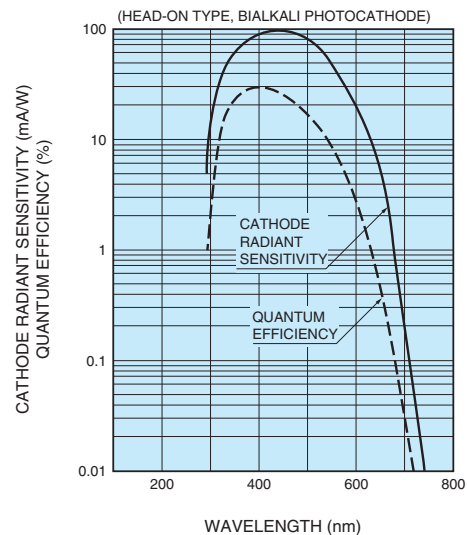


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**SPECTRAL RESPONSE**

The photocathode of a photomultiplier tube converts energy from incident light into electrons. The conversion efficiency (photocathode sensitivity) varies with the wavelength of the incident light. This relationship between photocathode sensitivity and wavelength is called the spectral response characteristic. Figure 4 shows the typical spectral response of a bialkali photomultiplier tube. The spectral response on long wavelengths is determined by the photocathode material and on short wavelengths by the window material. Typical spectral response characteristics for various types of photomultiplier tubes are shown on pages 128 and 129. In this catalog, the long-wavelength cutoff of the spectral response characteristic is defined as the wavelength at which the cathode radiant sensitivity is 1 % of the maximum sensitivity in bialkali and Ag-O-Cs photocathodes, and 0.1 % of the maximum sensitivity in multialkali photocathodes. Spectral response characteristics shown at the end of this catalog are typical curves for representative tube types. Actual data may be different from tube to tube.

Figure 4: Typical spectral response of bialkali photocathode



TPMOB0070EA

# Construction and operating characteristics

## PHOTOCATHODE MATERIALS

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

### 1) Ag-O-Cs

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

### 2) GaAs

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

### 3) GaAsP

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

### 4) InGaAs

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

### 5) InP/InGaAsP(Cs), InP/InGaAs(Cs)

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

### 6) Sb-Cs

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

### 7) Bialkali (Sb-Rb-Cs, Sb-K-Cs)

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

### 8) High temperature bialkali or low noise bialkali (Na-K-Sb)

This is particularly useful at higher operating temperatures since it can withstand up to 200 °C. One major application is in the oil well logging industry. At room temperatures, this photocathode operates with very low dark current, making it ideal for use in photon counting applications.

### 9) Multialkali (Na-K-Sb-Cs)

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

### 10) Cs-Te, Cs-I

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

## WINDOW MATERIALS

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

### 1) Borosilicate glass

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

### 2) UV-transmitting glass (UV glass)

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

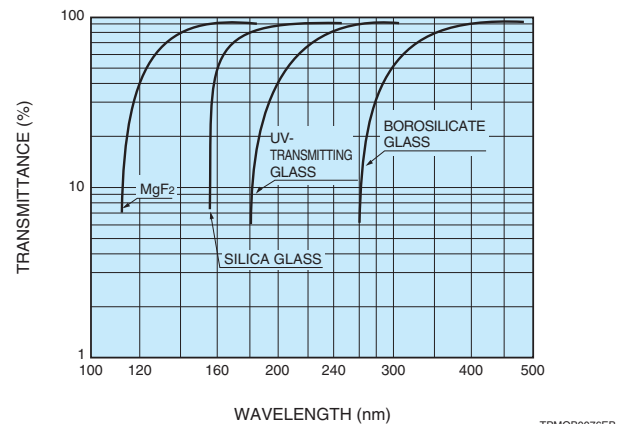
### 3) Silica glass

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

### 4) MgF<sub>2</sub> (magnesium fluoride)

Crystals of alkali halide are superior in transmitting ultraviolet radiation, but have the disadvantage of deliquescence. Among these crystals, MgF<sub>2</sub> is known as a practical window material because it offers low deliquescence and transmits ultraviolet radiation down to 115 nm.

Figure 5: Typical transmittance of various window materials



## RADIANT SENSITIVITY AND QUANTUM EFFICIENCY

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

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

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



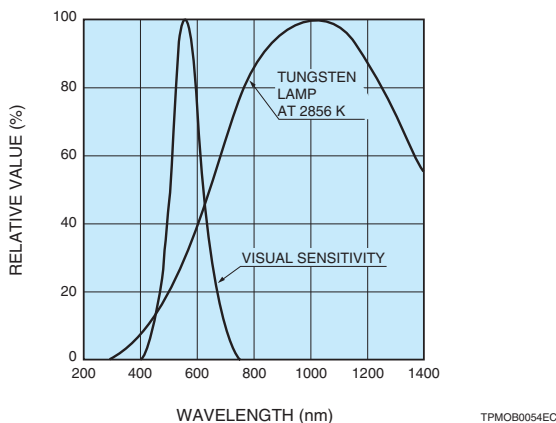
## LUMINOUS SENSITIVITY

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

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

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

Figure 6: Typical human eye response and spectral distribution of 2856 K tungsten lamp



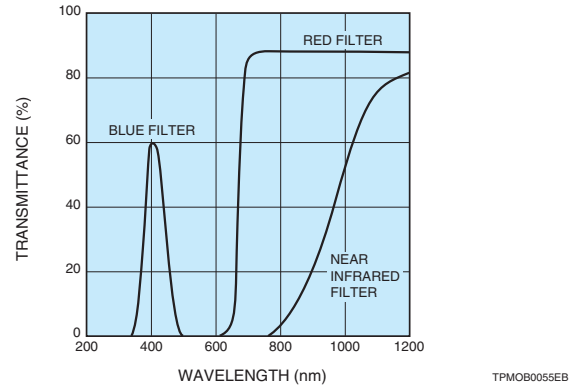
## BLUE SENSITIVITY INDEX AND RED/WHITE RATIO

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

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

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

Figure 7: Transmittance of various filters



## GAIN (CURRENT AMPLIFICATION)

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

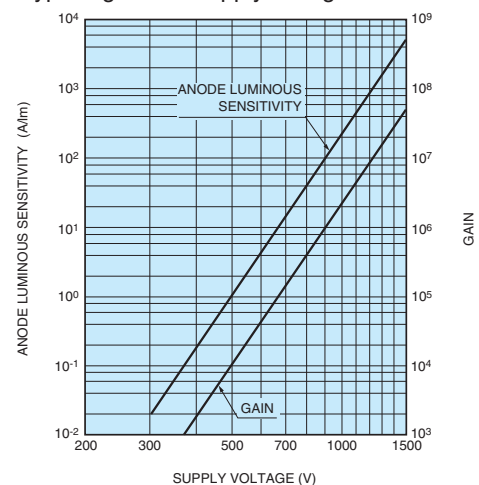
Gain is simply the ratio of the anode output current to the photoelectric current from the photocathode. Ideally, the gain of a photomultiplier tube having  $n$  dynode stages and an average secondary emission ratio  $\delta$  per stage is  $\delta^n$ . While the secondary electron emission ratio  $\delta$  is given by  $\delta = A \cdot E^\alpha$  where  $A$  is the constant,  $E$  is the interstage voltage, and  $\alpha$  is a coefficient determined by the dynode material and geometric structure. This usually has a value of 0.7 to 0.8.

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

$$\begin{aligned} \mu &= \delta^n = (A \cdot E^\alpha)^n = \left\{ A \cdot \left( \frac{V}{n+1} \right)^\alpha \right\}^n \\ &= \frac{A^n}{(n+1)^{\alpha n}} \cdot V^{\alpha n} = K \cdot V^{\alpha n} \quad (K: \text{constant}) \end{aligned}$$

Since photomultiplier tubes generally have 9 to 12 dynode stages, the anode output has a 6th to 10th power gain proportional to the input voltage. So just a slight fluctuation in the applied voltage will appear as magnified 6 to 10 times in the photomultiplier tube output. This means the photomultiplier tube is extremely susceptible to fluctuations in the power supply voltage, so the power supply must be extremely stable and provide a minimum ripple, drift and temperature coefficient. Various types of well-regulated high-voltage power supplies designed for these requirements are available from Hamamatsu (see page 110).

Figure 8: Typical gain vs. Supply voltage

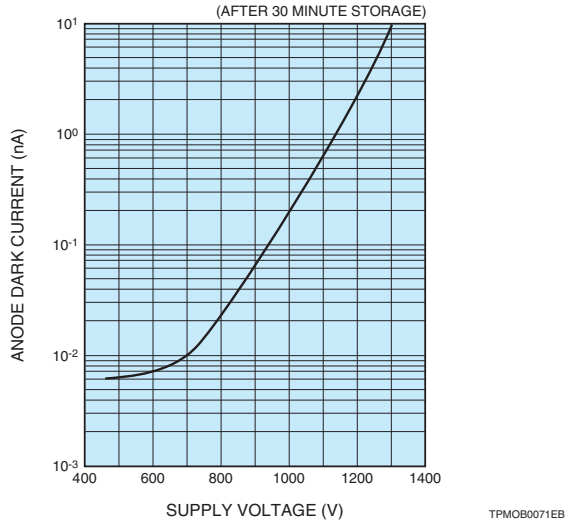


# Construction and operating characteristics

## ANODE DARK CURRENT

A small amount of current flows in a photomultiplier tube even when the tube is operated in a completely dark state. This output current is called the anode dark current, and the resulting noise is a critical factor in determining the lower limit of light detection. As Figure 9 shows, dark current is greatly dependent on the supply voltage.

Figure 9: Typical dark current vs. Supply voltage



Major sources of dark current may be categorized as follows:

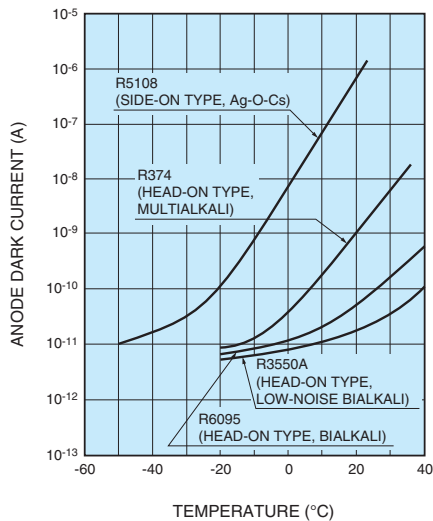
### 1) Thermionic emission of electrons

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

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

Hamamatsu provides thermoelectric coolers (C9143, C9144, C10372, C10373) designed for various sizes of photomultiplier tubes (see page 114, 116).

Figure 10: Anode dark current vs. Temperature



### 2) Ionization of residual gases (ion feedback)

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

### 3) Glass scintillation

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

### 4) Leakage current (ohmic leakage)

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

### 5) Field emissions

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

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

## ENI (EQUIVALENT NOISE INPUT)

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

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

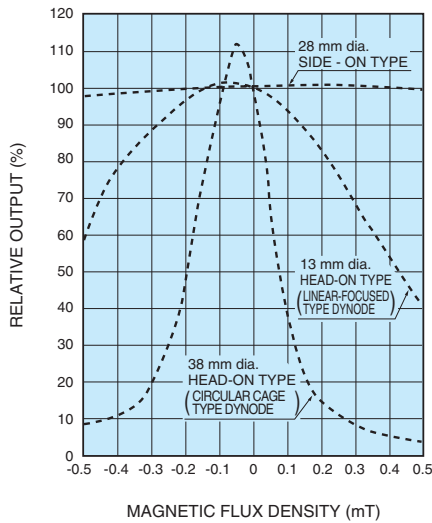
where  $q$  = electronic charge ( $1.60 \times 10^{-19}$  coul.)  
 $I_{db}$  = anode dark current in amperes after 30 minute storage in darkness  
 $g$  = gain  
 $\Delta f$  = bandwidth of the system in hertz (usually 1 hertz)  
 $S$  = anode radiant sensitivity in amperes per watt at the wavelength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

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

## MAGNETIC FIELD EFFECTS

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

Figure 11: Typical effects by magnetic fields perpendicular to tube axis

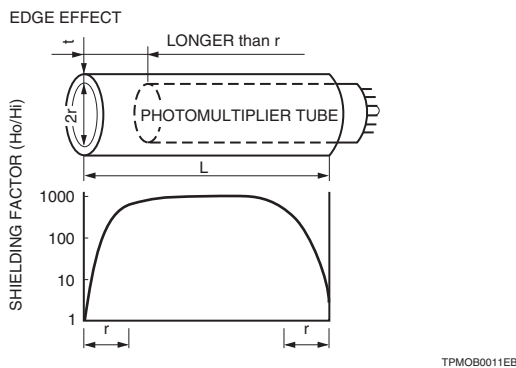


When a photomultiplier tube has to be operated in magnetic fields, it may be necessary to shield the tube with a magnetic shield case. (Hamamatsu provides a variety of magnetic shield cases. See page 120). The magnetic shielding factor is used to express the effect of a magnetic shield case. This is the ratio of the strength of the magnetic field outside the shield case or  $H_{out}$ , to that inside the shield case or  $H_{in}$ . The magnetic shielding factor is determined by the permeability  $\mu$ , the thickness  $t$  (mm) and inner diameter  $r$  (mm) of the shield case as follows.

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

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

Figure 12: Edge effect of magnetic shield case



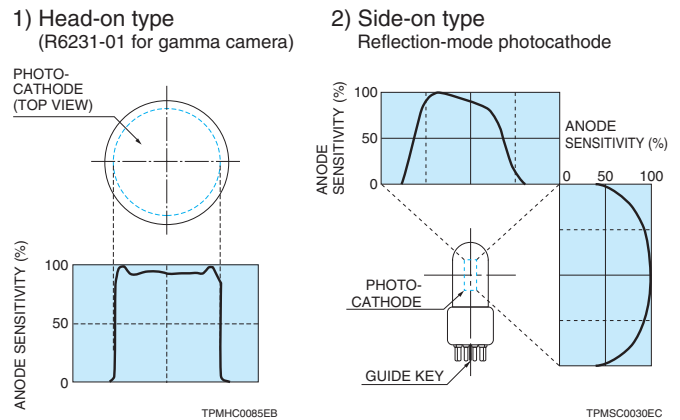
Hamamatsu provides photomultiplier tubes using fine-mesh type dynodes. These photomultiplier tubes exhibit much higher resistance to external magnetic fields than the photomultiplier tubes with other dynodes. When the light level to be measured is high, "triode" and "tetrode" type tubes can be used even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

## SPATIAL UNIFORMITY

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

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

Figure 13: Examples of spatial uniformity

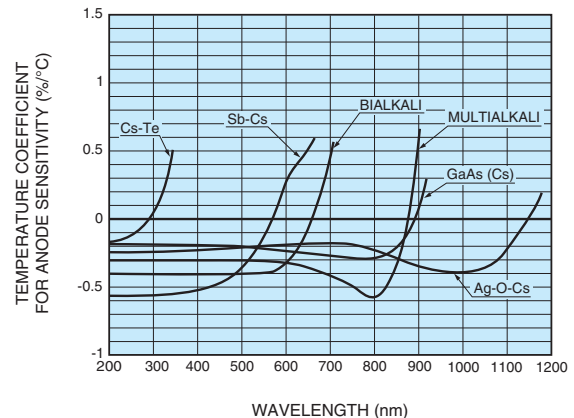


## TEMPERATURE CHARACTERISTICS

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

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

Figure 14: Temperature coefficient for anode sensitivity (Typ.)



# Construction and operating characteristics

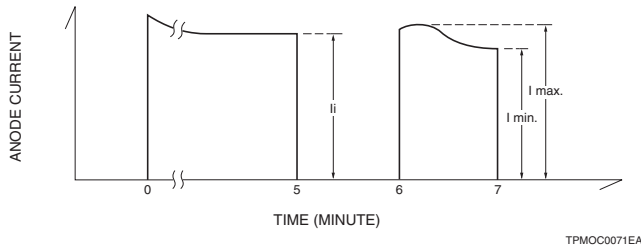
## HYSTERESIS

Photomultiplier tubes exhibit a slightly unstable output for several seconds to nearly 1 minute after a voltage is applied or light is input, and the output may overshoot or undershoot before reaching a stable level (Figure 15). This unstable condition is called hysteresis and may be a problem in spectrophotometry and other applications.

Hysteresis is mainly caused by electrons deviating from their planned trajectories and electrostatically charging the dynode support section and glass bulb. When the applied voltage changes along with a change in the input light, noticeable hysteresis can occur.

As a countermeasure, many Hamamatsu side-on photomultiplier tubes employ an "anti-hysteresis design" which virtually eliminates hysteresis.

Figure 15: Hysteresis

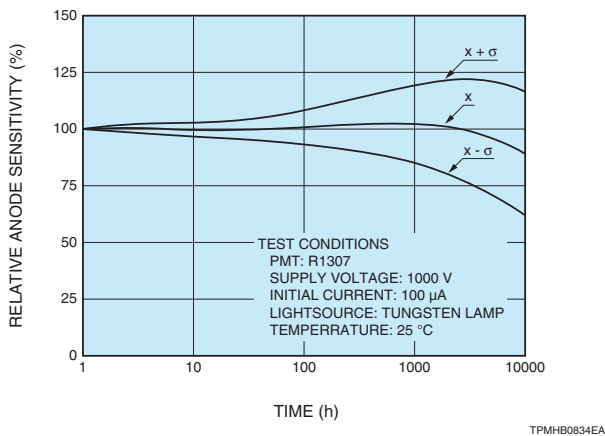


## DRIFT AND LIFE CHARACTERISTIC

While operating a photomultiplier tube continuously over a long period, the anode output current of the photomultiplier tube may vary slightly over time, even though operating conditions have not changed. Among the anode current fluctuations, changes over a relatively short time are called "drift", while changes over long periods such as 1000 to 10000 hours or more are called the life characteristic. Figure 16 shows typical life curves.

Drift is primarily caused by damage to the last dynode by heavy electron bombardment. Therefore the use of lower anode current is desirable. When stability is of prime importance, keeping the average anode current within 1  $\mu\text{A}$  or less is recommended.

Figure 16: Typical life characteristics



## TIME RESPONSE

In the measurement of pulsed light, the anode output signal should faithfully reproduce a waveform resembling the incident pulse waveform. This reproducibility is greatly affected by the electron transit time, anode pulse rise time, and electron transit time spread (T.T.S.).

As illustrated in Figure 17, the electron transit time is the time interval between the arrival of a delta function light pulse (pulse width less than 50 ps) at the photocathode and the instant when the anode output pulse reaches its peak amplitude. The anode pulse rise time is defined as the time needed to rise from 10% to 90% of peak amplitude when the entire photocathode is illuminated by a delta function light pulse (pulse width less than 50 ps).

The electron transit time fluctuates between individual light pulses. This fluctuation is called transit time spread (T.T.S.) and defined as the FWHM of the frequency distribution of electron transit times (Figure 18). The T.T.S. is an important factor in time-resolved measurement.

The time response characteristics depend on the dynode structure and applied voltage. In general, photomultiplier tubes using a linear-focused or circular-cage structure exhibit better time response than tubes using a box-and-grid or venetian blind structure. Photomultiplier tubes for high-speed photometry use a spherical window or plano-concave window (flat on one side and concave on the other) and electrodes specifically designed to shorten the electron transit time. MCP-PMTs, which employ an MCP in place of conventional dynodes, offer better time response than tubes using other dynodes. For example, these have a significantly better T.T.S. compared to normal photomultiplier tubes because a nearly parallel electric field is applied between the photocathode, the MCP and the anode. Figure 19 shows typical time response characteristics vs. applied voltage for Hamamatsu R2059 (51 mm diameter head-on, 12-stage, linear-focused type).

Figure 17: Anode pulse rise time and electron transit time

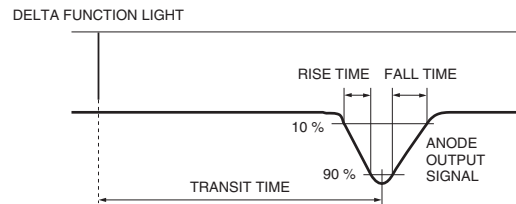


Figure 18: Electron transit time spread (T.T.S.)

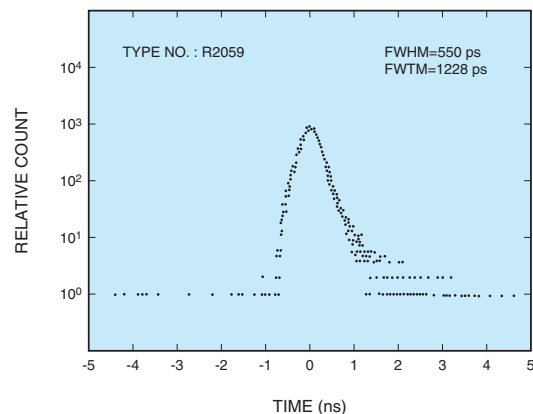
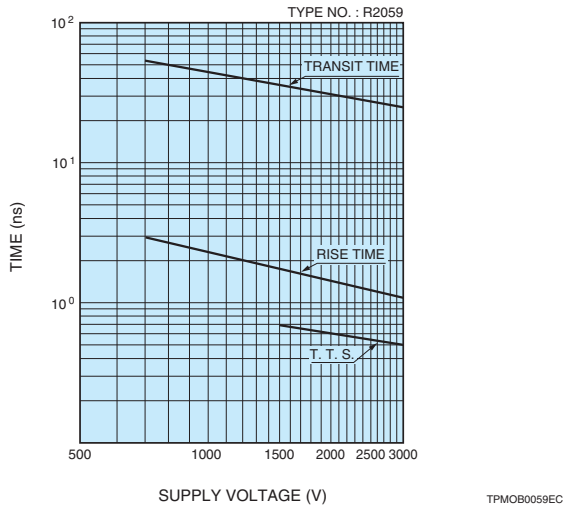


Figure 19: Time response characteristics vs. Supply voltage

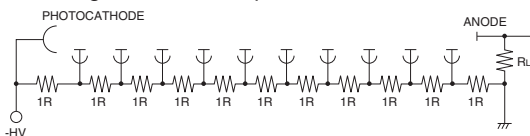


**VOLTAGE-DIVIDER CIRCUITS**

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

Figure 20: Schematic diagrams of voltage-divider circuits

a) Basic arrangement for DC operation



b) For pulse operation

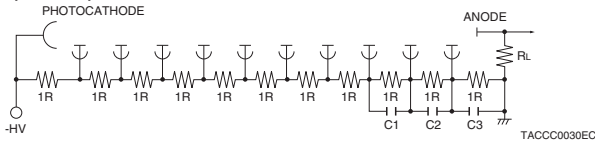
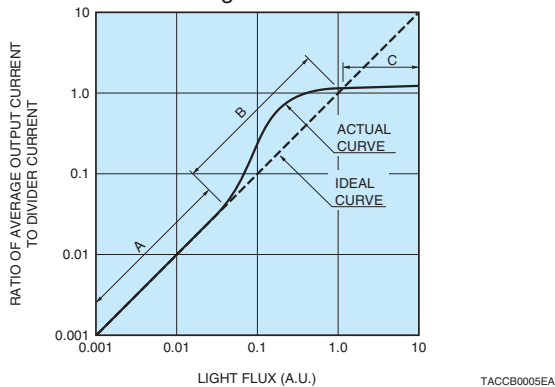


Figure 21: Output characteristics of PMT using voltage-divider circuit of Figure 20

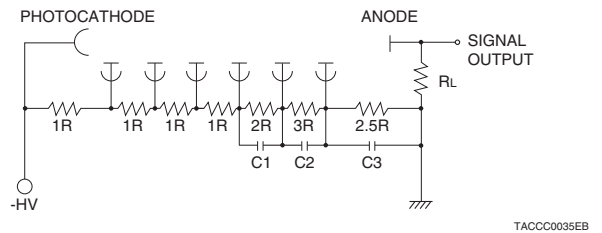


Generally high output current is required in pulsed light applications. In order to maintain dynode potentials at a constant value during pulse durations and obtain high peak currents, capacitors are placed in parallel with the divider resistors as shown in Figure 20 (b). The capacitor values depend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

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

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

Figure 22: Typical tapered divider circuit



**GROUND POLARITY AND HA TREATMENT**

The general technique used for voltage-divider circuits is to ground the anode with a high negative voltage applied to the cathode, as shown in Figure 20. This scheme facilitates the connection of such circuits as ammeters or current-to-voltage conversion operational amplifiers to the photomultiplier tube. However, when a grounded anode configuration is used, bringing a grounded metallic holder or magnetic shield case near the bulb of the tube can cause electrons to strike the inner bulb wall, resulting in the generation of noise. Also, in head-on type photomultiplier tubes, if the faceplate or bulb near the photocathode is grounded, the slight conductivity of the glass material causes a current to flow between the photocathode (which has a high negative potential) and ground. This may cause significant deterioration of the photocathode. For this reason, extreme care is required when designing housings for photomultiplier tubes and when using electrostatic or magnetic shield cases.

In addition, when using foam rubber or similar material to mount the tube in its housing, it is essential that material having sufficiently good insulation properties be used. This problem can be solved by applying a black conductive coat around the bulb, connecting it to the cathode potential and covering the bulb with a protective film. This is called an "HA Treatment" (see Figure 23).

# Construction and operating characteristics

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

Figure 23: HA treatment

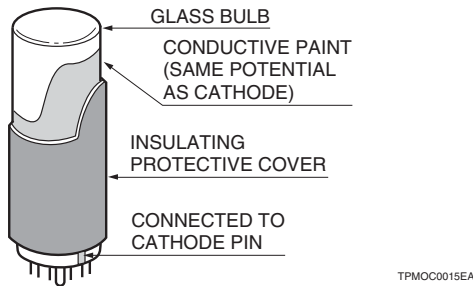
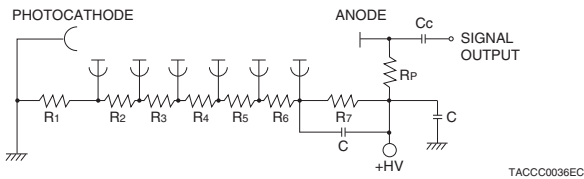


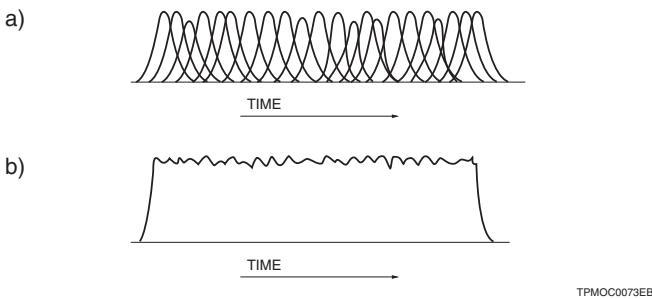
Figure 24: Cathode ground scheme



## PHOTON COUNTING

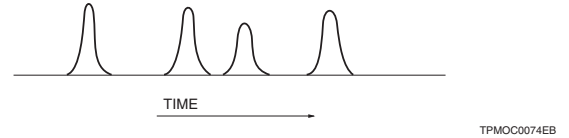
Photon counting is one effective way to use a photomultiplier tube for measuring extremely low light levels and is widely used in astronomical photometry and for making chemiluminescence and bioluminescence measurements. In its usual application, a number of photons enter the photomultiplier tube and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

Figure 25: Overlapping output pulses



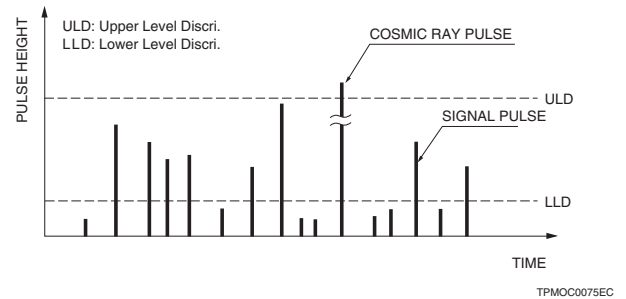
When the light intensity becomes so low that the incident photons are separated as shown in Figure 26. This condition is called a single photon event. The number of output pulses is in direct proportion to the amount of incident light and this pulse counting method has the advantages of better S/N ratio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

Figure 26: Discrete output pulses (Single photon event)



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

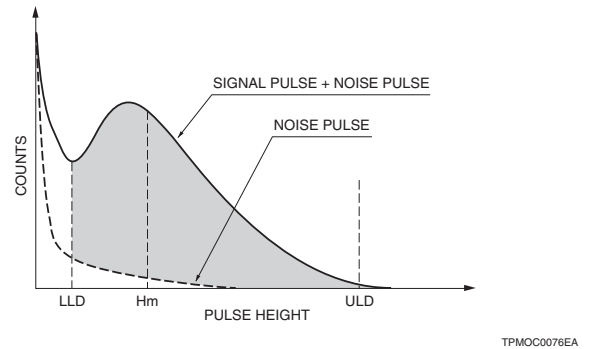
Figure 27: Output pulse and discrimination level



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

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

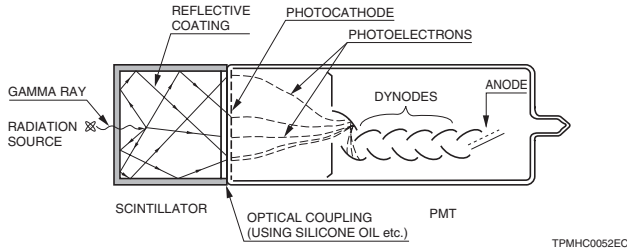
Figure 28: Typical single photon pulse height distribution



## SCINTILLATION COUNTING

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

Figure 29: Scintillation detector using PMT and scintillator



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

Figure 30: Incident radiation particles and PMT output

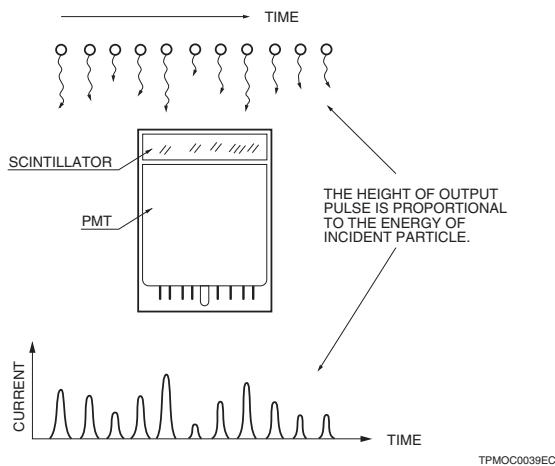


Figure 31: Typical pulse height distributions (Energy spectra)

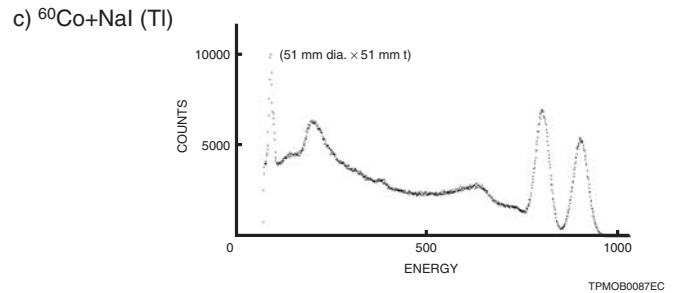
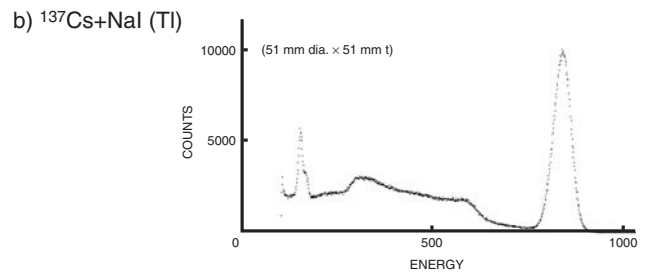
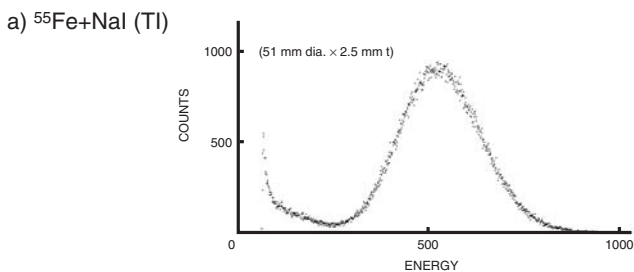
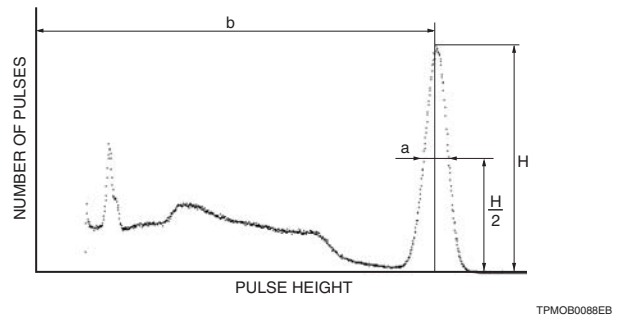
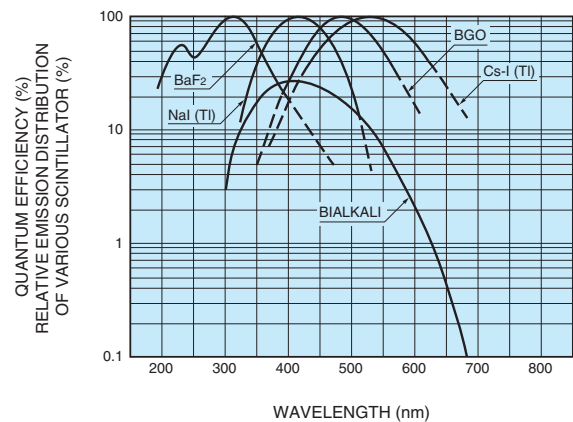


Figure 32: Definition of pulse height resolution (FWHM)



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

Figure 33: PMT spectral response and spectral emission of scintillators



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

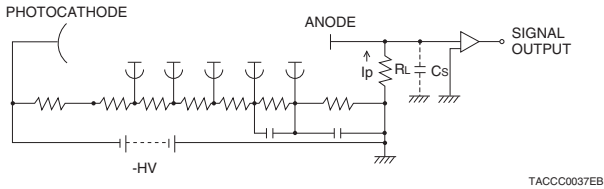
# Connections to external circuits

## LOAD RESISTANCE

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

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

Figure 34: Photomultiplier tube output circuit

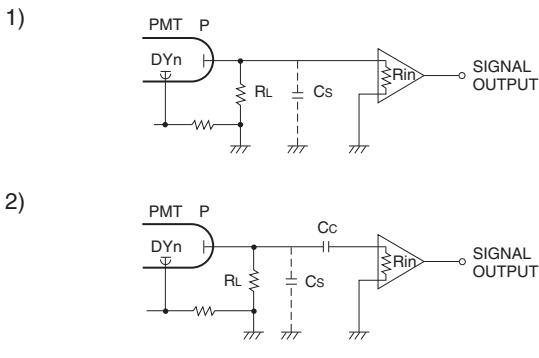


In the circuit of Figure 34, if we let the load resistance be  $R_L$  and the total capacitance of the photomultiplier tube anode to all other electrodes including stray capacitance such as wiring capacitance be  $C_s$ , then the cutoff frequency  $f_c$  is expressed by the following relationship.

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

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

Figure 35: Amplifier internal resistance



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

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

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

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

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

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

## HIGH-SPEED OUTPUT CIRCUITS

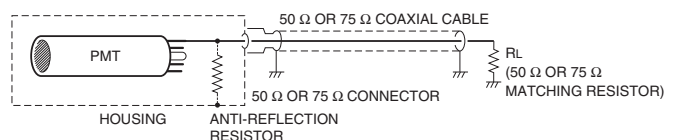
When detecting high-speed and pulsed light signals, a coaxial cable is used to make the connection between the photomultiplier tube and the electronic circuit. Since commonly used cables have characteristic impedances of  $50\ \Omega$ , this cable must be terminated in a pure resistance equal to the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

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

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

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

Figure 36: Connection to prevent ringing

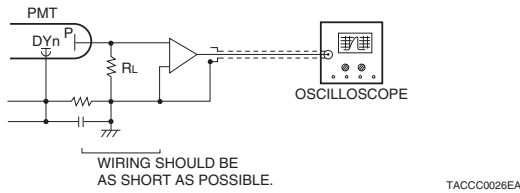




Next, let us consider waveform observation of high-speed pulses using an oscilloscope. This type of operation requires a low load resistance. However, the oscilloscope sensitivity is limited so an amplifier may be required.

Cables with a matching resistor have the advantage that the cable length will not affect the electrical characteristics of the cable. However, since the matching resistance is very low compared to the usual load resistance, the output voltage becomes too small. While this situation can be remedied with a high gain amplifier, the inherent noise of such an amplifier can itself hurt measurement performance. In such cases, the photomultiplier tube should be brought as close as possible to the amplifier to reduce stray capacitance and a larger load resistance should be used (while still maintaining the frequency response), to achieve the desired input voltage. (See Figure 37.)

Figure 37: Measurement with ringing suppression measures



It is relatively simple to implement a high-speed amplifier using a wide-band video amplifier or operational amplifier. However, as a trade-off for design convenience, these ICs tend to create performance problems (such as noise). This makes it necessary to know their performance limits and take corrective action if necessary.

As the pulse repetition frequency increases, baseline shift becomes one reason for concern. This occurs because the DC signal component has been eliminated from the signal circuit by coupling with a capacitor which blocks the DC components. If this occurs, the reference zero level observed at the last stage is not the actual zero level. Instead, the apparent zero level is a time-average of the positive and negative fluctuations of the signal waveform. This is known as baseline shift. Since the height of the pulses above this baseline level is affected by the repetition frequency, this phenomenon can be a problem when observing waveforms or discriminating pulse levels.

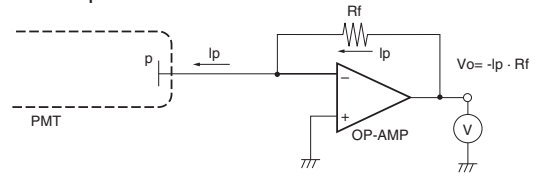
### OPERATIONAL AMPLIFIERS

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

$$V_o = -I_p \cdot R_f$$

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

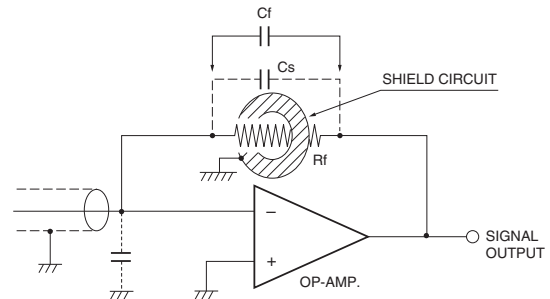
Figure 38: Current-voltage conversion using operational amplifier



If the operational amplifier has an offset current ( $I_{os}$ ), the above-described output voltage becomes  $V_o = -(I_p + I_{os}) \cdot R_f$ , with the offset current component being superimposed on the output. Furthermore, the magnitude of the temperature drift may create a problem. In general, a metallic film resistor which has a low temperature coefficient is used for the resistance  $R_f$ . Carbon resistors with their highly temperature-dependent resistance characteristics are not suitable for this application.

In addition to the above factors, when measuring extremely low level currents such as 100 pA and below, the materials used to fabricate the circuit also require careful selection. For example, materials such as bakelite are not suitable. More suitable materials include teflon, polystyrol or steatite. Low-noise cables should also be used, since general-purpose coaxial cables exhibit noise due to physical factors. An FET input operational amplifier is recommended for measuring low-level current.

Figure 39: Frequency compensation by operational amplifier



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

# Selection guide by applications

Applications	Required major characteristics	Applicable PMT
<b>Spectroscopy</b>		
<p><b>UV / Visible / IR spectrophotometer</b></p> <p>When light passes through a substance, the light energy causes changes in the electron energy of the substance, resulting in partial energy loss. This is called absorption and can be used to yield analytical data. In order to determine the quantity of a sample substance, it is irradiated while its light wavelength is scanned continuously. The spectral intensities of the light before and after passing through the sample are then detected by a photomultiplier tube and the amount of absorption in this way measured.</p>	<ol style="list-style-type: none"> <li>1) Wide spectral response</li> <li>2) High stability</li> <li>3) Low dark noise</li> <li>4) High quantum efficiency</li> <li>5) Low hysteresis</li> <li>6) Good polarization characteristics</li> </ol>	<p>R6357 R928, R955, R3896, R12896 R374 R375 H7260-20 H10515B-20</p>
<p><b>Atomic absorption spectrophotometer</b></p> <p>This is widely used in analysis of minute quantities of metallic elements. A special elementary hollow cathode lamp for each element to be analyzed is used to irradiate a sample which is burned to atomize it. A photomultiplier tube then detects the light passing through the sample to measure the amount of absorption, which is compared with a pre-measured reference sample.</p>		<p>R6354 R928 R955 R7154 R12896</p>
<p><b>Photoelectric emission spectrophotometer</b></p> <p>When external energy is applied to a sample, that sample then emits light. By using a monochromator to disperse this light emission into characteristic spectral lines of elements and measuring their presence and intensity simultaneously with photomultiplier tubes, the photoelectric emission spectrophotometer can perform rapid qualitative and quantitative analysis of the elements contained in the sample.</p>	<ol style="list-style-type: none"> <li>1) High gain</li> <li>2) Low dark noise</li> <li>3) High stability</li> </ol>	<p>R6350, R6351 R6354, R6355, R10824, R10825 R11568, R11558 R7446, R8486, R8487, R10454</p>
<p><b>Fluorescence spectrophotometer</b></p> <p>The fluorescence spectrophotometer is used in biological science, especially in molecular biology. When an excitation light is applied, some substances emit light with a wavelength longer than that of the excitation light. This light is known as fluorescence. The intensity and spectral characteristics of the fluorescence are measured by a photomultiplier tube, and the substance then analyzed qualitatively and quantitatively.</p>	<ol style="list-style-type: none"> <li>1) High quantum efficiency</li> <li>2) Low dark noise</li> <li>3) High stability</li> </ol>	<p>R6353, R6357, R6356-06 R3788, R4220, R1527 R928, R3896, R10699, R12829 H7260-20, H10515B-20</p>
<p><b>Raman spectroscopy</b></p> <p>When monochromatic light strikes a substance and scatters, a process called Raman scattering also occurs at a wavelength different from the excitation light. Since this wavelength differential is a unique characteristic of a molecule, spectral measurement of Raman scattering can provide qualitative and quantitative data of molecules. Raman scattering is extremely weak and a sophisticated optical system is required for measurement, with the photomultiplier tube operated in the photon counting mode.</p>	<ol style="list-style-type: none"> <li>1) High quantum efficiency</li> <li>2) Low dark count</li> <li>3) Single photon discrimination ability</li> </ol>	<p>R2949, R9110 R943-02, R649</p>
<p><b>Other spectrophotometric equipment using photomultiplier tubes</b></p> <ul style="list-style-type: none"> <li>• Liquid or gas chromatography</li> <li>• X-ray diffractometers, X-ray fluorescence analyzers</li> <li>• Electron microscopes</li> </ul>		<p>R3788, R4220 R647, R6095, R580 R9880U-01, R7600U-01 R9880U-110 R9880U-210</p>

Applications	Required major characteristics	Applicable PMT
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## Solid surface analysis

<p><b>Scanning Electron Microscope (SEM)</b></p> <p>A scanning electron microscope (SEM) is used to examine the structure near the surface of materials. It produces microscopic images by scanning the surface of a sample with a narrow-focused electron beam and measuring the secondary electrons emitted from near the surface of the sample. Unlike light, no diffraction occurs and so SEM allows high-precision measurement with an analysis capability in the order of nanometers. The emitted secondary electrons are guided to the scintillator and converted into visible light, which is measured with a photomultiplier tube. SEM is widely used for structural analysis of various structures including organisms, engineering materials, and semiconductors.</p>	<ol style="list-style-type: none"> <li>1) Low dark count</li> <li>2) Compact size</li> </ol>	<p>R6095, R6094 R12421 R9880U-110 R9880U-210</p>
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## Pollution monitoring

<p><b>Particle counter</b></p> <p>A particle counter measures the density of particles floating in the atmosphere or inside rooms by measuring light scattering. Microparticles such as PM2.5 can be measured by utilizing the absorption of beta rays.</p>	<ol style="list-style-type: none"> <li>1) Low dark count</li> <li>2) Low spike noise</li> <li>3) High quantum efficiency</li> </ol>	<p>R12421, R1924A, R6095 R9880U-110</p>
<p><b>NOx monitors</b></p> <p>NOx monitors are used to measure nitrogen oxides which are air pollutants contained in the air and exhaust gases emitted from various combustion engines. NOx monitors detect the NO gas concentration by measuring the intensity of chemiluminescence emitted when NO<sub>2</sub> excited by the reaction of NO gas and ozone (O<sub>3</sub>) returns to its ground state.</p>	<ol style="list-style-type: none"> <li>1) High sensitivity at near infrared to infrared range</li> <li>2) Low dark current</li> </ol>	<p>R3896, R5984, R374 R2228, R5929, R5070A R9182-01</p>
<p><b>SOx monitors</b></p> <p>SOx monitors or sulfur dioxide analyzers are used to measure the environmental concentration of sulfur dioxide in the air. Recent models use the ultraviolet fluorescence method that detects sulfur dioxide concentration in the air by irradiating ultraviolet light onto sulfur dioxides to excite SO<sub>2</sub> and then measure the fluorescence intensity emitted from the SO<sub>2</sub>.</p>	<ol style="list-style-type: none"> <li>1) High sensitivity at UV range</li> <li>2) Low dark current</li> </ol>	<p>R3788 R1527, R4220 R6095</p>

## Biotechnology

<p><b>Flow cytometer</b></p> <p>A flow cytometer uses a laser to irradiate cells labeled with fluorescent substance and measures the resulting fluorescence or scattered light from those cells with a photomultiplier tube, in order to identify each cell. A cell sorter is one kind of flow cytometer having the function of sorting specific cells.</p>	<ol style="list-style-type: none"> <li>1) High quantum efficiency</li> <li>2) High stability</li> <li>3) Low dark current</li> <li>4) High gain</li> </ol>	<p>R6357, R928 R3896 R9880U-01, R9880U-20 R5900U-20-L16 H7260-20 H9530-20, H10515B-20</p>
<p><b>Laser scanning microscopes</b></p> <p>Laser scanning microscopes are designed to acquire 2D or 3D fluorescence images by scanning a laser beam over the surface of a sample stained with a fluorescent dye. High-resolution images can be obtained by using the confocal function while scanning with a small laser light spot. Multiphoton microscopes that utilize two-photon absorption are also becoming widespread in recent years.</p>	<ol style="list-style-type: none"> <li>1) High quantum efficiency in the visible range</li> </ol>	<p>R6357 R3896, R10699 R9880-110 R9880-210 H7260-20</p>
<p><b>Hygiene monitors</b></p> <p>Hygiene monitors, also called ATP (adenosine triphosphate) monitors, are useful devices for monitoring sanitary conditions. These devices make use of the principle of bioluminescence that occurs by making a luminescent agent react with ATP extracted from bacteria or cells. Hygiene monitors are used for testing the degree of cleanliness in kitchens and food factories.</p>	<ol style="list-style-type: none"> <li>1) Low dark count</li> <li>2) High sensitivity at 560 nm</li> <li>3) Compact size</li> </ol>	<p>R4220, R1527 R1924A, R3550A</p>

# Selection guide by applications

Applications	Required major characteristics	Applicable PMT
<b>Medical applications</b>		
<p><b>Gamma camera</b></p> <p>The gamma camera obtains an image of a radioisotope injected into the body of a patient to locate abnormalities. Its detection section uses a large diameter NaI(Tl) scintillator and light-guide coupled to a photomultiplier tube array.</p>	<ol style="list-style-type: none"> <li>1) High energy resolution</li> <li>2) Good uniformity</li> <li>3) High stability</li> <li>4) Uniform gain (between each tube)</li> </ol>	<p>R6231-01, R6233-01 R6234-01, R6235-01 R6236-01, R6237-01 R1307-01 R8900U-00-C12</p>
<p><b>PET (Positron emission tomography)</b></p> <p>The PET provides tomographic images by detecting the coincident gamma-ray emission that accompanies the annihilation of positrons emitted from a tracer radioisotope (<sup>11</sup>C, <sup>15</sup>O, <sup>13</sup>N, <sup>18</sup>F, etc.) injected into the body. Photomultiplier tubes coupled to scintillators are used to detect these gamma-rays.</p>	<ol style="list-style-type: none"> <li>1) High energy resolution</li> <li>2) High stability</li> <li>3) Fast response time</li> <li>4) Compact size</li> </ol>	<p>R8900U-00-C12 R1450 R9800, R9420, R13089 R8619, R11194 R13478, R13449, R13408</p>
<p><b>Computed radiography (CR)</b></p> <p>Some X-ray image diagnostic systems use a special phosphor plate made of photostimulable phosphor. After temporarily accumulating an X-ray image onto this phosphor plate, scanning (exciting) the surface of the phosphor plate with a laser beam causes the phosphor plate to emit visible light according to the amount of accumulated X-rays. A photomultiplier tube converts this weak visible light into electrical signals which are then utilized to reconstruct an image through digital signal processing.</p>	<ol style="list-style-type: none"> <li>1) High quantum efficiency</li> <li>2) High stability</li> </ol>	<p>R1924A R11102 R6231, R6233</p>
<p><b>In-vitro assay</b></p> <p>In-vitro assay is used for physical checkups, diagnosis, and evaluation of drug potency by making use of the specific antigen/antibody reaction characteristics of tiny amounts of insulin, hormones, drugs and viruses that are contained in blood or urine. Photomultiplier tubes are used to optically measure the amount of antigens labeled by radioisotopes or fluorescent, chemiluminescent or bioluminescent substances.</p> <ul style="list-style-type: none"> <li>• Radioimmunoassay (RIA) Uses radioactive isotopes for labeling and scintillators for measurement.</li> <li>• Chemiluminescent immunoassay CLIA (Chemiluminescent immunoassay) CLEIA (Chemiluminescent Enzyme immunoassay) Uses luminescent substances for labeling to measure chemiluminescence or bioluminescence.</li> <li>• Fluoroimmunoassay Uses fluorescent substances for labeling.</li> </ul>	<ol style="list-style-type: none"> <li>1) High quantum efficiency</li> <li>2) High stability</li> <li>3) Low dark current</li> </ol>	<p>R1166, R5610A, R5611A-01 R6350, R6352, R6353 R6356-06, R6357 R4220, R928, R3788, R3896 R1463, R12421 R1925A, R1924A, R3550A R6095, R374 R9880U-01 R9880U-20</p>
<p><b>Others</b></p> <ul style="list-style-type: none"> <li>• X-ray phototimer This equipment automatically controls the X-ray film exposure during X-ray examinations. The X-rays transmitting through a subject are converted into visible light by a phosphor screen. A photomultiplier tube detects this light and converts it into electrical signals. When the accumulated electrical signal reaches a preset level, the X-ray irradiation is shut off, to allow obtaining an optimum film density.</li> </ul>	<ol style="list-style-type: none"> <li>1) High sensitivity</li> <li>2) Low dark current</li> <li>3) High stability</li> </ol>	<p>R6350 R11558</p>

Applications	Required major characteristics	Applicable PMT
<b>Radiation measurement</b>		
<b>Area monitor</b> Area monitors are designed to continuously measure changes in environmental radiation levels. Area monitors use a photomultiplier tube coupled to a scintillator to monitor low level gamma rays and neutron rays. Photomultiplier tubes are mainly used for gamma ray measurement.	<ol style="list-style-type: none"> <li>1) Long term stability</li> <li>2) Low background noise</li> <li>3) Good plateau characteristic</li> </ol>	R1306, R6231 R329-02, R7724 R1307, R6233 R877, R877-01
<b>Survey meter</b> Survey meters are used to measure low level gamma-rays and beta-rays by using a photomultiplier tube coupled to a scintillator.	<ol style="list-style-type: none"> <li>1) Long term stability</li> <li>2) Low background noise</li> <li>3) Good plateau characteristic</li> </ol>	R1635 R12421 R1924A R6095 R9880U-110
<b>Resource exploration</b>		
<b>Oil and natural gas well logging</b> Gamma-ray probing is used to determine the geological location and size of oil deposits and natural gas fields. A probe containing a radiation source, scintillator, and photomultiplier tube is lowered into a borehole drilled for an oil or natural gas well. The scattered radiation or natural radiation from the geological formation is detected with the probe, and the type and density of the geological formation is analyzed along with information obtained from other sensors. <small>* We provide a catalog of high temperature, ruggedized photomultiplier tubes designed and selected for oil and natural gas well logging applications.</small>	<ol style="list-style-type: none"> <li>1) Stable operation at high temperatures up to 175 °C</li> <li>2) Rugged structure resistant to shock and vibration</li> <li>3) Good plateau characteristic when combined with a scintillator</li> </ol>	R4177 series R3991A series R1288A series R9722A series R4607A series
<b>Industrial measurement</b>		
<b>Thickness meter</b> The thickness meter uses a radiation source and a scintillator/photomultiplier tube detector to measure product thickness such as for paper, plastic, copper sheet on factory production lines. Beta-rays are used as a radiation source to measure small density products such as rubber, plastic, and paper. Gamma-rays are used for large density products such as copper plates. X-ray fluorescence is utilized to measure film thickness for plating, evaporation, etc.	<ol style="list-style-type: none"> <li>1) Good pulse linearity</li> <li>2) High energy resolution</li> </ol>	R12421 R6095 R580 R1306, R6231 R329-02, R7724
<b>Liquid level meter</b> Liquid level needs to be controlled in a liquid production or oil and gas processing plant. Absorption of gamma rays are measured to determine the liquid level non-invasively with a PMT and scintillator. Highly reliable PMTs are used to monitor the liquid level continuously or at times.	<ol style="list-style-type: none"> <li>1) High reliability</li> <li>2) High stability</li> <li>3) Wide dynamic range</li> </ol>	R1924A R580 R2154-02 R6231 R6233
<b>Semiconductor inspection system</b> These are widely used in semiconductor wafer inspection systems. In wafer inspection, the wafer is scanned by a laser beam, and the scattered light caused by dirt or defects is detected by a photomultiplier tube.	<ol style="list-style-type: none"> <li>1) High quantum efficiency</li> <li>2) Good uniformity</li> <li>2) Low spike noise</li> </ol>	R3896 R9880U-01 R9880U-04 R9880U-20 R9880U-113

# Selection guide by applications

Applications	Required major characteristics	Applicable PMT
<b>High energy physics</b>		
<b>●Accelerator experiment</b>		
<b>Hodoscope</b> Photomultiplier tubes are coupled to the ends of long, thin plastic scintillator arrays arranged in two layers intersecting with each other in order to measure the time and position at which charged particles pass through the scintillator arrays.	1) Fast time response 2) Compact size	R7600U series R1635 (H3164-10) R647-01 (H3165-10) R12421 (H12690) R1450 (H6524), R1166 (H6520)
<b>TOF counter</b> Two counters are arranged along a path of charged particles, with each counter consisting of a scintillator and a photomultiplier tube. The velocity of the particles is measured by the time difference between the two counters.		3) Resistance to magnetic fields (when used in magnetic fields)
<b>Cherenkov counter</b> A Cherenkov counter is used to identify secondary particles generated by the collision reaction of particles. Cherenkov radiation is emitted from charged particles with energy higher than a certain level when they pass through a gas or silicon aerogel. This weak Cherenkov radiation is detected by a photomultiplier tube. These particles are then identified by measuring the Cherenkov radiation emission angle.	1) High quantum efficiency 2) Single photon discrimination ability 3) High gain 4) Fast time response	R329-02 (H6410) R1250 (H6527) R7600U series, R7724 H12700
<b>Calorimeter</b> The calorimeter measures the accurate energy of secondary particles generated by the collision reaction of particles.	1) Good pulse linearity 2) High energy resolution 3) High stability	R7899, R580 (H3178-51) R7600U series, R329-02 (H6410) R7724, R6091 (H6559)
<b>●Neutrino and proton decay experiment, cosmic ray detection</b>		
<b>Neutrino experiment</b> Research on solar neutrinos or particle astrophysics is utilized in a neutrino experiment. This experimental system consists of a large amount of a medium surrounded by a great number of large-diameter photomultiplier tubes. When cosmic rays such as neutrinos enter and pass through the medium, their energy and traveling direction are measured by detecting Cherenkov radiation that occurs from interaction with the medium.	1) Large photocathode area 2) Fast time response 3) High stability 4) Low dark count	R5912* R7081* R12860*
<b>Neutrino and proton decay experiment</b> In the neutrino and proton decay experiments being conducted at Kamioka, Japan, 11,200 photomultiplier tubes each 20" diameter are installed to surround from all directions a huge tank storing 50,000 t of pure water. The photomultiplier tubes are used to watch the subtle flash of Cherenkov radiation that occurs when proton decays or solar neutrinos pass through the pure water tank.		R329-02 (H6410) R6091 (H6559) R1250 (H6527)
<b>Air shower counter</b> When cosmic rays collide with the earth's atmosphere, secondary particles are created by the interaction of the cosmic rays and atmospheric atoms. These secondary particles generate more secondary particles, which continue to increase in a geometrical progression. This is called an air shower. The gamma-rays and Cherenkov radiation emitted in this air shower are detected by photomultiplier tubes arranged in a lattice array on the ground.		

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

The assembly type is given in parentheses.

Applications	Required major characteristics	Applicable PMT
<b>Aerospace</b>		
<p><b>Astronomical X-ray measurement</b>  X-rays from outer space include information on the enigmas of space. As an example, the X-ray observation satellite "Asuka" developed by a group of the ISAS (Institute of Space and Astronomical Science - Japan), uses a gas-scintillation proportional counter in conjunction with a position-sensitive photomultiplier tube to measure X-rays from supernovas, etc.</p>	<ol style="list-style-type: none"> <li>1) High energy resolution</li> <li>2) Resistance to shock and vibration</li> </ol>	<p>R3998-02  R3991A  R6231</p> <p>Ruggedized PMT with high resistance to vibration and shock will be required. Consult with our sales office.</p>
<p><b>Measurement of scattered light from fixed stars and interstellar dust</b>  Ultraviolet rays from space contain a great deal of information about the surface temperatures of stars and interstellar substances. However, these ultraviolet rays are absorbed by the earth's atmosphere making it impossible to measure them from the earth's surface. So photomultiplier tubes are mounted in rockets or artificial satellites, to measure ultraviolet rays with wavelengths shorter than 300 nm.</p>	<ol style="list-style-type: none"> <li>1) Resistance to shock and vibration</li> <li>2) Sensitivity only in VUV to UV range (Solar blind response with no sensitivity to visible light: See page 6 for Cs-Te and CsI photocathodes)</li> </ol>	<p>R1080, R976  R6834, R6835, R6836</p> <p>Ruggedized PMT with high resistance to vibration and shock will be required. Consult with our sales office.</p>
<b>Lasers</b>		
<p><b>Laser radar (LiDAR)</b>  The laser radar is used in applications such as atmospheric measurement for highly accurate range finding or aerosol scattering detection.</p>	<ol style="list-style-type: none"> <li>1) Fast time response</li> <li>2) Low dark count</li> <li>3) High gain</li> <li>4) Low afterpulses</li> </ol>	<p>R3809U series  R5916U series  R9880U-20  H7260-20  H10515B-20</p>
<p><b>Fluorescence lifetime measurement</b>  A laser is used as an excitation light for fluorescence lifetime measurement. The molecular structure of a substance can be studied by measuring the changes in temporal intensity in the emitted fluorescence.</p>		<p>R9880U series  R3809U series  R5916U series</p>

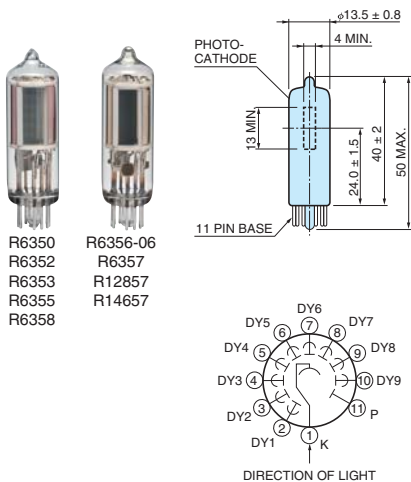
# Side-on type photomultiplier tubes

A Type No.	Spectral response							Remarks				Max. ratings H			
	Effective area (mm) ← Wavelength (nm) →	Spectral response range (nm)	Curve code B	Peak wavelength (nm)	Photo-cathode material C	Window material D	Out-line No. E	Dynode structure / Stages F	Socket & Socket assembly G	Anode to cathode voltage (V) J	Average anode current (mA)	Anode to cathode supply voltage (V) L			
<b>13 mm (1/2") Dia. types</b>															
R6350	4 × 13	185 to 650	350U	340	Sb-Cs	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			
R6352	4 × 13	185 to 750	452U	420	BA	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			
R6353	4 × 13	185 to 680	456U	400	LBA	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			
R6355	4 × 13	185 to 850	550U	530	MA	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			
R6356-06	4 × 13	185 to 900	—	400	MA	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			
R6357	4 × 13	185 to 900	—	450	MA	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			
R12857	4 × 13	185 to 900	—	450	MA	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			
*R14657	4 × 13	185 to 900	—	480	MA	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			
R6358	4 × 13	185 to 830	561U	530	MA	U	1	CC/9	E678-11U* 1 2	1250	0.01	1000 ①			

Lenses for side-on type photomultipliers are available. See page 71 for more details.

## Dimensional outlines (Unit: mm)

### ① R6350, R6352, R6353 etc.



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(at 25 °C)

Cathode characteristics					Anode characteristics <sup>M</sup>							Notes	Type No. <sup>A</sup>	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response			
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)			Transit time Typ. (ns)
20	40	5.0	—	48	50	300	$3.6 \times 10^5$	$7.5 \times 10^6$	0.5	5	1.4	15	For photon counting: R6350P Silica glass window: R6351	R6350
80	120	10.0	—	90	100	700	$5.2 \times 10^5$	$5.8 \times 10^6$	1	10	1.4	15		R6352
30	70	6.5	—	65	100	400	$3.7 \times 10^5$	$5.7 \times 10^6$	0.1	2	1.4	15	For photon counting: R6353P	R6353
80	150	6.0	0.15	45	100	600	$1.8 \times 10^5$	$4.0 \times 10^6$	1	10	1.4	15		R6355
200	300	10.0	0.3	77	400	1200	$3.1 \times 10^5$	$4.0 \times 10^6$	1	10	1.4	15		R6356-06
350	500	13.0	0.4	105	1000	2000	$4.2 \times 10^5$	$4.0 \times 10^6$	2	10	1.4	15		R6357
620	650	15.0	0.43	109	400	1500	$2.5 \times 10^5$	$2.3 \times 10^6$	3	10	1.4	15		R12857
700	750	17.0	0.45	116	400	1800	$2.8 \times 10^5$	$2.4 \times 10^6$	4	10	1.4	15		R14657*
140	200	7.5	0.15	70	300	700	$2.5 \times 10^5$	$3.5 \times 10^6$	0.1	1	1.4	15	For photon counting: R6358-10	R6358

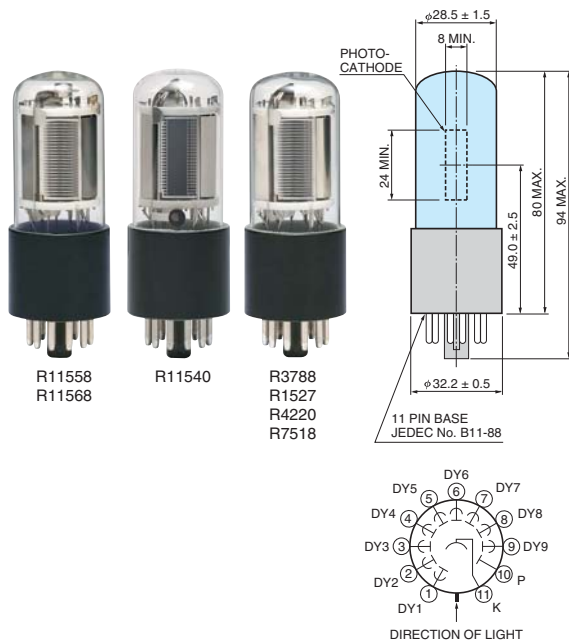
# Side-on type photomultiplier tubes

A Type No.	Spectral response							Remarks					Max. ratings H		
	Effective area (mm)		Spectral response range (nm)	Curve code	Peak wavelength (nm)	Photo-cathode material	Window material	Out-line No.	Dynode structure / Stages	Socket & Socket assembly	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)		
← Wavelength (nm) →															
<b>28 mm (1-1/8") Dia. types with UV to visible sensitivity</b>															
R11558	8 × 24		300 to 650	453K	400	BA	K	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	
R11568	8 × 24		185 to 650	453U	400	BA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	
R3788	8 × 24		185 to 750	452U	420	BA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	
R11540	8 × 24		185 to 760	452U	420	BA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	
R1527	8 × 24		185 to 680	456U	400	LBA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	
R4220	8 × 24		185 to 710	456U	410	LBA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	
R7518	8 × 24		185 to 730	456U	410	LBA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	
R5983	10 × 24		185 to 710	456U	410	LBA	U	②	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	
R11715-01	8 × 24		185 to 710	456U	410	LBA	U	③	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪	

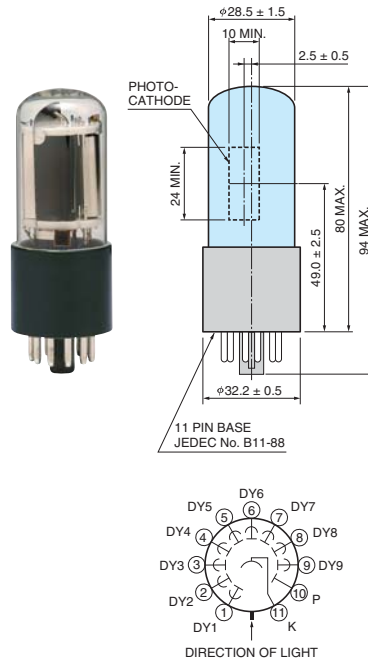
Lenses for side-on type photomultipliers are available. See page 71 for more details.

## Dimensional outlines (Unit: mm)

### ① R11558, R3788, R11540 etc.



### ② R5983



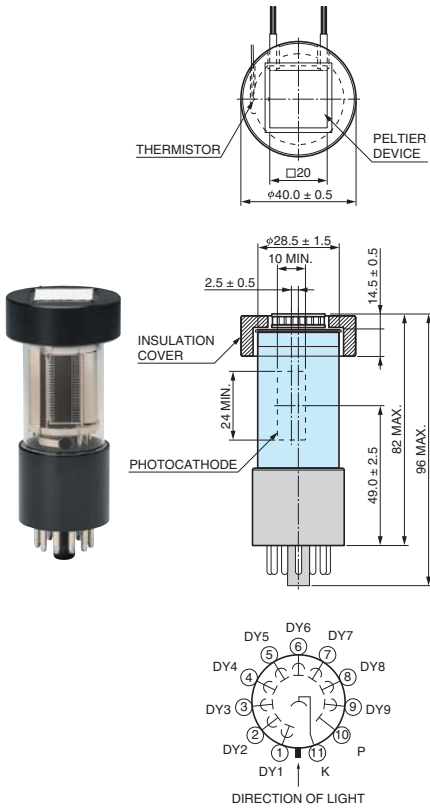
**Cathode characteristics**

**Anode characteristics <sup>M</sup>**

(at 25 °C)

Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
40	60	7.1	—	60	200	600	$6.0 \times 10^5$	$1.0 \times 10^7$	1	10	2.2	22		R11558
40	60	7.1	—	60	200	600	$6.0 \times 10^5$	$1.0 \times 10^7$	1	10	2.2	22		R11568
100	120	10.0	0.01	90	500	1200	$9.0 \times 10^5$	$1.0 \times 10^7$	5	50	2.2	22	Silica glass window: R4332	R3788
160	190	16.0	0.02	120	1300	1900	$1.2 \times 10^6$	$1.0 \times 10^7$	5	50	2.2	22		R11540
40	60	6.4	—	60	200	400	$4.0 \times 10^5$	$6.7 \times 10^6$	0.1	2	2.2	22	For photon counting: R1527P Silica glass window: R7446	R1527
80	100	8.0	—	70	1000	1200	$8.4 \times 10^5$	$1.2 \times 10^7$	0.2	2	2.2	22	For photon counting: R4220P Silica glass window: R7447	R4220
120	130	10.0	—	85	1200	1560	$1.0 \times 10^6$	$1.2 \times 10^7$	0.2	2	2.2	22	For photon counting: R7518P	R7518
60	100	8.0	—	70	500	1000	$7.0 \times 10^5$	$1.0 \times 10^7$	0.2	2	2.2	22	For photon counting: R5983P Borosilicate glass window: R10491	R5983
50	100	8.0	—	70	1000	1200	$8.4 \times 10^5$	$1.2 \times 10^7$	0.2	0.5	2.2	22		R11715-01

**3 R11715-01**



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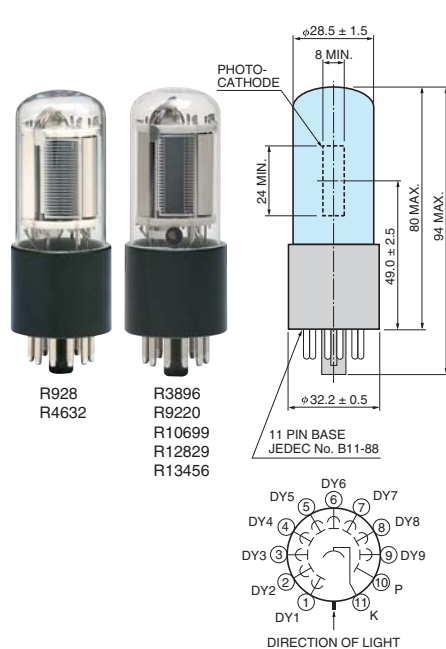
# Side-on type photomultiplier tubes

A Type No.	Spectral response										Remarks					Max. ratings <sup>H</sup>		
	Effective area (mm)		Spectral response range (nm)	Curve code	Peak wavelength (nm)	Photo-cathode material	Window material	Out-line No.	Dynode structure / Stages	Socket & Socket assembly	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)					
← Wavelength (nm) →																		
<b>28 mm (1-1/8") Dia. types with UV to near IR sensitivity</b>																		
R12829	8 × 24		185 to 900	557U	450	MA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
R10699	8 × 24		185 to 900	557U	450	MA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
R3896	8 × 24		185 to 900	555U	450	MA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
R9220	8 × 24		185 to 900	555U	450	MA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
R928	8 × 24		185 to 900	562U	400	MA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
*R13456	8 × 24		185 to 980	563U	400	MA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
R5984	10 × 24		185 to 900	562U	400	MA	U	②	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
<b>28 mm (1-1/8") Dia. types with low dark current</b>																		
R9110	8 × 6		185 to 900	555U	450	MA	U	③	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
R2949	8 × 6		185 to 900	562U	400	MA	U	③	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
R9182-01	10 × 14		185 to 900	555U	450	MA	U	④	CC/9	E678-11A	③④⑤	1250	0.1	1000 ⑪				
R4632	8 × 24		185 to 850	556U	430	MA	U	①	CC/9	E678-11A	③④⑤	1250	0.1	1000 ①				

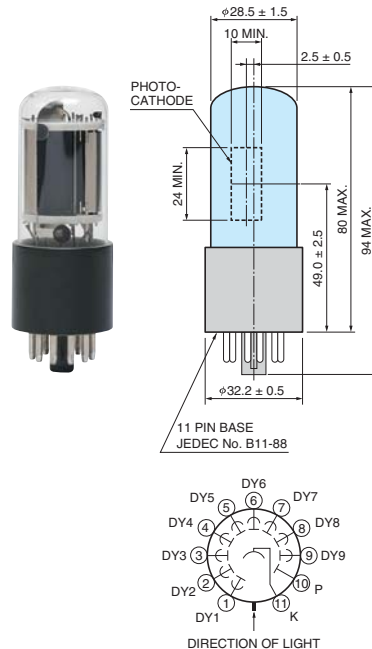
Lenses for side-on type photomultipliers are available. See page 71 for more details.

## Dimensional outlines (Unit: mm)

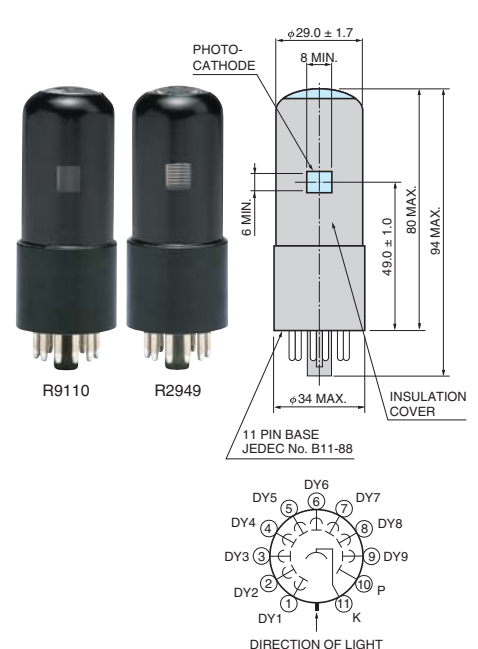
### ① R10699, R3896, R928 etc.



### ② R5984



### ③ R9110, R2949



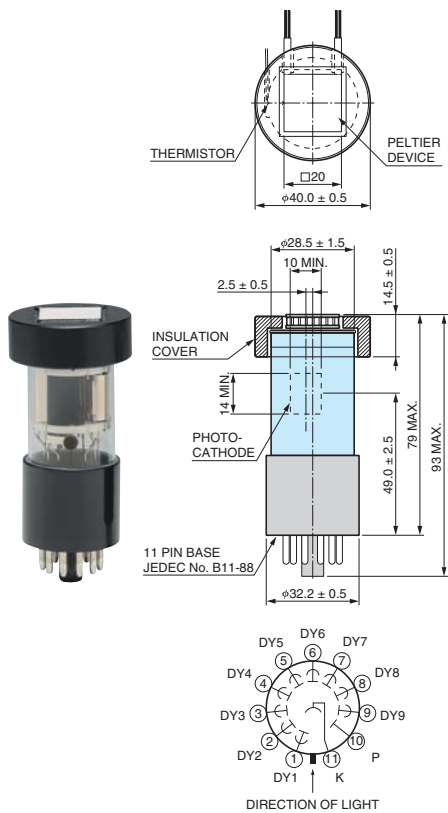
**Cathode characteristics**

**Anode characteristics <sup>M</sup>**

(at 25 °C)

Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
620	650	15.0	0.45	109	1600	8500	$1.4 \times 10^6$	$1.3 \times 10^7$	2 <sup>g</sup>	10 <sup>g</sup>	2.2	22	High sensitivity for 800 nm of R10699	R12829
620	650	15.0	0.43	109	1600	8500	$1.4 \times 10^6$	$1.3 \times 10^7$	2 <sup>g</sup>	10 <sup>g</sup>	2.2	22		R10699
475	525	15.0	0.4	90	3000	5000	$8.6 \times 10^5$	$9.5 \times 10^6$	10	50	2.2	22	Silica glass window: R12896	R3896
375	450	12.5	0.4	85	1000	4500	$8.5 \times 10^5$	$1.0 \times 10^7$	10	50	2.2	22		R9220
140	250	8.0	0.3	74	400	2500	$7.4 \times 10^5$	$1.0 \times 10^7$	3	50	2.2	22	Silica glass window: R955	R928
140	280	8.0	0.4	74	400	2800	$7.4 \times 10^5$	$1.0 \times 10^7$	5	50	2.2	22		R13456*
140	300	9.0	0.32	76	400	3000	$7.6 \times 10^5$	$1.0 \times 10^7$	5	50	2.2	22	High sensitivity type: R13096	R5984
400	525	15.0	0.4	90	4000	10000	$1.7 \times 10^6$	$1.9 \times 10^7$	5	15	2.2	22	For photon counting: R9110P	R9110
140	250	8.0	0.3	74	1000	2500	$7.4 \times 10^5$	$1.0 \times 10^7$	300 <sup>e</sup>	500 <sup>e</sup>	2.2	22		R2949
400	525	13.0	0.3	90	3000	5000	$8.6 \times 10^5$	$9.5 \times 10^6$	0.3 <sup>h</sup>	1 <sup>h</sup>	2.2	22		R9182-01
140	200	7.5	0.15	80	300	700	$2.8 \times 10^5$	$3.5 \times 10^6$	50 <sup>e</sup>	100 <sup>e</sup>	2.2	22		R4632

**4 R9182-01**



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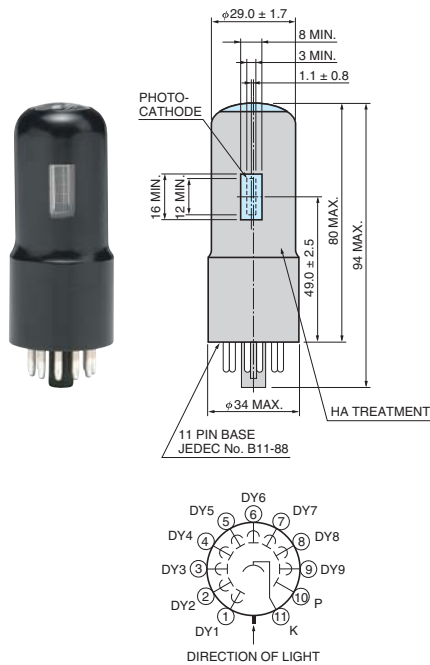
# Side-on type photomultiplier tubes

A Type No.	Spectral response				Remarks					Max. ratings H		
	Effective area (mm) ← Wavelength (nm) →	Spectral response range (nm)	Curve code B	Peak wavelength (nm)	Photo-cathode material C	Window material D	Out-line No. E	Dynode structure / Stages F	Socket & Socket assembly G	Anode to cathode voltage (V) J	Average anode current (mA)	Anode to cathode supply voltage (V) L
<b>R636-10</b>	3 × 12	185 to 930	650U	300-800	GaAs	U	①	CC/9	E678-11A ③④	1500	0.001	1250 ⑪
<b>R2658</b>	3 × 12	185 to 1010	850U	400	InGaAs	U	②	CC/9	E678-11A ③④	1500	0.001	1250 ⑪
<b>R5108</b>	18 × 16	400 to 1200	700K	800	Ag-O-Cs	K	③	CC/9	E678-11A ③④	1500	0.01	1250 ⑪

Lenses for side-on type photomultiplier tubes are available. See page 71 for more details.

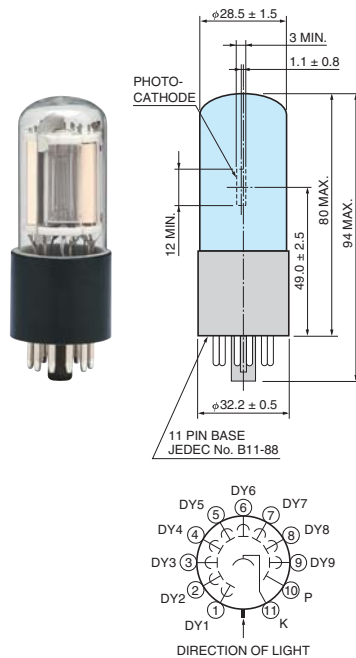
## Dimensional outlines (Unit: mm)

### ① R636-10



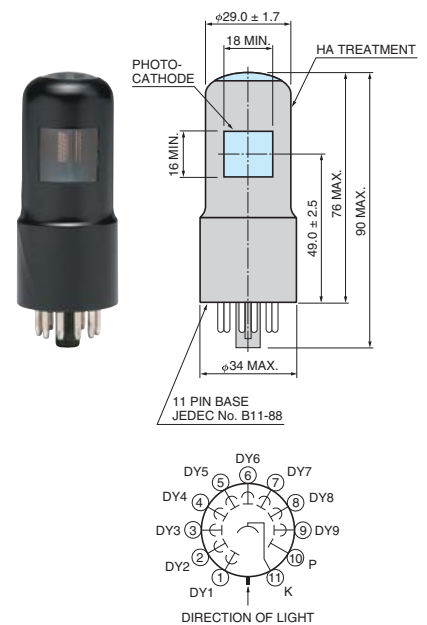
TPMSA0027EF

### ② R2658



TPMSA0012ED

### ③ R5108



TPMSA0023EC

(at 25 °C)

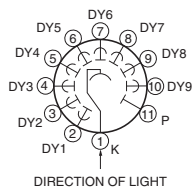
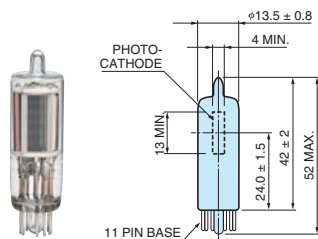
Cathode characteristics					Anode characteristics <sup>M</sup>								Notes	Type No. <sup>A</sup>
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response			
Min. (μA/lm)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

# Side-on type photomultiplier tubes

A Type No.	Spectral response										Remarks				Max. ratings H						
	Effective area (mm)		Spectral response range (nm)	Curve code B	Peak wavelength (nm)	Photo-cathode material C	Window material D	Out-line No. E	Dynode structure / Stages F	Socket & socket assembly G	Anode to cathode voltage (V) J	Average anode current (mA)	Anode to cathode supply voltage (V) L								
← Wavelength (nm) →																					
<b>13 mm (1/2") Dia. types with solar blind response</b>																					
R6354	4 × 13										160 to 320	250S	230	Cs-Te	Q	①	CC/9	E678-11U* ① ②	1250	0.01	1000 ⑩
R10824	4 × 9.5										115 to 320	250M	200	Cs-Te	MF	②	CC/9	E678-11U*	1250	0.01	1000 ⑩
R10825	4 × 9.5										115 to 195	150M	130	Cs-I	MF	②	CC/9	E678-11U*	1250	0.01	1000 ⑩
R13194	4 × 9.5										115 to 195	150M	130	Cs-I	MF	②	CC/9	E678-11U*	1250	0.01	1000 ⑩
<b>28 mm (1-1/8") Dia. types with solar blind response</b>																					
R7154	8 × 24										160 to 320	250S	230	Cs-Te	Q	③	CC/9	E678-11A ③ ④ ⑤	1250	0.1	1000 ⑩
R8486	8 × 12										115 to 320	250M	200	Cs-Te	MF	④	CC/9	E678-11A	1250	0.1	1000 ⑩
R8487	8 × 12										115 to 195	150M	130	Cs-I	MF	④	CC/9	E678-11A	1250	0.1	1000 ⑩
R10454	8 × 12										115 to 195	150M	130	Cs-I	MF	④	CC/9	E678-11A	1250	0.1	1000 ⑩

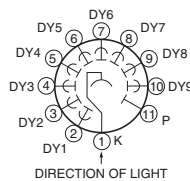
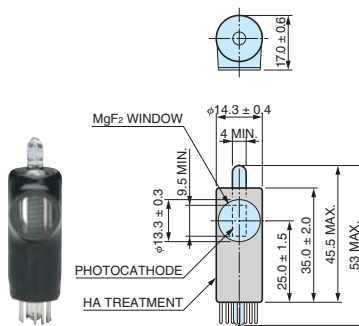
## Dimensional outlines (Unit: mm)

### ① R6354



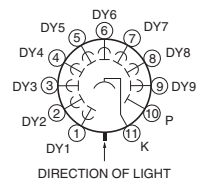
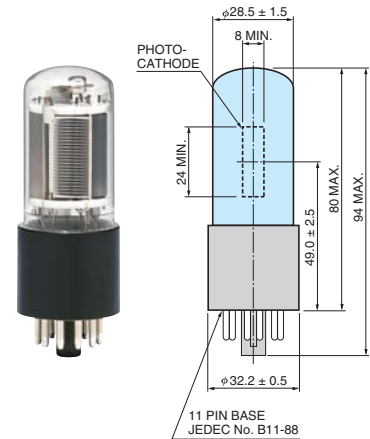
TPMSA0034EE

### ② R10824, R10825, R13194



TPMSA0044EA

### ③ R7154



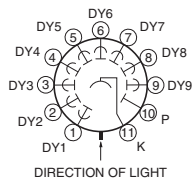
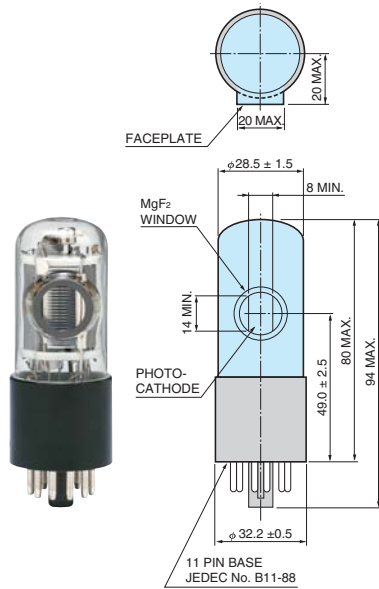
TPMSA0001EA



(at 25 °C)

Cathode characteristics				Anode characteristics <sup>M</sup>								Notes	Type No. <sup>A</sup>	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response			
Min. ( $\mu$ A/lm)	Typ. ( $\mu$ A/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)			Transit time Typ. (ns)
—	—	—	—	50 <sup>b</sup>	—	—	$2.0 \times 10^5$ <sup>b</sup>	$4.0 \times 10^6$	0.5	5	1.4	15		R6354
—	—	—	—	40 <sup>b</sup>	—	—	$1.6 \times 10^5$ <sup>b</sup>	$4.0 \times 10^6$	0.1	2	1.4	15		R10824
—	—	—	—	25.5 <sup>a</sup>	—	—	$1.0 \times 10^5$ <sup>a</sup>	$3.9 \times 10^6$	0.05	1	1.4	15		R10825
—	—	—	—	25.5 <sup>a</sup>	—	—	$1.0 \times 10^5$ <sup>a</sup>	$3.9 \times 10^6$	0.05	1	1.4	15	R10825 Better solar-blind characteristics Anode sensitivity ratio (122/300): 8500	R13194
—	—	—	—	62 <sup>b</sup>	—	—	$6.2 \times 10^5$ <sup>b</sup>	$1.0 \times 10^7$	1	10	2.2	22		R7154
—	—	—	—	52 <sup>b</sup>	—	—	$5.2 \times 10^5$ <sup>b</sup>	$1.0 \times 10^7$	1	10	2.2	22		R8486
—	—	—	—	25.5 <sup>a</sup>	—	—	$1.0 \times 10^5$ <sup>a</sup>	$3.9 \times 10^6$	0.1	—	2.2	22		R8487
—	—	—	—	25.5 <sup>a</sup>	—	—	$1.0 \times 10^5$ <sup>a</sup>	$3.9 \times 10^6$	0.1	—	2.2	22	R8487 Better solar-blind characteristics Anode sensitivity ratio (122/300): 8500	R10454

#### ④ R8486, R8487, R10454



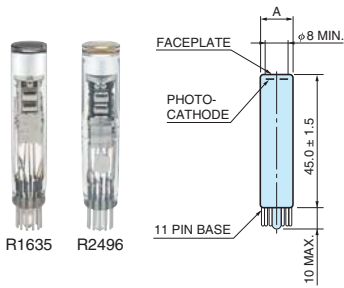
TPMSA0042EB

# Head-on type photomultiplier tubes

Type No.	Spectral response										Remarks				Max. ratings <sup>H</sup>		
	Effective area (mm)		Spectral response range (nm)		Curve code	Peak wavelength (nm)	Photo-cathode material	Window material	Out-line No.	Dynode structure / Stages	Socket & socket assembly	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)			
<b>10 mm (3/8") Dia. types</b>																	
R2496	φ8		160 to 650	400S	420	BA	Q	①	L/8	E678-11N* ⑦	1500	0.03	1250 ③				
R1635	φ8		300 to 650	400K	420	BA	K	①	L/8	E678-11N* ⑥	1500	0.03	1250 ①				
<b>13 mm (1/2") Dia. types</b>																	
R1081	φ6		115 to 200	100M	140	Cs-I	MF	②	L/10	E678-12A*	2250	0.01	2000 ⑭				
R1080	φ6		115 to 320	200M	240	Cs-Te	MF	②	L/10	E678-12A*	1250	0.01	1000 ⑭				
R759	φ10		160 to 320	200S	240	Cs-Te	Q	③	L/10	E678-13F* ⑧ ⑨	1250	0.01	1000 ⑭				
R647	φ10		300 to 650	400K	420	BA	K	③	L/10	E678-13F* ⑧ ⑨	1250	0.1	1000 ⑭				
R12421	φ10		300 to 650	400K	420	BA	K	④	L/10	E678-13F* ⑩	1250	0.1	1000 ⑰				
R2557	φ10		300 to 650	402K	375	LBA	K	③	L/10	E678-13F*	1250	0.03	1000 ⑰				
R4177-01	φ10		300 to 650	401K	375	HBA	K	⑤	L/10	E678-13E*	1800	0.02	1500 ⑭				
R1463	φ10		185 to 850	500U	420	MA	U	③	L/10	E678-13F* ⑧ ⑨	1250	0.01	1000 ⑭				

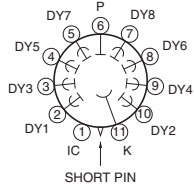
## Dimensional outlines (Unit: mm)

### ① R2496, R1635



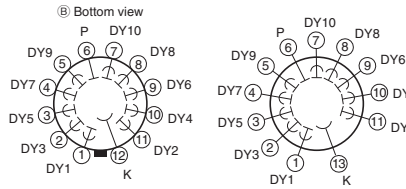
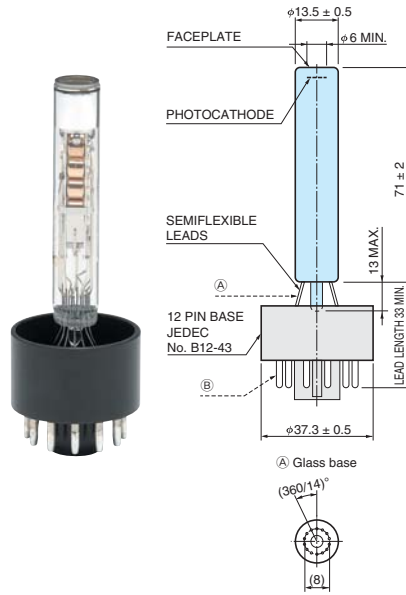
	R1635	R2496
A	φ9.7 ± 0.4	φ10.5 ± 0.5

R2496 has a plano-concave faceplate.



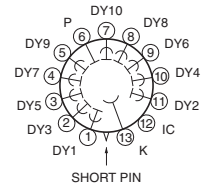
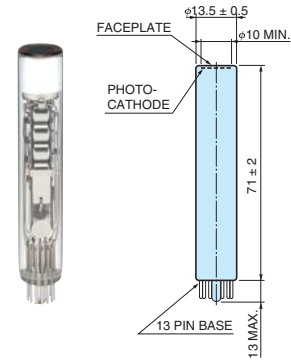
TPMHA0100EB

### ② R1081, R1080



TPMHA0207EA

### ③ R759, R647, R2557, R1463

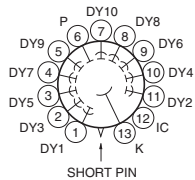
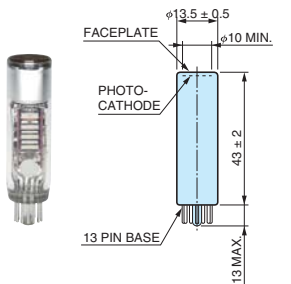


TPMHA0014EA

(at 25 °C)

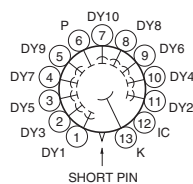
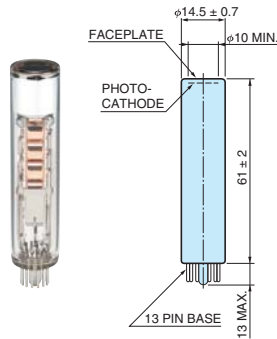
Cathode characteristics					Anode characteristics <sup>M</sup>							Notes	Type No. <sup>A</sup>	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response			
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)			Transit time Typ. (ns)
60	100	10.0	—	80	30	100	$8.0 \times 10^4$	$1.0 \times 10^6$	2	50	0.7	9.0	R2496	
60	100	10.0	—	80	30	100	$8.0 \times 10^4$	$1.0 \times 10^6$	1	50	0.8	9.0	R1635	
—	—	—	—	12 <sup>a</sup>	$2 \times 10^2$ (A/W) <sup>a</sup>	—	$1.2 \times 10^3$ <sup>a</sup>	$1.0 \times 10^5$	0.03	0.05	1.8	18	R1081	
—	—	—	—	28 <sup>b</sup>	$4 \times 10^3$ (A/W) <sup>b</sup>	—	$1.4 \times 10^4$ <sup>b</sup>	$5.0 \times 10^5$	0.3	1	2.5	24	R1080	
—	—	—	—	28 <sup>b</sup>	$4 \times 10^3$ (A/W) <sup>b</sup>	—	$1.4 \times 10^4$ <sup>b</sup>	$5.0 \times 10^5$	0.3	1	2.5	24	R759	
40	110	10.0	—	80	30	110	$8.0 \times 10^4$	$1.0 \times 10^6$	1	15	2.1	22	For photon counting: R647P UV glass window: R960 Silica glass window: R760 R647	
80	110	10.0	—	80	100	220	$1.6 \times 10^5$	$2.0 \times 10^6$	0.5	2	1.2	14	For photon counting UV glass window: R12421-03 Low dark count type: R12421P R12421	
25	40	5.5	—	50	50	200	$2.5 \times 10^5$	$5.0 \times 10^6$	0.5	4	2.2	22	For photon counting: R2557P R2557	
20	40	6.0	—	51	10	20	$2.6 \times 10^4$	$5.0 \times 10^5$	0.5	10	2.0	20	Semiflexible lead: R4177 High temp. operation (Maximum Temp.: +175 °C) R4177-01	
80	120	—	0.2	51	30	120	$5.1 \times 10^4$	$1.0 \times 10^6$	4	20	2.5	24	R1463	

## 4 R12421



TPMHA0603EA

## 5 R4177-01



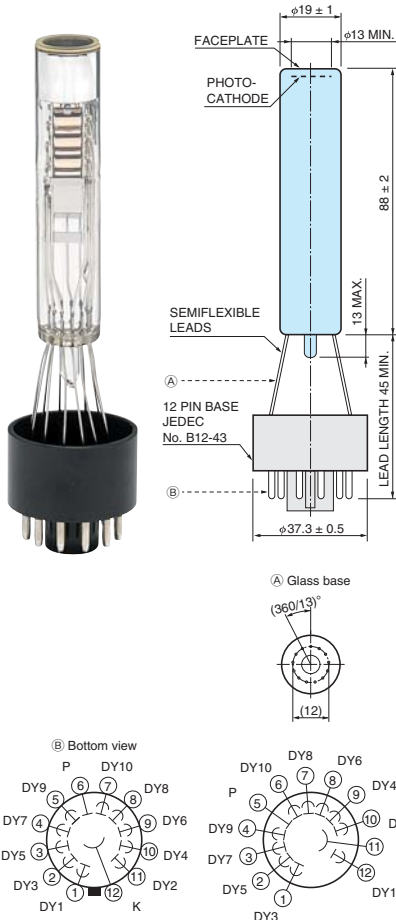
TPMHA0006EA

# Head-on type photomultiplier tubes

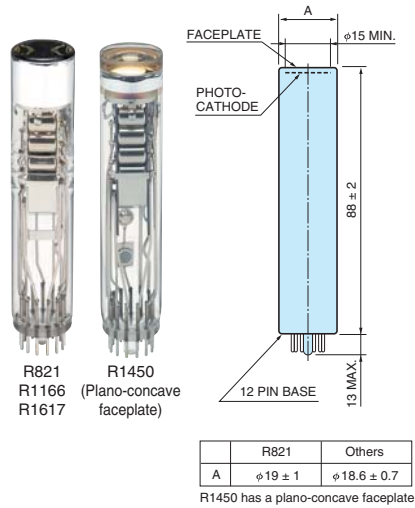
A Type No.	Spectral response										Remarks				Max. ratings H	
	Effective area (mm)		Spectral response range (nm)	Curve code	Peak wavelength (nm)	Photo-cathode material	Window material	Out-line No.	Dynode structure / Stages	Socket & socket assembly	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)			
Wavelength (nm)																
<b>19 mm (3/4") Dia. types</b>																
R972	φ13		115 to 200	100M	140	Cs-I	MF	①	L/10	E678-12A*	2250	0.01	2000 ⑩			
R821	φ15		160 to 320	200S	240	Cs-Te	Q	②	L/10	E678-12L* ⑪⑫⑬	1250	0.01	1000 ⑩			
R1166	φ15		300 to 650	400K	420	BA	K	②	L/10	E678-12L* ⑪⑫⑬	1250	0.1	1000 ⑩			
R1450	φ15		300 to 650	400K	420	BA	K	②	L/10	E678-12L* ⑭	1800	0.1	1500 ⑱			
R3478	φ15		300 to 650	400K	420	BA	K	③	L/8	E678-12L* ⑮⑯	1800	0.1	1700 ④			
R5610A	φ15		300 to 650	402K	375	LBA	K	④	C+L/10	E678-12T* ⑰	1250	0.1	1000 ⑱			
R5611A-01	φ15		300 to 650	400K	420	BA	K	⑤	C+L/10	E678-12A*	1250	0.1	1000 ⑱			
R3991A	φ15		300 to 650	401K	375	HBA	K	⑤	C+L/10	E678-12R*	1800	0.02	1500 ⑱			
R1617	φ15		300 to 850	500K	420	MA	K	②	L/10	E678-12L* ⑪⑫⑬	1250	0.1	1000 ⑩			
R1878	φ4		300 to 850	500K	420	MA	K	⑥	L/10	E678-12L* ⑰	1250	0.1	1000 ⑱			

## Dimensional outlines (Unit: mm)

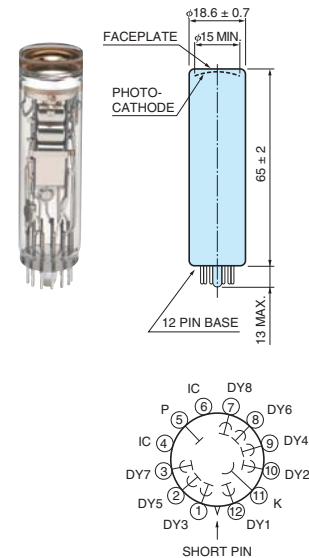
### ① R972



### ② R821, R1166, R1450, R1617



### ③ R3478



TPMHA0119EB

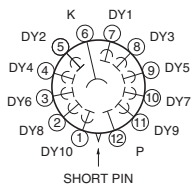
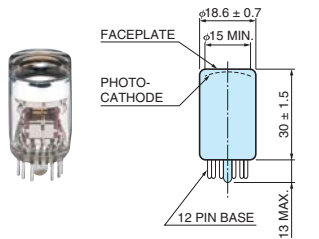
**Cathode characteristics**

**Anode characteristics <sup>M</sup>**

(at 25 °C)

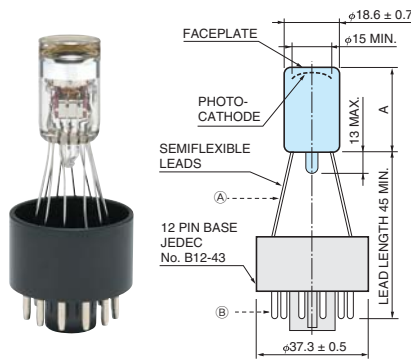
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
—	—	—	—	12 <sup>a</sup>	$2 \times 10^2$ (A/W) <sup>a</sup>	—	$1.2 \times 10^3$ <sup>a</sup>	$1.0 \times 10^5$	0.03	0.05	1.6	17		R972
—	—	—	—	28 <sup>b</sup>	$4 \times 10^3$ (A/W) <sup>b</sup>	—	$1.0 \times 10^4$ <sup>b</sup>	$3.6 \times 10^5$	0.3	0.5	2.5	27	MgF <sub>2</sub> window: R976 (Dimensional Outline: ①)	R821
70	110	10.5	—	85	10	110	$8.5 \times 10^4$	$1.0 \times 10^6$	1	5	2.5	27	For photon counting: R1166P UV glass window: R750	R1166
70	115	11.0	—	88	100	200	$1.5 \times 10^5$	$1.7 \times 10^6$	3	50	1.8	19		R1450
70	115	11.0	—	88	100	200	$1.5 \times 10^5$	$1.7 \times 10^6$	10	300	1.3	14	UV glass window: R3479 Silica glass window: R2076	R3478
30	50	6.5	—	50	20	100	$1.0 \times 10^5$	$2.0 \times 10^6$	0.5	4	1.3	12	For photon counting: R5610P Maximum Temp.: +70 °C	R5610A
60	90	10.5	—	85	40	180	$1.7 \times 10^5$	$2.0 \times 10^6$	3	20	1.3	12	Button stem: R5611A	R5611A-01
20	40	6.0	—	51	5	20	$2.6 \times 10^4$	$5.0 \times 10^5$	0.1	10	1.0	10	High temp. operation (Maximum Temp.: +175 °C)	R3991A
80	120	—	0.2	51	30	120	$5.1 \times 10^4$	$1.0 \times 10^6$	4	20	2.5	27	UV glass window: R1464 Silica glass window: R2027	R1617
80	120	—	0.2	51	30	150	$6.1 \times 10^4$	$1.2 \times 10^6$	100 <sup>⊕</sup>	250 <sup>⊕</sup>	1.7	24	Bialkali photocathode: R2295	R1878

**④ R5610A**

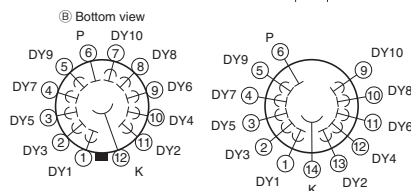
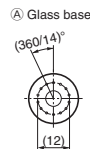


TPMHA0269EA

**⑤ R5611A-01, R3991A**

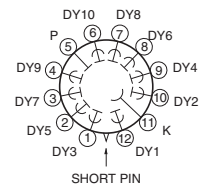
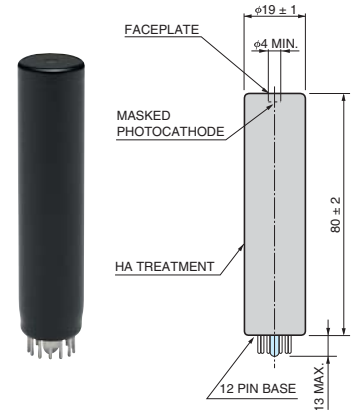


	R5611A-01	R3991A
A	30 ± 1.5	28 ± 1.5



TPMHA0036EC

**⑥ R1878**



TPMHA0027EA



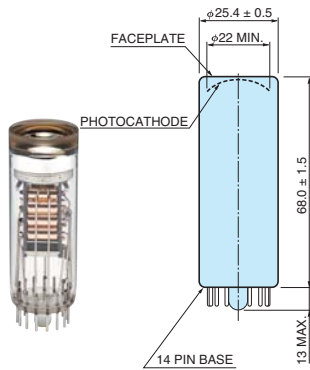
**Cathode characteristics**

**Anode characteristics <sup>M</sup>**

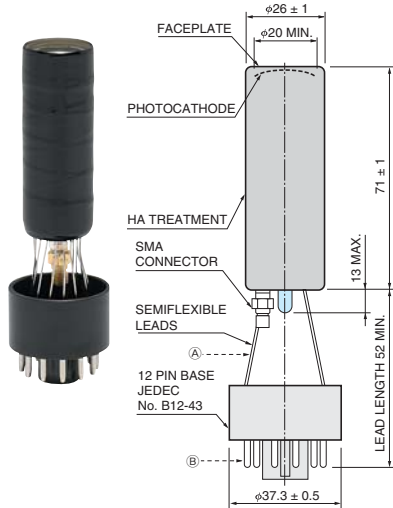
(at 25 °C)

Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No.
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
—	—	—	—	29 <sup>b</sup>	$2 \times 10^3$ (A/W) <sup>b</sup>	—	$1.5 \times 10^4$ <sup>b</sup>	$5.0 \times 10^5$	0.015	0.1	1.5	14	Better solar-blind characteristics	<b>R2078</b>
70	95	11.0	—	88	20	100	$9.7 \times 10^4$	$1.1 \times 10^6$	5	50	1.0	11	UV glass type: R10560	<b>R9800</b>
70	95	10.0	—	80	10	50	$4.2 \times 10^4$	$5.3 \times 10^5$	3	30	0.9	9.1		<b>R13478*</b>
70	95	11.0	—	88	—	190	$1.8 \times 10^5$	$2.0 \times 10^6$	2	15	1.6	17	Semiflexible lead: R7899-01	<b>R7899</b>
60	80	9.5	—	76	100	400	$3.8 \times 10^5$	$5.0 \times 10^6$	10	200	0.7	10	Assembly type: H6533 Silica glass window: R5320 Silica glass window assembly type: H6610	<b>R4998</b>
60	90	10.5	—	85	40	180	$1.7 \times 10^5$	$2.0 \times 10^6$	3	20	1.5	17	For photon counting: R1924P	<b>R1924A</b>
30	50	7.0	—	55	45	100	$1.1 \times 10^5$	$2.0 \times 10^6$	0.5	4	1.5	17	For photon counting: R3550P Maximum Temp.: +70 °C	<b>R3550A</b>
20	40	6.0	—	51	8	20	$2.6 \times 10^4$	$5.0 \times 10^5$	0.1	10	1.3	13	Button stem: R1288A-01 High temp. operation (Maximum Temp.: +175 °C)	<b>R1288A</b>
80	150	—	0.2	64	20	75	$3.2 \times 10^4$	$5.0 \times 10^5$	3	20	1.5	17	Silica glass window: R1926A	<b>R1925A</b>
130	230	—	0.25	65	20	100	$2.8 \times 10^4$	$4.3 \times 10^5$	3	20	2.2	19	Prism window	<b>R5070A</b>

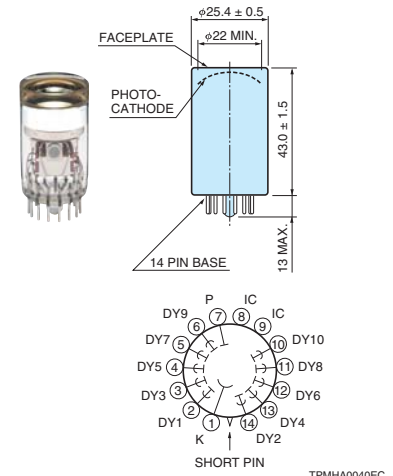
**4 R7899**



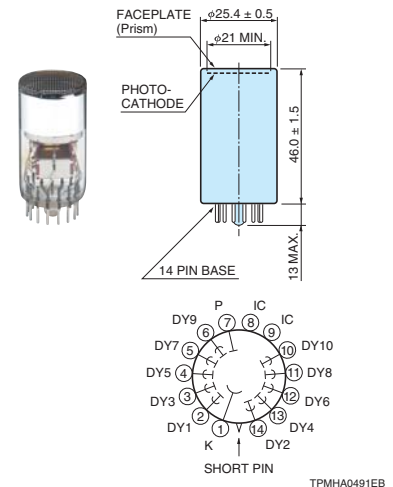
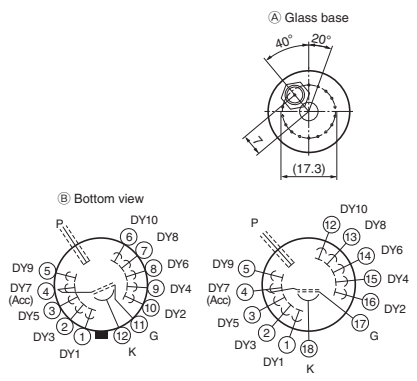
**5 R4998**



**6 R1924A, R3550A, R1925A**



**7 R5070A**

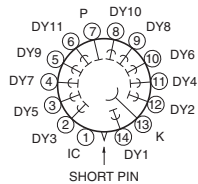
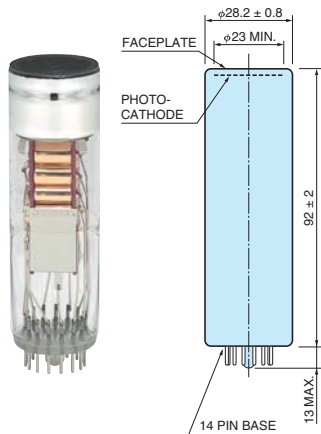


# Head-on type photomultiplier tubes

A Type No.	Spectral response										Remarks				Max. ratings <sup>H</sup>		
	Effective area (mm)		Spectral response range (nm)		B Curve code	C Peak wavelength (nm)	D Photo-cathode material	E Window material	F Out-line No.	G Dynode structure / Stages	H Socket & socket assembly	I Anode to cathode voltage (V)	J Average anode current (mA)	K Anode to cathode supply voltage (V)			
<b>28 mm (1-1/8") Dia. types</b>																	
R6835	φ23		115 to 200	100M	140	Cs-I	MF	①	B+L/11	E678-14C*	2500	0.01	2000 <sup>26</sup>				
R6836	φ23		115 to 320	200M	240	Cs-Te	MF	①	B+L/11	E678-14C*	1500	0.01	1000 <sup>26</sup>				
R6834	φ25		160 to 320	200S	240	Cs-Te	Q	②	B+L/11	E678-14C* <sup>23 24 25</sup>	1500	0.01	1000 <sup>26</sup>				
R6095		φ25	300 to 650	400K	420	BA	K	③	B+L/11	E678-14C* <sup>23 24 25</sup>	1500	0.1	1000 <sup>26</sup>				
R6094		φ25	300 to 650	400K	420	BA	K	④	B+L/11	E678-14C* <sup>23 24 25</sup>	1500	0.1	1000 <sup>26</sup>				
R6427		φ25	300 to 650	400K	420	BA	K	⑤	L/10	E678-14C* <sup>26 27 28</sup>	2000	0.1	1500 <sup>22</sup>				
*R13449		φ25	300 to 650	400K	420	BA	K	⑥	L/8	E678-20B*	1750	0.1	1500 <sup>9</sup>				
R374		φ25	185 to 850	500U	420	MA	U	③	B/11	E678-14C* <sup>23 24 25</sup>	1500	0.1	1000 <sup>26</sup>				

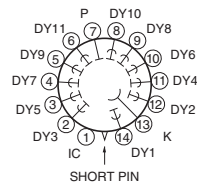
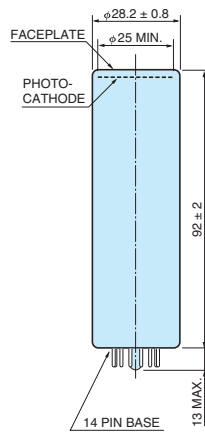
## Dimensional outlines (Unit: mm)

### ① R6835, R6836



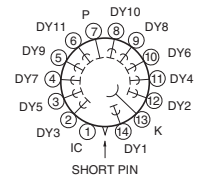
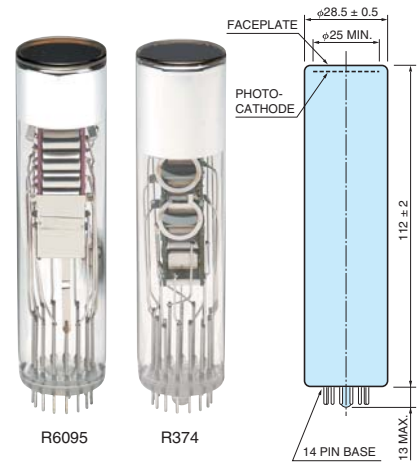
TPMHA0115EC

### ② R6834



TPMHA0226EC

### ③ R6095, R374



TPMHA0482EA



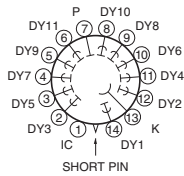
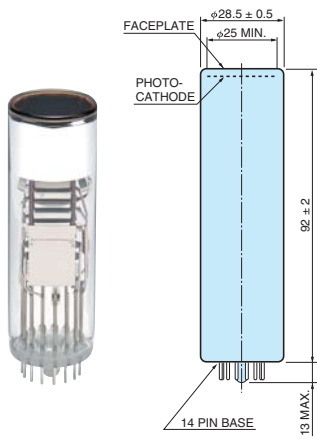
**Cathode characteristics**

**Anode characteristics <sup>M</sup>**

(at 25 °C)

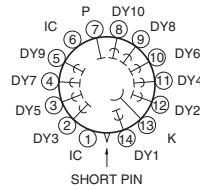
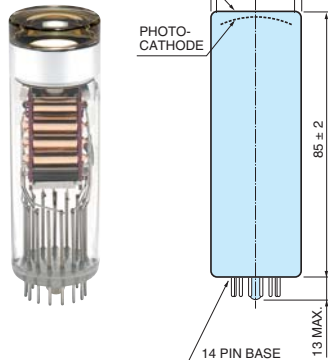
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
—	—	—	—	12 <sup>a</sup>	—	—	$1.2 \times 10^3$ <sup>a</sup>	$1.0 \times 10^5$	0.03	0.05	2.8	22		R6835
—	—	—	—	28 <sup>b</sup>	$4 \times 10^3$ (A/W) <sup>b</sup>	—	$1.4 \times 10^4$ <sup>b</sup>	$5.0 \times 10^5$	0.3	1	4.0	30		R6836
—	—	—	—	28 <sup>b</sup>	$4 \times 10^3$ (A/W) <sup>b</sup>	—	$1.4 \times 10^4$ <sup>b</sup>	$5.0 \times 10^5$	0.3	1	4.0	30		R6834
60	95	11.0	—	88	50	200	$1.8 \times 10^5$	$2.1 \times 10^6$	2	10	4.0	30	For photon counting: R6095P-01	R6095
60	95	11.0	—	88	50	200	$1.8 \times 10^5$	$2.1 \times 10^6$	2	10	4.0	30	For photon counting: R6094P-01	R6094
70	100	11.0	—	88	100	500	$4.4 \times 10^5$	$5.0 \times 10^6$	10	200	1.7	16	UV glass window: R7056	R6427
70	95	10.0	—	80	—	50	$4.2 \times 10^4$	$5.3 \times 10^5$	3	30	0.9	10		R13449*
80	150	—	0.2	64	20	80	$3.4 \times 10^4$	$5.3 \times 10^5$	3	15	15	60	High gain: R1104	R374

**4 R6094**



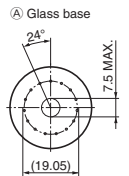
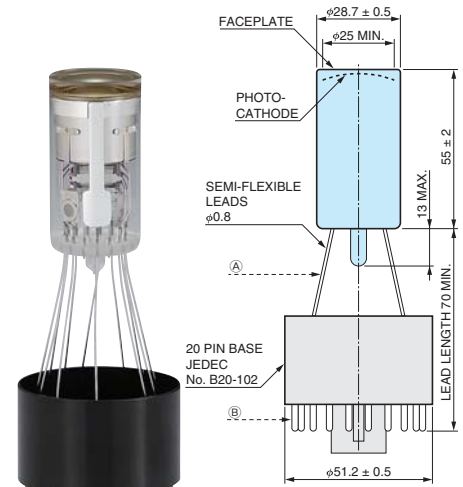
TPMHA0493EA

**5 R6427**



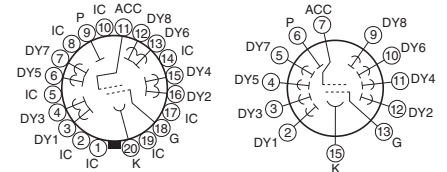
TPMHA0387EA

**6 R13449**



<sup>A</sup> Temporary base removed

<sup>B</sup> Bottom view



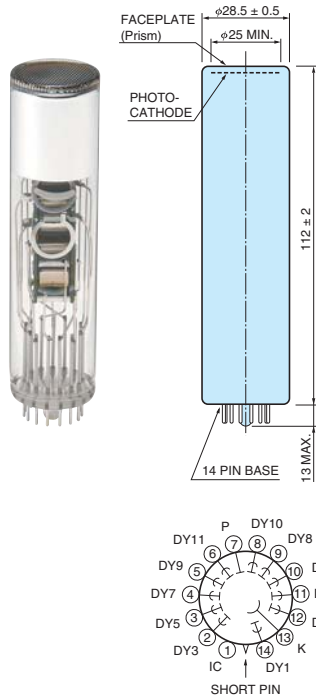
TPMHA0638EA

# Head-on type photomultiplier tubes

A Type No.	Spectral response										Remarks					Max. ratings H		
	Effective area (mm)		Spectral response range (nm)	Curve code B	Peak wavelength (nm)	Photo-cathode material C	Window material D	Out-line No. E	Dynode structure / Stages F	Socket & socket assembly G	Anode to cathode voltage (V) I	Average anode current (mA) J	Anode to cathode supply voltage (V) L					
← Wavelength (nm) →																		
<b>28 mm (1-1/8") Dia. types</b>																		
R5929	φ25		300 to 900	502K	420	MA	K	①	B/11	E678-14C* 23 24 25	1500	0.1	1000 26					
R2228	φ25		300 to 900	501K	600	ERMA	K	②	B/11	E678-14C* 23 24 25	1500	0.1	1000 26					
R7205-01	φ10		300 to 650	400K	420	BA	K	③	B+L/11	E678-14C* 29	1500	0.01	1000 28					
R7206-01	φ10		300 to 850	500K	420	MA	K	③	B+L/11	E678-14C* 29	1500	0.01	1000 28					
R3998-02	φ25		300 to 650	400K	420	BA	K	④	B+L/9	E678-14C* 30	1500	0.1	1000 12					
R7111	φ25		300 to 650	400K	420	BA	K	⑤	C+L/10	E678-14C* 20 21 22	1250	0.1	1000 19					

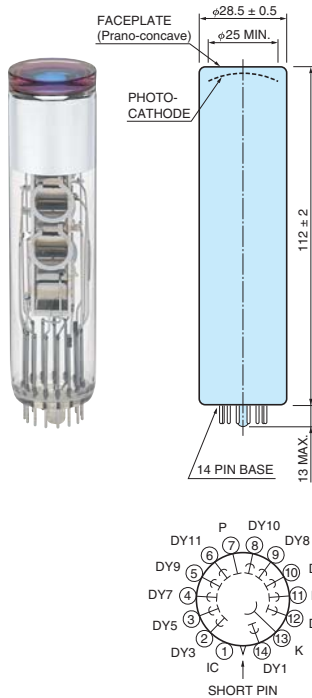
## Dimensional outlines (Unit: mm)

① R5929



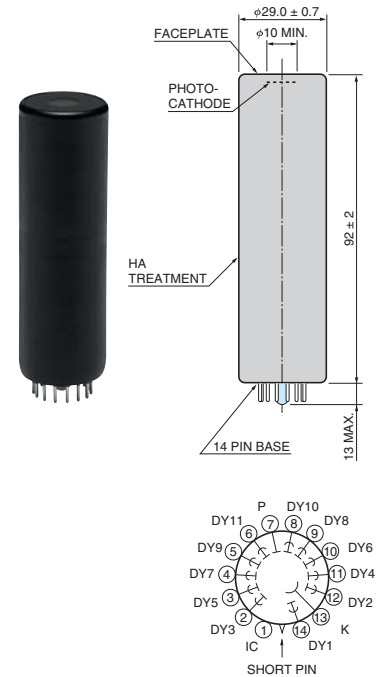
TPMHA0532EA

② R2228



TPMHA0533EA

③ R7205-01, R7206-01



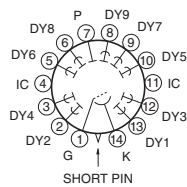
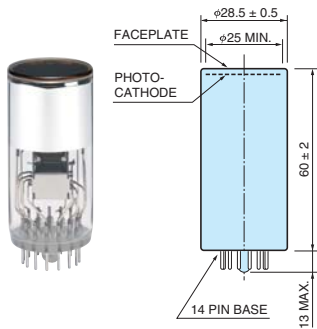
TPMHA0412EC

(at 25 °C)

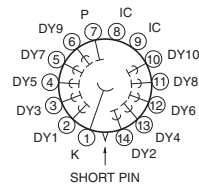
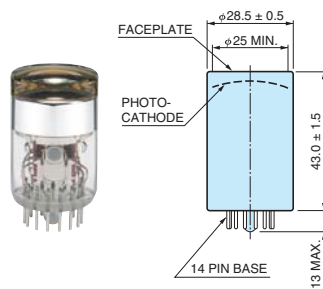
Cathode characteristics					Anode characteristics <sup>M</sup>							Notes	Type No. <sup>A</sup>	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response			
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)			Transit time Typ. (ns)
130	230	—	0.25	65	30	180	$5.1 \times 10^4$	$7.8 \times 10^5$	5	25	15	60	Prism window	R5929
100	200	—	0.3	40	20	150	$3.0 \times 10^4$	$7.5 \times 10^5$	8	30	15	60		R2228
40	70	9.0	—	70	200	700	$7.0 \times 10^5$	$1.0 \times 10^7$	10 <sup>⊕</sup>	30 <sup>⊕</sup>	1.7	26	Silica glass window: R7207-01	R7205-01
80	150	—	0.2	64	200	1500	$6.4 \times 10^5$	$1.0 \times 10^7$	300 <sup>⊕</sup>	1000 <sup>⊕</sup>	1.7	26		R7206-01
60	90	10.5	—	85	50	120	$1.1 \times 10^5$	$1.3 \times 10^6$	2	10	4.4	32		R3998-02
60	90	10.5	—	85	40	180	$1.7 \times 10^5$	$2.0 \times 10^6$	3	20	1.6	18		R7111

## 4 R3998-02

## 5 R7111



TPMHA0114EA



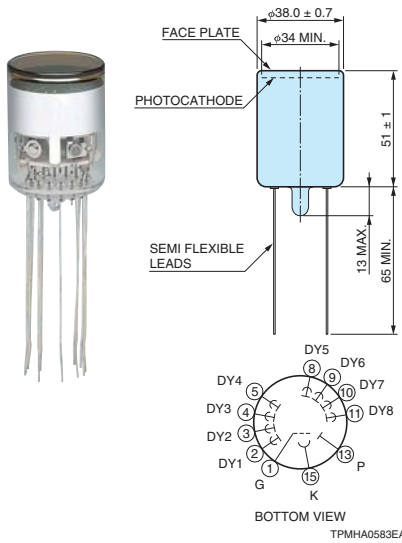
TPMHA0395EB

# Head-on type photomultiplier tubes

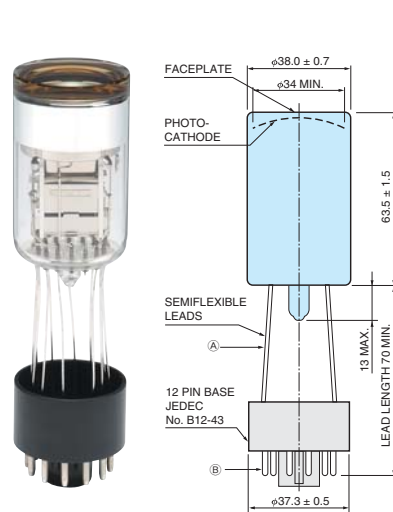
Type No.	Spectral response										Remarks				Max. ratings <sup>H</sup>									
	Effective area (mm)		Spectral response range (nm)	Curve code	Peak wavelength (nm)	Photo-cathode material	Window material	Out-line No.	Dynode structure / Stages	Socket & socket assembly	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)											
← Wavelength (nm) →																								
	100	200	300	400	500	600	700	800	900	1000	1100	1200												
<b>38 mm (1-1/2") Dia. types</b>																								
*R10601																								
R11102																								
R3886A																								
R9420																								
*R13408																								
R580																								
R9722A																								

## Dimensional outlines (Unit: mm)

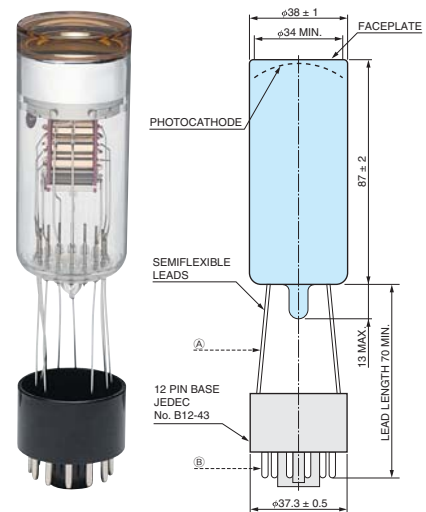
① R10601



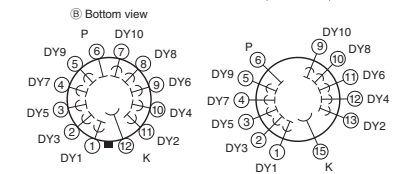
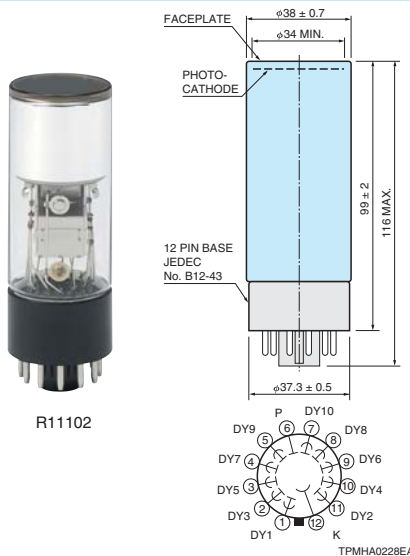
③ R3886A



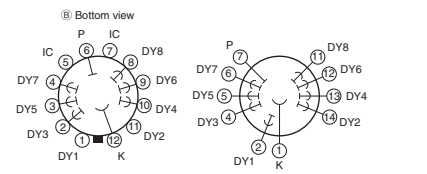
④ R9420



② R11102



TPMHA0104EA



TPMHA0519EC

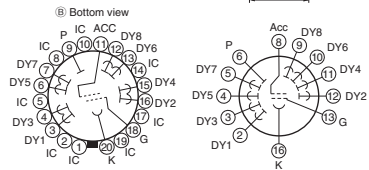
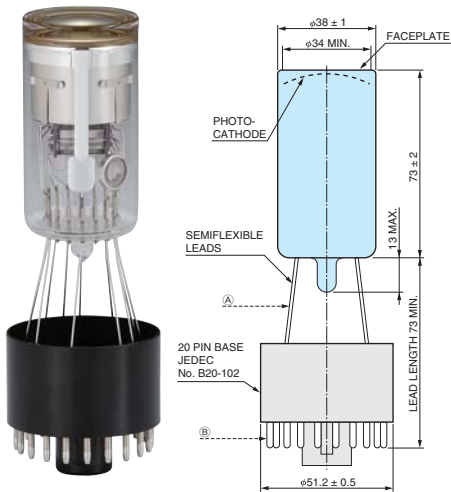
### Cathode characteristics

### Anode characteristics <sup>M</sup>

(at 25 °C)

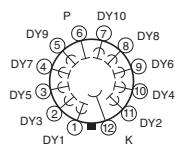
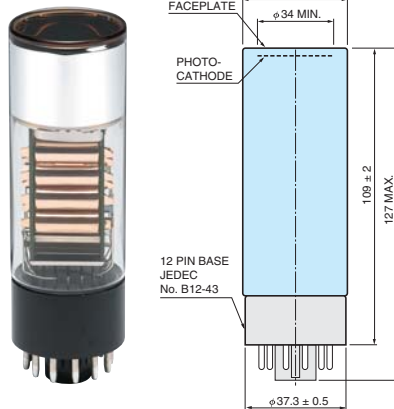
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
80	100	11.5	—	95	3	20	$1.9 \times 10^4$	$2.0 \times 10^5$	2	20	5.3	37	Temporary base: R10601-01	R10601*
80	120	11.5	—	89	10	120	$8.9 \times 10^4$	$1.0 \times 10^6$	2	20	3.2	34		R11102
60	90	10.5	—	85	40	180	$1.7 \times 10^5$	$2.0 \times 10^6$	3	20	2.6	30		R3886A
70	95	11.0	—	88	5	47	$4.4 \times 10^4$	$5.0 \times 10^5$	10	100	1.6	17		R9420
70	95	10.0	—	80	—	50	$4.2 \times 10^4$	$5.3 \times 10^5$	3	30	1.2	13		R13408*
70	95	11.0	—	88	10	100	$9.7 \times 10^4$	$1.1 \times 10^6$	3	20	2.7	37		R580
20	40	6.0	—	51	5	20	$2.6 \times 10^4$	$5.0 \times 10^5$	0.5	10	2.2	26	Button stem: R9722A-01 High temp. operation (Maximum Temp.: +175 °C)	R9722A

### 5 R13408



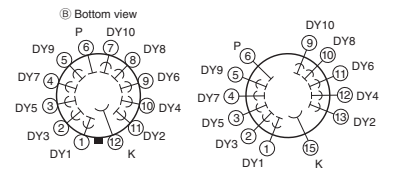
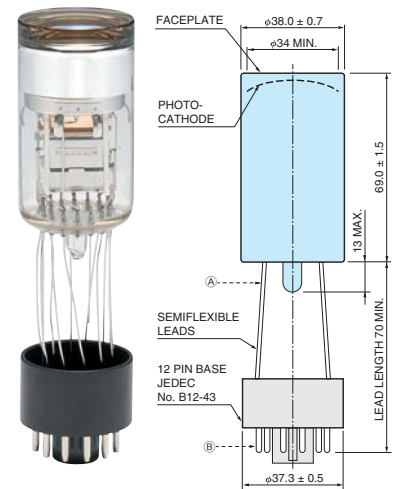
TPMHA0639EA

### 6 R580



TPMHA0121EA

### 7 R9722A



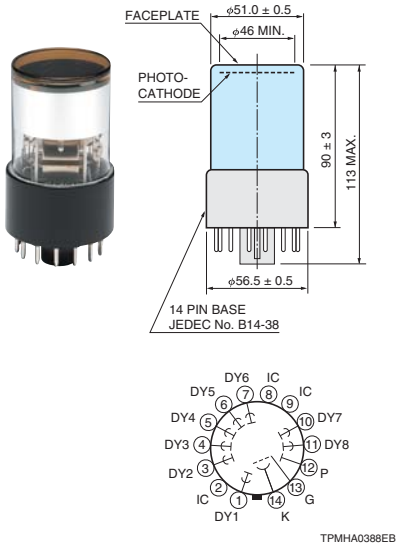
TPMHA0042EB

# Head-on type photomultiplier tubes

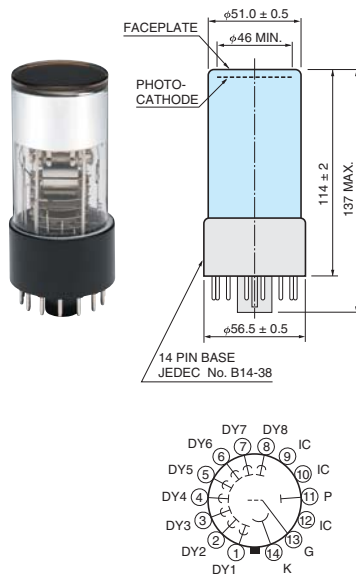
A Type No.	Spectral response				Remarks						Max. ratings <sup>H</sup>		
	Effective area (mm) ← Wavelength (nm) →		Spectral response range (nm)	B Curve code	C Peak wavelength (nm)	C Photo-cathode material	D Window material	E Out-line No.	F Dynode structure / Stages	G Socket & socket assembly	J Anode to cathode voltage (V)	J Average anode current (mA)	L Anode to cathode supply voltage (V)
51 mm (2") Dia. types with plastic base													
R6231	φ46		300 to 650	400K	420	BA	K	①	B+L/8	E678-14W <sup>33 34</sup>	1500	0.1	1000 <sup>5</sup>
*R10131	φ46		300 to 650	400K	420	BA	K	②	B+L/8	E678-14W	1500	0.1	1000 <sup>8</sup>
R1306	φ46		300 to 650	400K	420	BA	K	③	B/8	E678-14W <sup>35 36</sup>	1500	0.1	1000 <sup>2</sup>
R878	φ46		300 to 650	400K	420	BA	K	④	B/10	E678-14W <sup>39 40 41 42</sup>	1500	0.1	1250 <sup>15</sup>
R13089	φ46		300 to 650	400K	420	BA	K	⑤	L/8	E678-20B*	1750	0.1	1500 <sup>9</sup>
*R14550	φ46		300 to 650	400K	420	BA	K	⑥	L/10	E678-14W	1500	0.1	1250 <sup>17</sup>
R1828-01	φ46		300 to 650	400K	420	BA	K	⑦	L/12	E678-20B* <sup>38</sup>	3000	0.2	2500 <sup>29</sup>
R550	φ46		300 to 850	500K	420	MA	K	④	B/10	E678-14W <sup>39 40 41 42</sup>	1500	0.3	1000 <sup>15</sup>

## Dimensional outlines (Unit: mm)

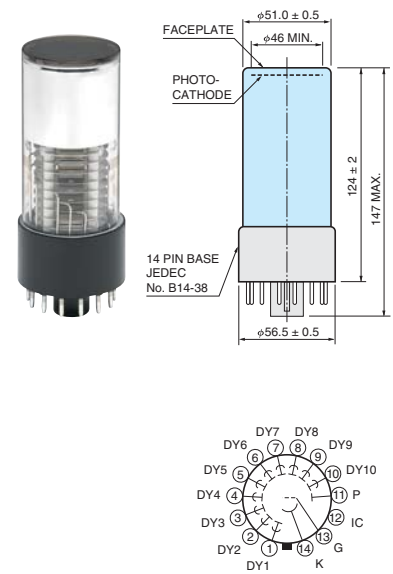
### ① R6231



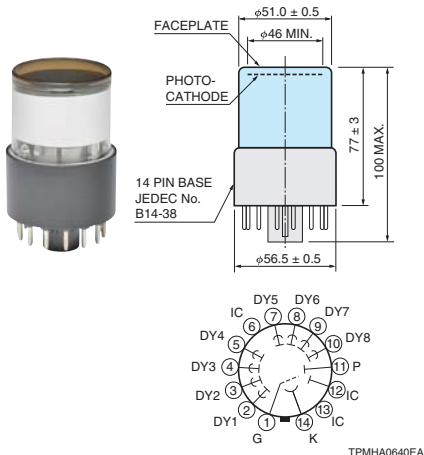
### ③ R1306



### ④ R878, R550



### ② R10131



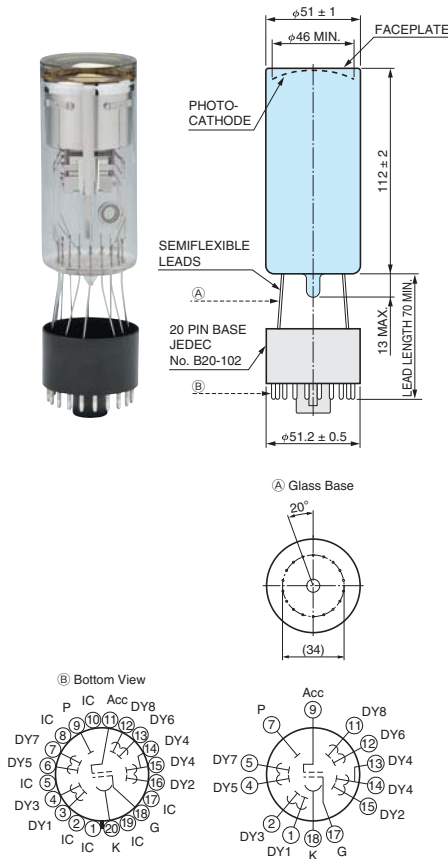
**Cathode characteristics**

**Anode characteristics <sup>M</sup>**

(at 25 °C)

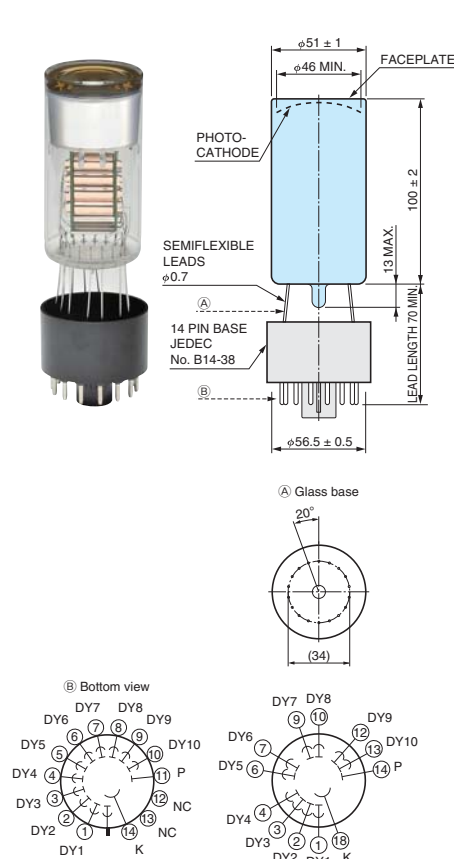
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	8.5	48	Semiflexible lead: R6231-01	<b>R6231</b>
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	7.3	49		<b>R10131*</b>
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	7.0	60		<b>R1306</b>
60	100	11.5	—	90	20	100	$9.0 \times 10^4$	$1.0 \times 10^6$	5	20	7.0	70		<b>R878</b>
70	95	10.0	—	80	10	30	$2.6 \times 10^4$	$3.2 \times 10^5$	10	50	2.0	20		<b>R13089</b>
60	90	10.5	—	85	300	700	$6.6 \times 10^5$	$7.8 \times 10^6$	10	50	3.0	31		<b>R14550*</b>
60	90	10.5	—	85	200	1800	$1.7 \times 10^6$	$2.0 \times 10^7$	50	400	1.3	28	Silica glass window: R2059	<b>R1828-01</b>
100	150	—	0.2	64	20	100	$4.3 \times 10^4$	$6.7 \times 10^5$	10	30	9.0	70		<b>R550</b>

**5 R13089**



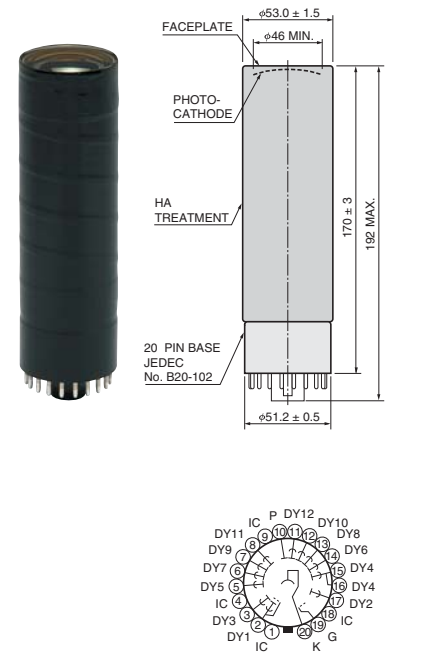
TPMHA0606EA

**6 R14550**



TPMHA0641EA

**7 R1828-01**



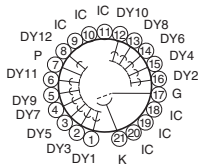
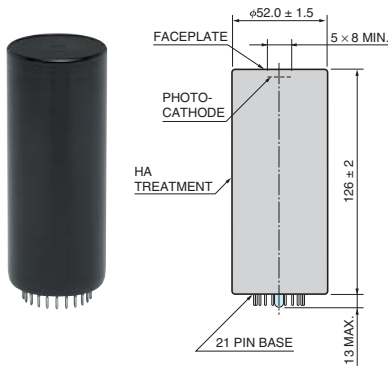
TPMHA0064ED

# Head-on type photomultiplier tubes

A Type No.	Spectral response				Remarks						Max. ratings H		
	Effective area (mm) ← Wavelength (nm) →		Spectral response range (nm)	B Curve code	Peak wave-length (nm)	C Photo-cathode material	D Win-dow material	E Out-line No.	F Dynode structure / Stages	G Socket & socket assembly	J Anode to cathode voltage (V)	K Average anode current (mA)	L Anode to cathode supply voltage (V)
<b>51 mm (2") Dia. types with glass base</b>													
R464	5 × 8		300 to 650	400K	420	BA	K	①	B/12	E678-21C* ④③	1500	0.01	1000 ③①
R7724	φ46		300 to 650	400K	420	BA	K	②	L/10	E678-21C* ④④	2000	0.2	1750 ②③
R329-02	φ46		300 to 650	400K	420	BA	K	③	L/12	E678-21C* ④⑤④⑥④⑦	2700	0.2	1500 ③⑥
R331-05	φ46		300 to 650	400K	420	BA	K	④	L/12	E678-21C* ④⑤④⑥④⑦	2500	0.2	1500 ③⑥
R2083	φ46		300 to 650	400K	420	BA	K	⑤	L/8	E678-19J*	3500	0.2	3000 ①⑥
R4607A-01	φ46		300 to 650	401K	375	HBA	K	⑥	C+L/10	E678-15C*	1800	0.02	1500 ①⑦
R649	5 × 8		300 to 850	500K	420	MA	K	①	B/12	E678-21C* ④③	1500	0.01	1000 ③①

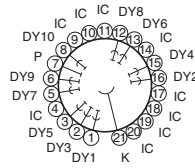
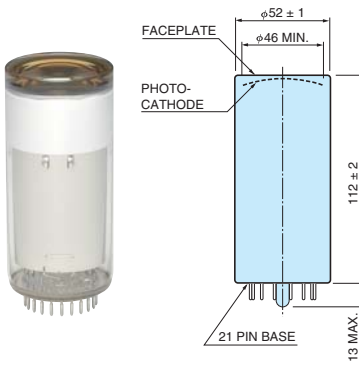
## Dimensional outlines (Unit: mm)

### ① R464, R649



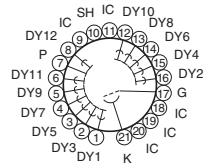
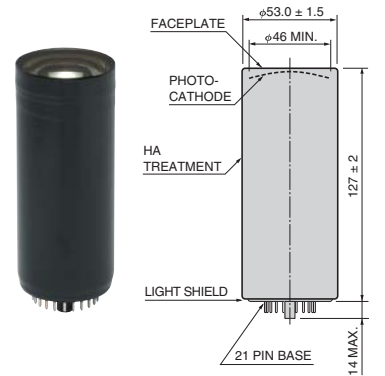
TPMHA0216EC

### ② R7724



TPMHA0509EC

### ③ R329-02



\*CONNECT SH TO DY5

TPMHA0123EE



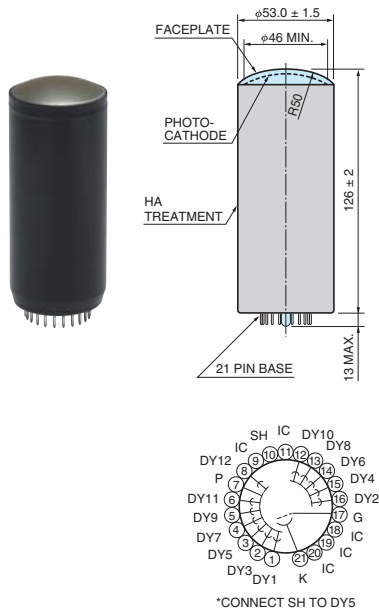
**Cathode characteristics**

**Anode characteristics <sup>M</sup>**

(at 25 °C)

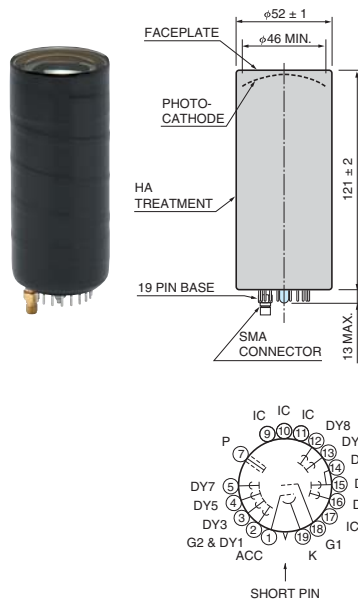
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
30	50	—	—	50	100	300	$3.0 \times 10^5$	$6.0 \times 10^6$	5 <sup>⊕</sup>	15 <sup>⊕</sup>	13	70	Silica glass window: R585 For photon counting	R464
60	90	10.5	—	85	30	300	$2.8 \times 10^5$	$3.3 \times 10^6$	6	40	2.1	29		R7724
60	90	10.5	—	85	30	100	$9.4 \times 10^4$	$1.1 \times 10^6$	6	40	2.6	48	Silica glass window: R2256-02	R329-02
60	90	10.5	—	85	30	120	$1.1 \times 10^5$	$1.3 \times 10^6$	1000 <sup>⊕</sup>	2000 <sup>⊕</sup>	2.6	48		R331-05
60	80	10.0	—	80	50	200	$2.0 \times 10^5$	$2.5 \times 10^6$	100	800	0.8	16	Assembly type: H2431-50 Recommended Silica glass window: R3377 Silica glass window assembly type: H3378-50	R2083
20	40	6.0	—	51	5	20	$2.6 \times 10^4$	$5.0 \times 10^5$	3	50	2.6	28		High temp. operation (Maximum Temp.: +175 °C)
80	120	—	0.2	51	100	800	$3.4 \times 10^5$	$6.7 \times 10^6$	200 <sup>⊕</sup>	350 <sup>⊕</sup>	13	70		R649

**4 R331-05**



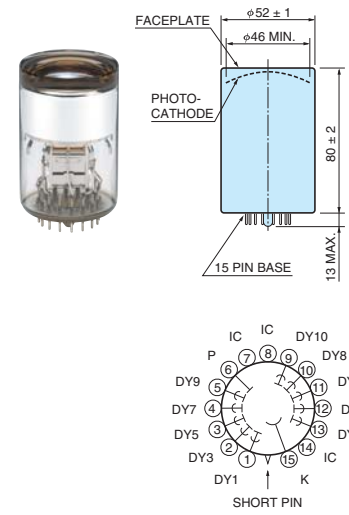
TPMHA0072EC

**5 R2083**



TPMHA0185EC

**6 R4607A-01**



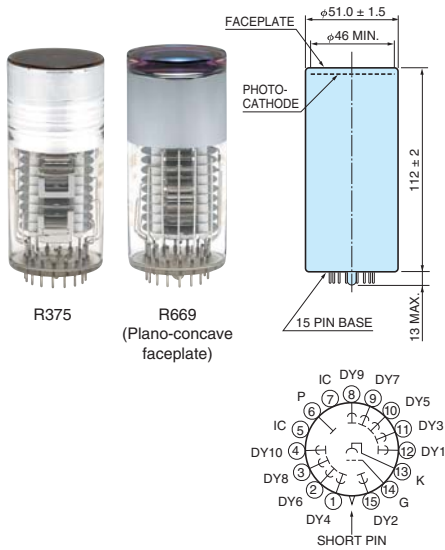
TPMHA0003EC

# Head-on type photomultiplier tubes

A Type No.	Spectral response					Remarks					Max. ratings H		
	Effective area (mm)		Spectral response range (nm)	Curve code B	Peak wavelength (nm)	Photo-cathode material C	Window material D	Out-line No. E	Dynode structure / Stages F	Socket & socket assembly G	Anode to cathode voltage (V) I	Average anode current (mA) J	Anode to cathode supply voltage (V) L
← Wavelength (nm) →													
<b>51 mm (2") Dia. types with glass base</b>													
R375	φ46		160 to 850	500S	420	MA	Q	①	B/10	E678-15C* ④⑧	1500	0.1	1000 ⑮
R669	φ46		300 to 900	501K	600	ERMA	K	①	B/10	E678-15C* ④⑧	1500	0.1	1000 ⑮
R943-02	□10		160 to 930	650S	300-800	GaAs	Q	②	L/10	E678-21C*	2200	0.001	1500 ⑰
R2257	φ46		300 to 900	501K	600	ERMA	K	③	L/12	E678-21C* ④⑤④⑦	2500	0.2	1500 ⑳

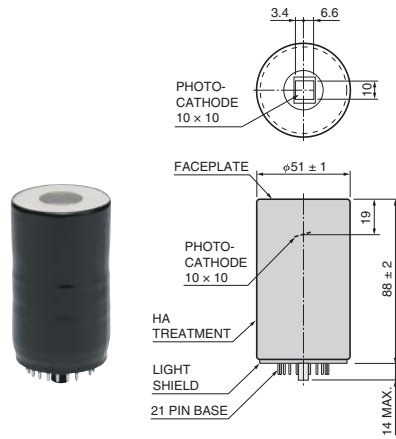
## Dimensional outlines (Unit: mm)

### ① R375, R669



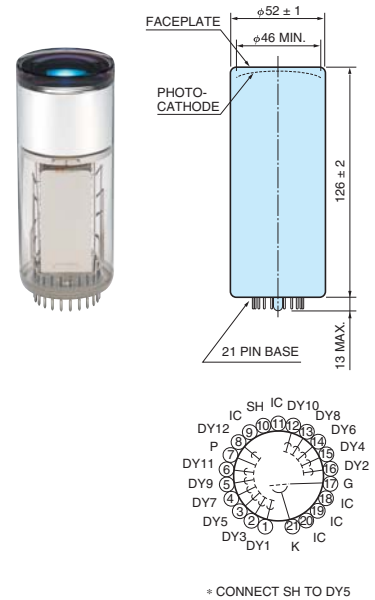
TPMHA0211EA

### ② R943-02



TPMHA0021EF

### ③ R2257



TPMHA0359EB

(at 25 °C)

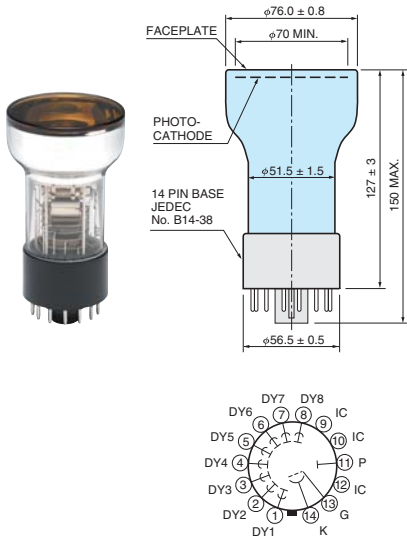
Cathode characteristics					Anode characteristics <sup>M</sup>							Notes	Type No. <sup>A</sup>	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response			
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)			Transit time Typ. (ns)
80	150	—	0.2	64	20	80	$3.4 \times 10^4$	$5.3 \times 10^5$	5	20	9.0	70		<a href="#">R375</a>
140	230	—	0.35	50	20	75	$1.7 \times 10^4$	$3.3 \times 10^5$	7	15	9.0	70		<a href="#">R669</a>
300	600	—	0.58	71	150	300	$3.6 \times 10^4$	$5.0 \times 10^5$	20 <sup>f</sup>	50 <sup>f</sup>	3.0	23	For photon counting	<a href="#">R943-02</a>
140	230	—	0.35	50	15	100	$2.2 \times 10^4$	$4.3 \times 10^5$	30	100	2.6	48		<a href="#">R2257</a>

# Head-on type photomultiplier tubes

A Type No.	Spectral response										Remarks				Max. ratings H						
	Effective area (mm) ← Wavelength (nm) →										Spectral response range (nm)	Curve code B	Peak wavelength (nm)	Photo-cathode material C	Window material D	Out-line No. E	Dynode structure / Stages F	Socket & socket assembly G	Anode to cathode voltage (V) J	Average anode current (mA)	Anode to cathode supply voltage (V) L
<b>76 mm (3") Dia. types</b>																					
R1307											300 to 650	400K	420	BA	K	①	B/8	E678-14W 35 36	1500	0.1	1000 ②
R6233											300 to 650	400K	420	BA	K	②	B+L/8	E678-14W 33 34	1500	0.1	1000 ⑤
*R12772											300 to 650	400K	420	BA	K	③	B/10	E678-14W 39 40 41 42	1500	0.1	1000 ⑬
R6091											300 to 650	400K	420	BA	K	④	L/12	E678-21C* 45 46 47	2500	0.2	1500 ⑳

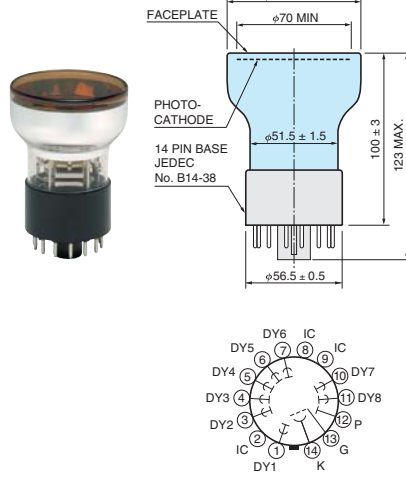
## Dimensional outlines (Unit: mm)

① R1307



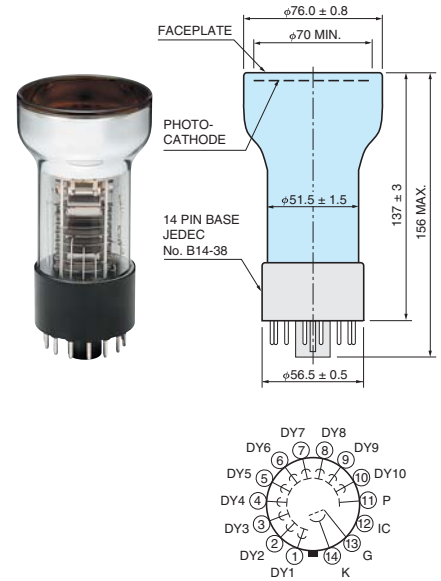
TPMHA0078EA

② R6233



TPMHA0389EB

③ R12772

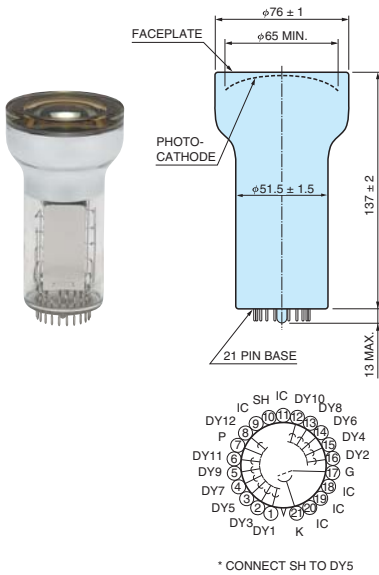


TPMHA0557EA

(at 25 °C)

Cathode characteristics					Anode characteristics <sup>M</sup>							Notes	Type No. <sup>A</sup>	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response			
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)			Transit time Typ. (ns)
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	8.0	64	Semiflexible lead: R1307-01	<b>R1307</b>
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	9.5	52	Semiflexible lead: R6233-01	<b>R6233</b>
80	110	11.5	—	95	10	90	$7.8 \times 10^4$	$8.2 \times 10^5$	2	20	18.5	85		<b>R12772*</b>
60	90	10.5	—	85	50	450	$4.3 \times 10^5$	$5.0 \times 10^6$	10	60	2.6	48		<b>R6091</b>

#### 4 R6091



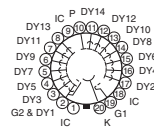
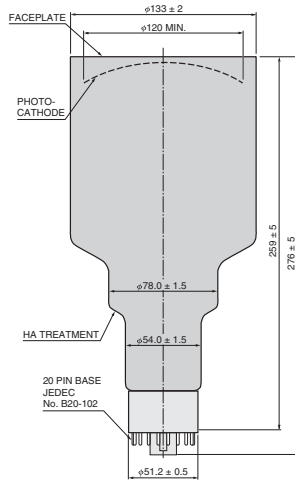
TPMHA0285ED



(at 25 °C)

Cathode characteristics					Anode characteristics <sup>M</sup>							Notes	Type No. <sup>A</sup>	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response			
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)			Transit time Typ. (ns)
60	80	9.5	—	76	10	40	$3.8 \times 10^4$	$5.0 \times 10^5$	10	50	3.3	41		R11833-03*
60	90	10.5	—	85	20	40	$3.7 \times 10^4$	$4.4 \times 10^5$	10	50	20	115	K-free borosilicate glass: R877-01	R877
100	150	—	0.2	64	10	50	$2.1 \times 10^4$	$3.3 \times 10^5$	30	150	15	82		R1513
55	70	9.0	—	72	300	1000	$1.0 \times 10^6$	$1.4 \times 10^7$	50	300	2.5	54		R1250

### 3 R1250



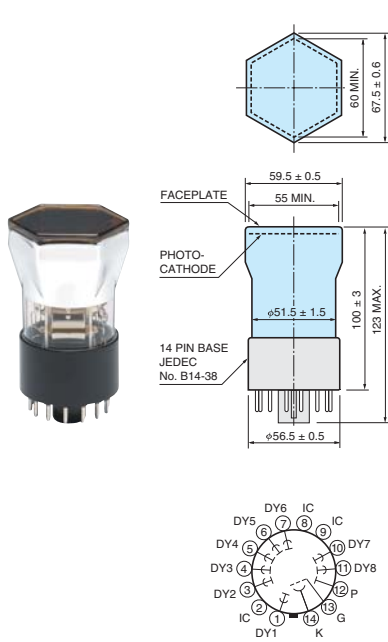
TPMHA0018EC

# Hexagonal type, Rectangular type photomultiplier tubes

A Type No.	Spectral response										Remarks				Max. ratings H		
	Effective area (mm)		Spectral response range (nm)	Curve code	Peak wavelength (nm)	Photo-cathode material	Window material	Out-line No.	Dynode structure / Stages	Socket & socket assembly	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)				
← Wavelength (nm) →																	
<b>Hexagonal types</b>																	
R6234	55 (6)		300 to 650	400K	420	BA	K	①	B+L/8	E678-14W ③④	1500	0.1	1000 ⑤				
R6235	70 (6)		300 to 650	400K	420	BA	K	②	B+L/8	E678-14W ③④	1500	0.1	1000 ⑤				
<b>Rectangular types</b>																	
R6236	□54		300 to 650	400K	420	BA	K	③	B+L/8	E678-14W ③④	1500	0.1	1000 ⑤				
R6237	□70		300 to 650	400K	420	BA	K	④	B+L/8	E678-14W ③④	1500	0.1	1000 ⑤				
R2248	□8		300 to 650	400K	420	BA	K	⑤	L/8	E678-11N* ⑥	1500	0.03	1250 ①				

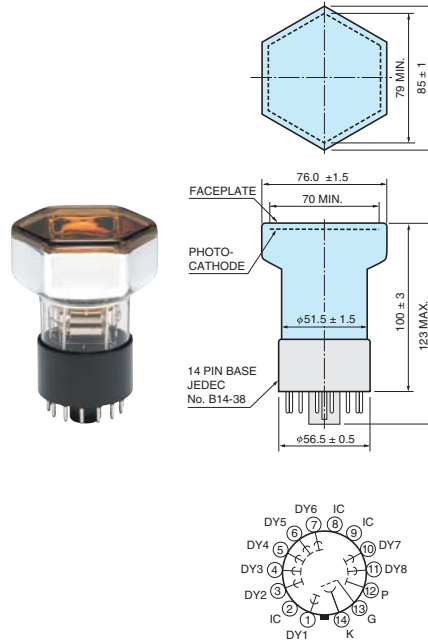
## Dimensional outlines (Unit: mm)

① R6234



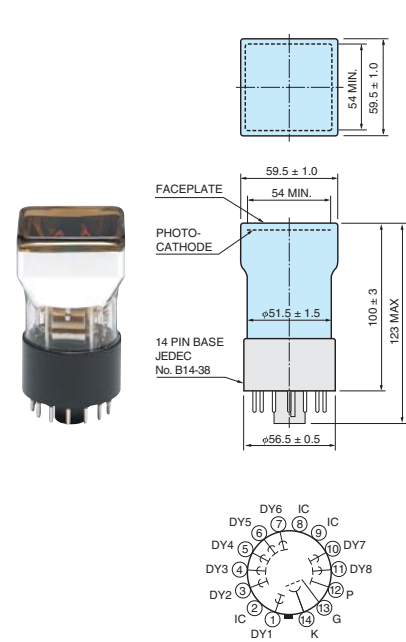
TPMHA0390EB

② R6235



TPMHA0391EB

③ R6236



TPMHA0392EC



**Cathode characteristics**

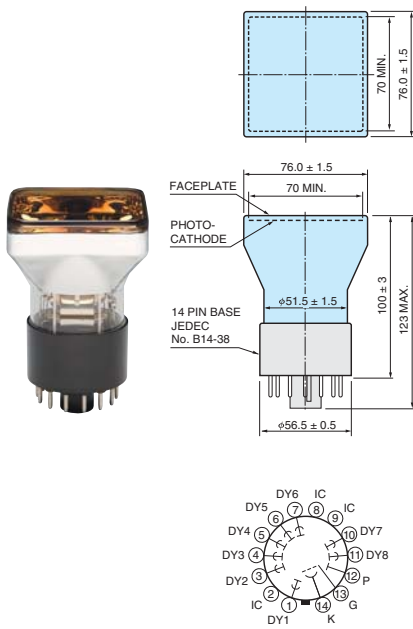
**Anode characteristics <sup>M</sup>**

(at 25 °C)

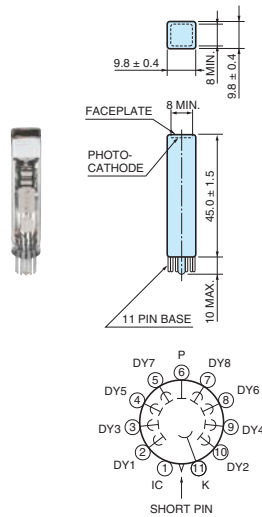
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	9.5	52	Semiflexible lead: R6234-01	<b>R6234</b>
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	9.5	52	Semiflexible lead: R6235-01	<b>R6235</b>
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	9.5	52	Semiflexible lead: R6236-01	<b>R6236</b>
80	110	11.5	—	95	3	30	$2.6 \times 10^4$	$2.7 \times 10^5$	2	20	9.5	52	Semiflexible lead: R6237-01	<b>R6237</b>
60	95	9.5	—	76	30	100	$8.0 \times 10^4$	$1.1 \times 10^6$	1	50	0.9	9		<b>R2248</b>

**4 R6237**

**5 R2248**



TPMHA0393EC



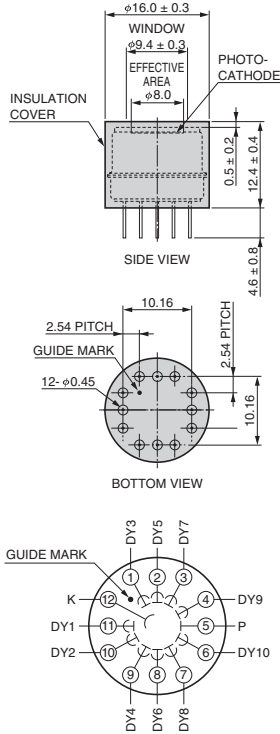
TPMHA0098EB

# Metal package photomultiplier tubes

A Type No.	Spectral response		Spectral response range (nm)	Peak wave-length (nm)	Remarks					Max. ratings H		
	Effective area (mm)	Wavelength (nm)			C Photo-cathode material	D Win-dow material	E Out-line No.	F Dynode structure / Stages	G Socket & socket assembly	I Anode to cathode voltage (V)	J Average anode current (mA)	L Anode to cathode supply voltage (V)
R9880U-01	$\phi 8$	← 100 200 300 400 500 600 700 800 900 1000 1100 1200 →	230 to 870	400	MA	K	①	MC/10	E678-12-01 50 51	1100	0.1	1000 ⑬
R9880U-04	$\phi 8$		185 to 870	400	MA	U	①	MC/10	E678-12-01 50 51	1100	0.1	1000 ⑬
R9880U-20	$\phi 8$		230 to 920	630	ERMA	K	①	MC/10	E678-12-01 50 51	1100	0.1	1000 ⑬
R9880U-110	$\phi 8$		230 to 700	400	SBA	K	①	MC/10	E678-12-01 50 51	1100	0.1	1000 ⑬
R9880U-113	$\phi 8$		185 to 700	400	SBA	U	①	MC/10	E678-12-01 50 51	1100	0.1	1000 ⑬
*R9880U-116	$\phi 8$		160 to 700	400	SBA	Q	②	MC/10	E678-12-01 50 51	1100	0.1	1000 ⑬
R9880U-210	$\phi 8$		230 to 700	400	UBA	K	①	MC/10	E678-12-01 50 51	1100	0.1	1000 ⑬

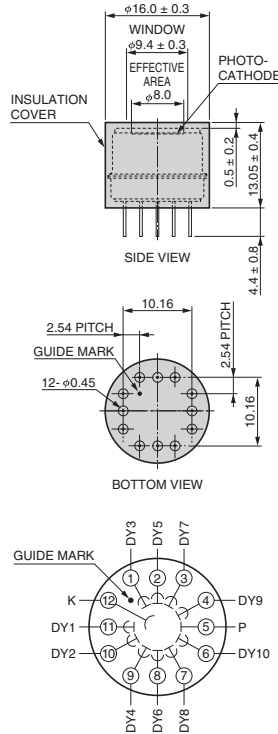
## Dimensional outlines (Unit: mm)

### ① R9880U-01, -20, etc.



TPMHA0539ED

### ② R9880U-116



TPMHA0642ED

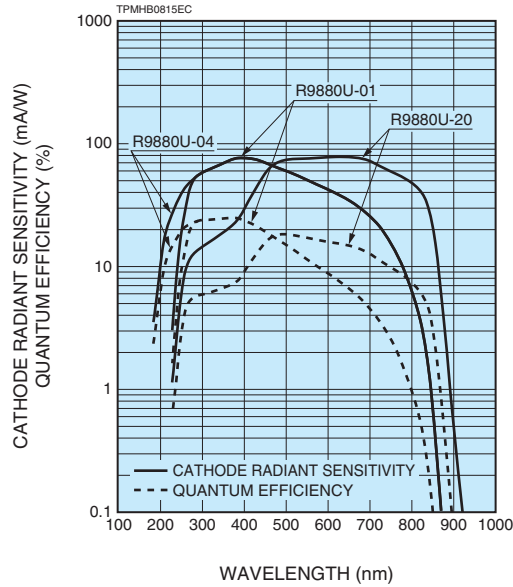
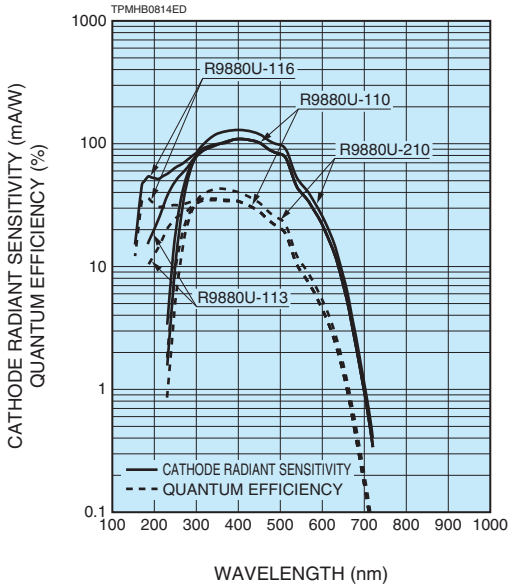
**Cathode characteristics**

**Anode characteristics <sup>M</sup>**

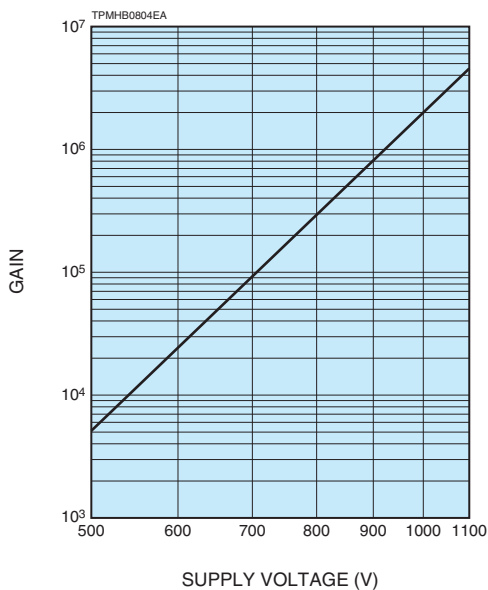
(at 25 °C)

Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
100	200	—	0.2	77	100	400	$1.5 \times 10^5$	$2.0 \times 10^6$	1	10	0.57	2.7		R9880U-01
100	200	—	0.2	77	100	400	$1.5 \times 10^5$	$2.0 \times 10^6$	1	10	0.57	2.7		R9880U-04
350	500	—	0.45	78	350	1000	$1.5 \times 10^5$	$2.0 \times 10^6$	10	100	0.57	2.7		R9880U-20
80	105	13.5	—	110	80	210	$2.2 \times 10^5$	$2.0 \times 10^6$	1	10	0.57	2.7		R9880U-110
80	105	13.5	—	110	80	210	$2.2 \times 10^5$	$2.0 \times 10^6$	1	10	0.57	2.7		R9880U-113
80	105	13.5	—	110	80	210	$2.2 \times 10^5$	$2.0 \times 10^6$	1	10	0.57	2.7		R9880U-116*
100	135	15.5	—	130	100	270	$2.6 \times 10^5$	$2.0 \times 10^6$	1	10	0.57	2.7		R9880U-210

**Spectral response**



**Gain**





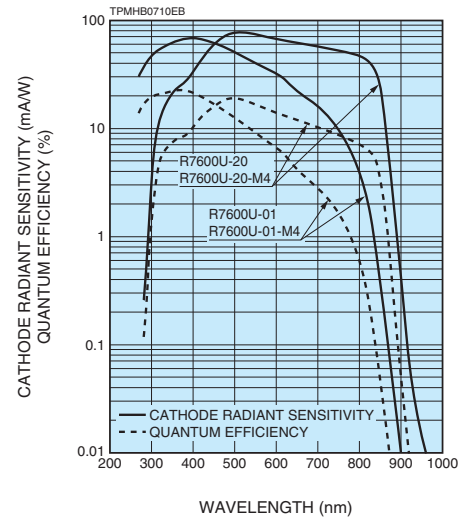
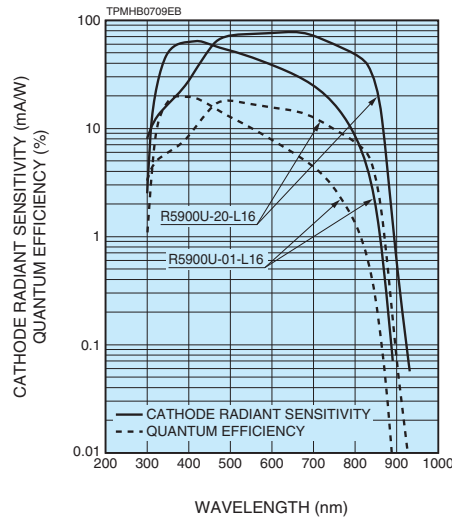
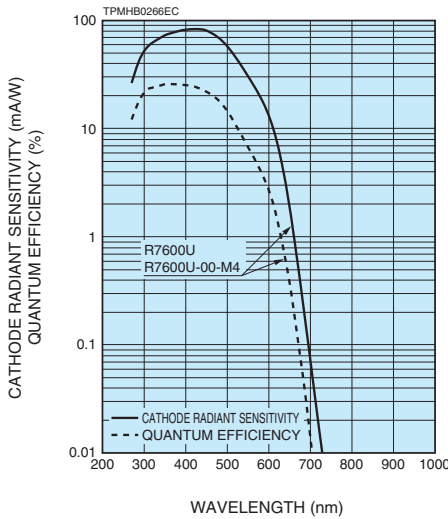
### Cathode characteristics

### Anode characteristics <sup>M</sup>

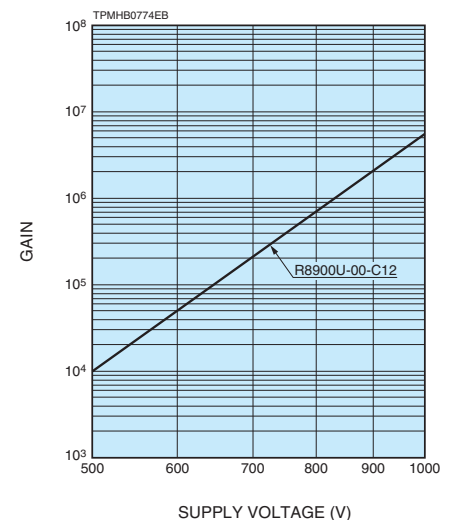
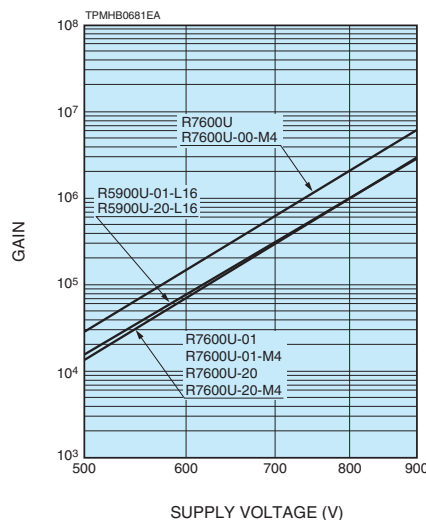
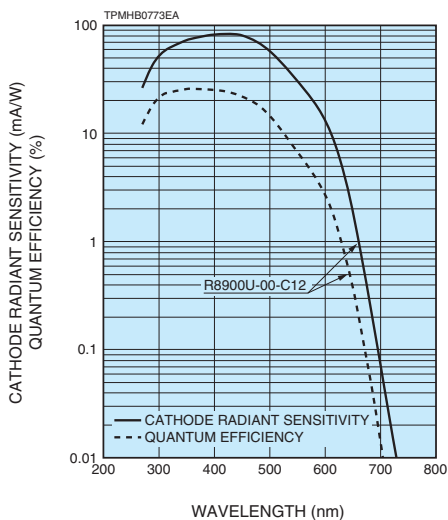
(at 25 °C)

Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No.
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
60	80	9.5	—	80	40	160	$1.6 \times 10^5$	$2.0 \times 10^6$	2	20	1.6	9.6	UV glass window: R7600U-03 For photon counting: R7600P	R7600U
150	200	—	0.2	65	50	200	$6.5 \times 10^4$	$1.0 \times 10^6$	10	50	1.6	9.6		R7600U-01
350	500	—	0.4	78	100	500	$7.8 \times 10^4$	$1.0 \times 10^6$	20	50	1.6	9.6		R7600U-20
60	80	9.5	—	80	25	140	$1.4 \times 10^5$	$1.8 \times 10^6$	0.5/ch	5/ch	1.2	9.5	UV glass window: R7600U-03-M4	R7600U-00-M4
150	200	—	0.2	65	50	200	$6.5 \times 10^4$	$1.0 \times 10^6$	2.5/ch	12.5/ch	1.2	9.5		R7600U-01-M4
350	500	—	0.4	78	100	500	$7.8 \times 10^4$	$1.0 \times 10^6$	2.5/ch	12.5/ch	1.2	9.5		R7600U-20-M4
150	250	—	0.3	65	75	250	$6.5 \times 10^4$	$1.0 \times 10^6$	0.5/ch	5/ch	0.6	7.4	UV glass window: R5900U-04-L16	R5900U-01-L16
350	500	—	0.45	78	175	500	$7.8 \times 10^4$	$1.0 \times 10^6$	1/ch	10/ch	0.6	7.4		R5900U-20-L16
60	85	10.0	—	82	15	60	$5.8 \times 10^4$	$0.7 \times 10^6$	2	10	2.2	11.9		R8900U-00-C12
350	500	—	0.4	78	250	1200	$1.9 \times 10^5$	$2.4 \times 10^6$	30	200	1.3	5.8		R11265U-20*

### Spectral response



### Gain



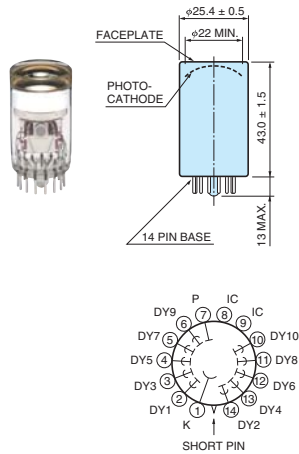
# UBA (Ultra Bialkali), SBA (Super Bialkali) photomultiplier tubes,

A Type No.	Spectral response											Remarks				Max. ratings <sup>H</sup>		
	Effective area (mm)		Spectral response range (nm)	Curve code	QE Peak wavelength (nm)	C Photo-cathode material	D Window material	E Out-line No.	F Dynode structure / Stages	G Socket & socket assembly	J Anode to cathode voltage (V)	K Average anode current (mA)	L Anode to cathode supply voltage (V)					
← Wavelength (nm) →																		
R1924A-100	φ22		300 to 650	440K	350	SBA	K	①	C+L/10	E678-14C* 20 21 22	1250	0.1	1000 19					
R3998-100-02	φ25		300 to 650	440K	350	SBA	K	②	B+L/9	E678-14C* 30	1500	0.1	1000 12					
R9420-100	φ34		300 to 650	440K	350	SBA	K	③	L/8	E678-12A*	1500	0.1	1300 ⑥					
*R10601-100	φ34		300 to 650	440K	420	SBA	K	④	B+L/8	E678-14W	1250	0.1	1000 ⑧					
R6231-100	φ46		300 to 650	440K	350	SBA	K	⑤	B+L/8	E678-14W 33 34	1500	0.1	1000 ⑤					
R6233-100	φ70		300 to 650	440K	350	SBA	K	⑥	B+L/8	E678-14W 33 34	1500	0.1	1000 ⑤					
*R11833-100-03	φ111		300 to 650	440K	350	SBA	K	⑦	B+L/8	E678-14W	1500	0.1	1250 ⑦					
R877-100	φ111		300 to 650	440K	350	SBA	K	⑧	B/10	E678-14W 39 40 41 42	1500	0.1	1250 15					

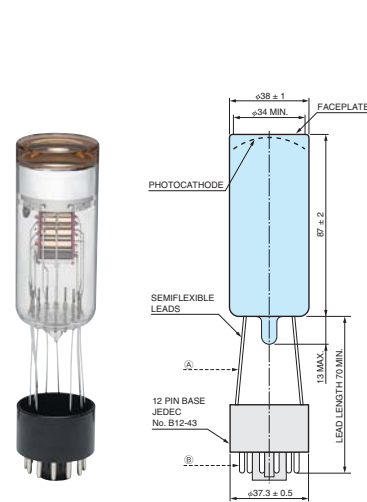
## Head-on types

### Dimensional outlines (Unit: mm)

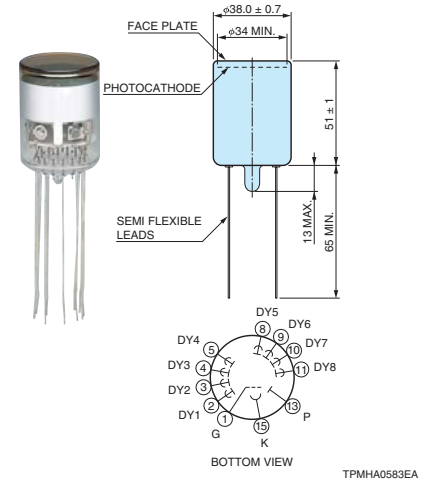
#### ① R1924A-100



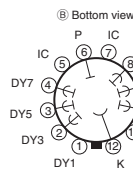
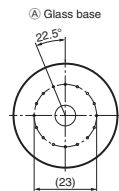
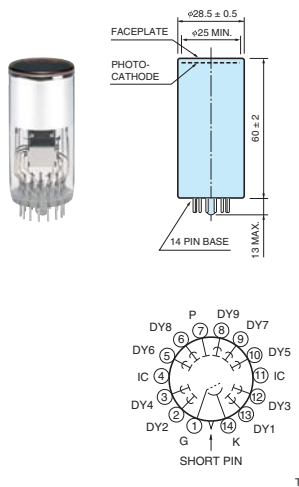
#### ③ R9420-100



#### ④ R10601-100

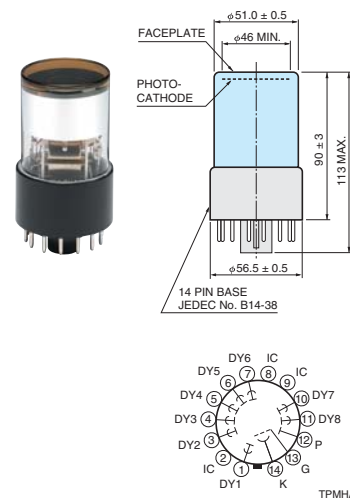


#### ② R3998-100-02



TPMHA0519EC

#### ⑤ R6231-100

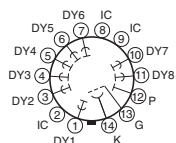
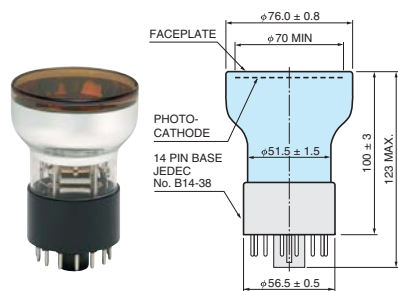


# EGBA (Extended Green Bialkali) photomultiplier tubes

Cathode characteristics					Anode characteristics <sup>M</sup>							(at 25 °C)		
Luminous		Blue sensitivity index (CS 5-58) Typ.	Quantum efficiency Typ. (%)	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
100	130	13.5	35	110	50	260	$2.2 \times 10^5$	$2.0 \times 10^6$	5	25	1.5	17		R1924A-100
100	130	13.5	35	110	50	130	$1.1 \times 10^5$	$1.0 \times 10^6$	5	25	4.4	32		R3998-100-02
100	130	13.5	35	110	5	48	$4.1 \times 10^4$	$3.7 \times 10^5$	10	100	1.6	17		R9420-100
110	130	13.5	35	110	—	20	$1.7 \times 10^4$	$1.5 \times 10^5$	3	30	5.3	37	Temporary base: R10601-100-01	R10601-100*
110	130	13.5	35	110	3	30	$2.5 \times 10^4$	$2.3 \times 10^5$	10	30	8.5	48		R6231-100
110	130	13.5	35	110	3	30	$2.5 \times 10^4$	$2.3 \times 10^5$	10	30	9.5	52		R6233-100
90	105	13.5	35	110	10	50	$5.5 \times 10^4$	$5.0 \times 10^5$	20	100	3.3	41		R11833-100-03*
90	105	13.5	35	110	20	46	$4.8 \times 10^4$	$4.4 \times 10^5$	20	100	20	115		R877-100

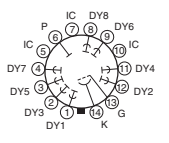
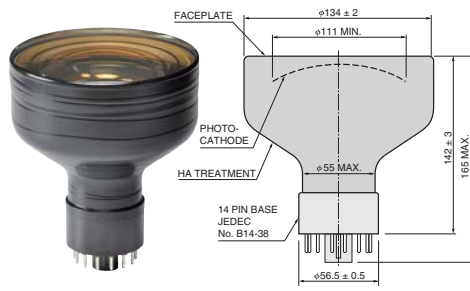
Quantum efficiency is measured at the peak wavelength (350 nm).  
Cathode radiant sensitivity is measured at the 400 nm.

## 6 R6233-100



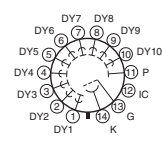
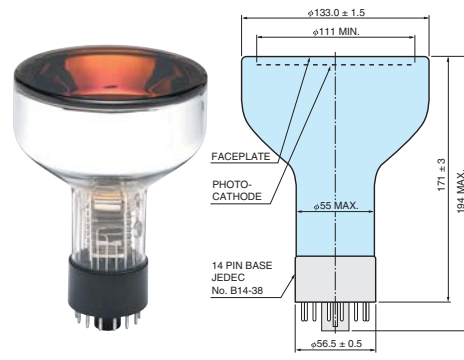
TPMHA0389EB

## 6 R11833-100-03



TPMHA0638EA

## 8 R877-100



TPMHA0074EC

# UBA (Ultra Bialkali), SBA (Super Bialkali) photomultiplier tubes,

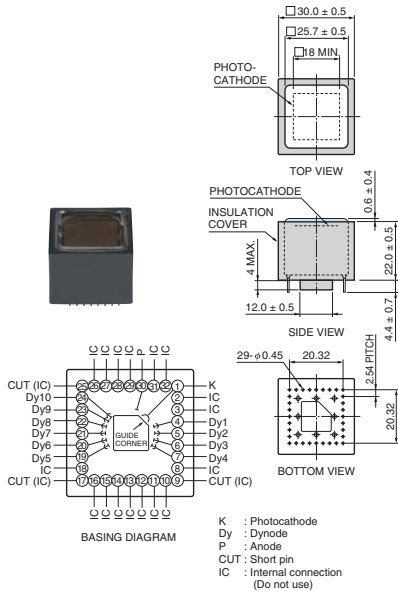
A	Spectral response				Remarks						Max. ratings <sup>H</sup>		
	Type No.	Effective area (mm) ← Wavelength (nm) →	Spectral response range (nm)	Curve code	QE Peak wavelength (nm)	Photo-cathode material	Window material	Out-line No.	Dynode structure / Stages	Socket & socket assembly	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)

## Metal package types

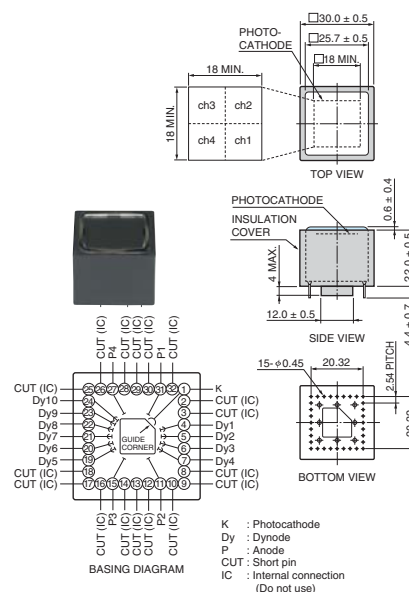
R7600U-100	□18				300 to 650	440K	350	SBA	K	①	MC/10	E678-32B <sup>52</sup>	900	0.1	800 <sup>25</sup>
R7600U-200	□18				300 to 650	441K	350	UBA	K	①	MC/10	E678-32B <sup>52</sup>	900	0.1	800 <sup>25</sup>
*R7600U-300	□18				300 to 700	444K	380	EGBA	K	①	MC/10	E678-32B <sup>52</sup>	900	0.1	800 <sup>25</sup>
R7600U-100-M4	□18 (M4 ch)				300 to 650	440K	350	SBA	K	②	MC/10	E678-32B <sup>53</sup>	900	0.1	800 <sup>25</sup>
R7600U-200-M4	□18 (M4 ch)				300 to 650	441K	350	UBA	K	②	MC/10	E678-32B <sup>53</sup>	900	0.1	800 <sup>25</sup>
R5900U-100-L16	0.8x16x(L16 ch)				300 to 650	440K	350	SBA	K	③	MC/10	E678-32B <sup>54</sup>	900	0.1	800 <sup>14</sup>
R5900U-200-L16	0.8x16x(L16 ch)				300 to 650	441K	350	UBA	K	③	MC/10	E678-32B <sup>54</sup>	900	0.1	800 <sup>14</sup>
R11265U-100	□23				300 to 650	440K	350	SBA	K	④	MC/12	E678-19K <sup>56</sup>	1000	0.1	900 <sup>34</sup>
*R11265U-100-M4	□23 (M4 ch)				300 to 650	440K	350	SBA	K	⑤	MC/12	—	1100	0.1	1000 <sup>35</sup>
R11265U-200	□23				300 to 650	441K	350	UBA	K	④	MC/12	E678-19K <sup>56</sup>	1000	0.1	900 <sup>34</sup>
*R11265U-200-M4	□23 (M4 ch)				300 to 650	441K	350	UBA	K	⑤	MC/12	—	1100	0.1	1000 <sup>35</sup>
*R11265U-300	□23				300 to 700	444K	380	EGBA	K	④	MC/12	E678-19K <sup>56</sup>	1000	0.1	900 <sup>34</sup>
H8711-100	□18.1 (M16 ch)				300 to 650	440K	350	SBA	K	P80 <sup>20</sup>	MC/12	—	-1000	0.017	-800 <sup>32</sup>
H8711-200	□18.1 (M16 ch)				300 to 650	441K	350	UBA	K	P80 <sup>20</sup>	MC/12	—	-1000	0.017	-800 <sup>32</sup>
H8711-300	□18.1 (M16 ch)				300 to 700	444K	380	EGBA	K	P80 <sup>20</sup>	MC/12	—	-1000	0.017	-800 <sup>32</sup>
H12445-100	□23 (M16 ch)				300 to 650	440K	350	SBA	K	P80 <sup>20</sup>	MC/12	—	-1100	0.018	1000 <sup>35</sup>
H12445-200	□23 (M16 ch)				300 to 650	441K	350	UBA	K	P80 <sup>20</sup>	MC/12	—	-1100	0.018	1000 <sup>35</sup>
H7546B-100	□18.1 (M64 ch)				300 to 650	440K	350	SBA	K	P80 <sup>20</sup>	MC/12	—	-1000	0.023	-800 <sup>33</sup>
H7546B-200	□18.1 (M64 ch)				300 to 650	441K	350	UBA	K	P80 <sup>20</sup>	MC/12	—	-1000	0.023	-800 <sup>33</sup>
H7546B-300	□18.1 (M64 ch)				300 to 700	444K	380	EGBA	K	P80 <sup>20</sup>	MC/12	—	-1000	0.023	-800 <sup>33</sup>
H12428-100	□23 (M64 ch)				300 to 650	440K	350	SBA	K	P80 <sup>20</sup>	MC/12	—	-1100	0.018	1000 <sup>35</sup>
H12428-200	□23 (M64 ch)				300 to 650	441K	350	UBA	K	P80 <sup>20</sup>	MC/12	—	-1100	0.018	1000 <sup>35</sup>
H7260-100	0.8 x 7 x (L32 ch)				300 to 650	440K	350	SBA	K	P80 <sup>20</sup>	MC/10	—	-900	0.1	-800 <sup>14</sup>
H7260-200	0.8 x 7 x (L32 ch)				300 to 650	441K	350	UBA	K	P80 <sup>20</sup>	MC/10	—	-900	0.1	-800 <sup>14</sup>

## Dimensional outlines (Unit: mm)

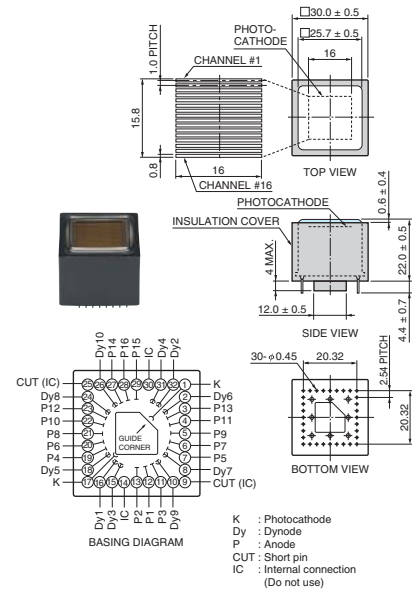
### ① R7600U-100, R7600U-200, R7600U-300



### ② R7600U-100-M4, R7600U-200-M4



### ③ R5900U-100-L16, R5900U-200-L16





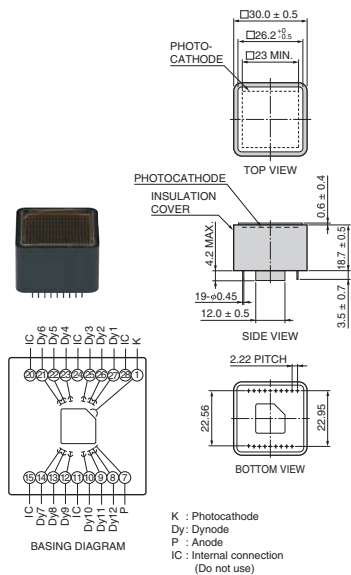
# EGBA (Extended Green Bialkali) photomultiplier tubes

Cathode characteristics					Anode characteristics <sup>M</sup>								(at 25 °C)	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Quantum efficiency Typ. (%)	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
90	105	13.5	35	110	40	210	$2.2 \times 10^5$	$2.0 \times 10^6$	2	20	1.6	9.6		R7600U-100
110	135	15.5	43	130	50	270	$2.6 \times 10^5$	$2.0 \times 10^6$	2	20	1.6	9.6		R7600U-200
120	160	14	14	125	80	320	$2.5 \times 10^5$	$2.0 \times 10^6$	2	20	1.6	9.6		R7600U-300*
90	105	13.5	35	110	25	140	$1.4 \times 10^5$	$1.3 \times 10^6$	0.5/ch	5/ch	1.2	9.5		R7600U-100-M4
110	135	15.5	43	130	25	175	$1.7 \times 10^5$	$1.3 \times 10^6$	0.5/ch	5/ch	1.2	9.5		R7600U-200-M4
90	105	13.5	35	110	90	315	$3.3 \times 10^5$	$3.0 \times 10^6$	0.2/ch	2/ch	0.6	7.4	UV glass window: R5900U-103-L16	R5900U-100-L16
110	135	15.5	43	130	110	405	$3.9 \times 10^5$	$3.0 \times 10^6$	0.2/ch	2/ch	0.6	7.4		R5900U-200-L16
90	105	13.5	35	110	50	130	$1.3 \times 10^5$	$1.2 \times 10^6$	2	20	1.3	5.8	UV glass window: R11265U-103 Assembly type: H11934-100	R11265U-100
90	105	13.5	35	110	25	105	$1.1 \times 10^5$	$1.0 \times 10^6$	1/ch	4/ch	1.1	5.3	Assembly type: H13226A-100	R11265U-100-M4*
110	135	15.5	43	130	50	160	$1.6 \times 10^5$	$1.2 \times 10^6$	2	20	1.3	5.8	UV glass window: R11265U-203 Assembly type: H11934-200	R11265U-200
110	135	15.5	43	130	25	135	$1.3 \times 10^5$	$1.0 \times 10^6$	1/ch	4/ch	1.1	5.3	Assembly type: H13226A-200	R11265U-200-M4*
120	160	14	14	125	50	190	$1.5 \times 10^5$	$1.2 \times 10^6$	2	20	1.3	5.8	Assembly type: H11934-300	R11265U-300*
90	105	13.5	35	110	50	210	$2.2 \times 10^5$	$2.0 \times 10^6$	0.8/ch	4/ch	0.83	12		H8711-100
110	135	15.5	43	130	50	270	$2.6 \times 10^5$	$2.0 \times 10^6$	0.8/ch	4/ch	0.83	12		H8711-200
120	160	14	14	125	50	400	$3.1 \times 10^5$	$2.5 \times 10^6$	0.8/ch	4/ch	0.83	12		H8711-300
90	105	13.5	35	110	25	105	$1.1 \times 10^5$	$1.0 \times 10^6$	0.2/ch	4/ch	0.52	5	UV glass window: H12445-103	H12445-100
110	135	15.5	43	130	25	135	$1.3 \times 10^5$	$1.0 \times 10^6$	0.2/ch	4/ch	0.52	5	UV glass window: H12445-203	H12445-200
90	105	13.5	35	110	15	53	$5.5 \times 10^4$	$5.0 \times 10^5$	0.2/ch	2/ch	1.0	12		H7546B-100
110	135	15.5	43	130	15	68	$6.5 \times 10^4$	$5.0 \times 10^5$	0.2/ch	2/ch	1.0	12		H7546B-200
120	160	14	14	125	—	80	$6.3 \times 10^4$	$5.0 \times 10^5$	0.2/ch	2/ch	1.0	12		H7546B-300
90	105	13.5	35	110	25	105	$1.1 \times 10^5$	$1.0 \times 10^6$	0.4/ch	4/ch	0.6	5.1	UV glass window: H12428-103	H12428-100
110	135	15.5	43	130	25	135	$1.3 \times 10^5$	$1.0 \times 10^6$	0.4/ch	4/ch	0.6	5.1	UV glass window: H12428-203	H12428-200
90	105	13.5	35	110	90	210	$2.2 \times 10^5$	$2.0 \times 10^6$	0.2/ch	2/ch	0.6	6.8	UV glass window: H7260-103 Silica glass window: H7260-106	H7260-100
110	135	15.5	43	130	110	270	$2.6 \times 10^5$	$2.0 \times 10^6$	0.2/ch	2/ch	0.6	6.8		H7260-200

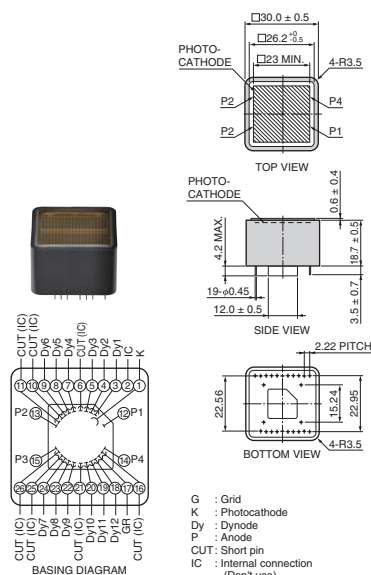
Quantum efficiency is measured at the peak sensitivity wavelength (UBA/SBA: 350 nm, EGBA: 550 nm).  
Cathode radiant sensitivity is measured at the peak sensitivity wavelength (400 nm).

## ④ R11265U-100, R11265U-200, R11265U-300

## ⑤ R11265U-100-M4, R11265U-200-M4



TPMHA0585EB



TPMHA0622EA

# Microchannel plate-photomultiplier tubes (MCP-PMTs)

Type No.	Spectral response				Remarks						Max. ratings <sup>H</sup>	
	Effective area (mm)	Spectral response range (nm)	Peak wave-length (nm)	Photo-cathode material	Win-dow material	Out-line No.	No. of MCP stage	-HV input terminals	Signal output terminals	Anode to cathode voltage (V)	Anode current	
	← Wavelength (nm) →										Continuous (nA)	Pulsed peak (mA)
	100 200 300 400 500 600 700 800 900 1000 1100 1200											

## Standard types

R3809U-50	φ11	160 to 850	430	MA	Q	①	2	SHV-R	SMA-R	-3400	100	350
R3809U-52	φ11	160 to 650	400	BA	Q	①	2	SHV-R	SMA-R	-3400	100	350
R3809U-53	φ11	160 to 320	230-250	Cs-Te	Q	①	2	SHV-R	SMA-R	-3400	100	350
R3809U-61	φ10	370 to 920	750-850	GaAs	K	①	2	SHV-R	SMA-R	-3400	100	350
R3809U-63	φ10	280 to 820	550-650	Extended Red GaAsP	K	①	2	SHV-R	SMA-R	-3400	100	350
R3809U-64	φ10	280 to 720	550-650	GaAsP	K	①	2	SHV-R	SMA-R	-3400	100	350
*H15547-07	φ11	160 to 850	430	MA	Q	①	2	SHV-R	SMA-R	-2400	100	350

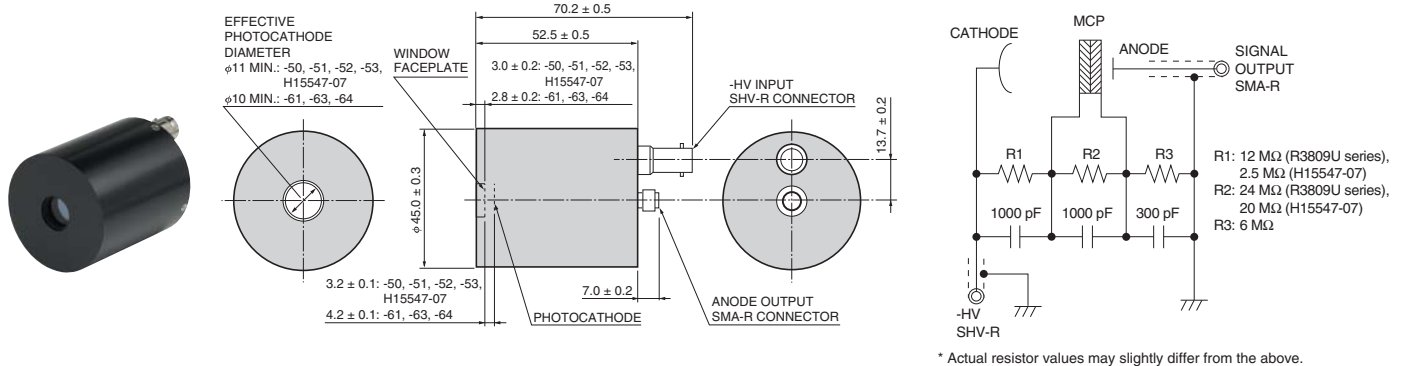
## Gated types

R5916U-50	φ10	160 to 850	430	MA	Q	②	2	SHV-R	SMA-R	-3400	100	350
R5916U-52	φ10	160 to 650	400	BA	Q	②	2	SHV-R	SMA-R	-3400	100	350
R5916U-53	φ10	160 to 320	230-250	Cs-Te	Q	②	2	SHV-R	SMA-R	-3400	100	350

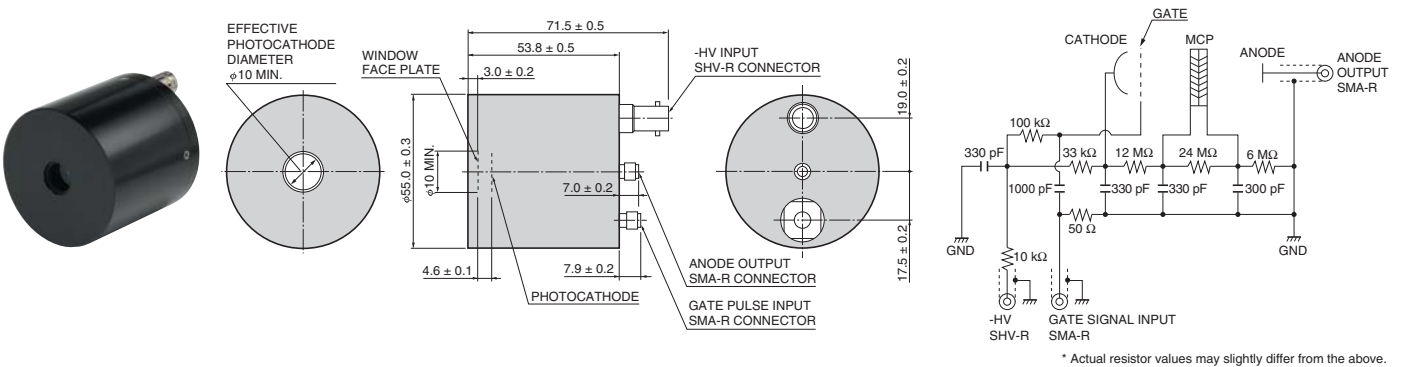
The R5916 series can be gated by input of a +10 V to +20 V gate signal. Standard types are normally OFF, but normally ON types are also available. Gate operation is 5 ns, though this depends on the gate signal input pulse. Consult us regarding the R5916U series with a GaAs or GaAsP photocathode. Gate operation types may have slightly lower sensitivity in the ultraviolet region.

## Dimensional outlines (Unit: mm)

### ① R3809U series, H15547-07



### ② R5916U series



**Cathode characteristics**

**Anode characteristics**

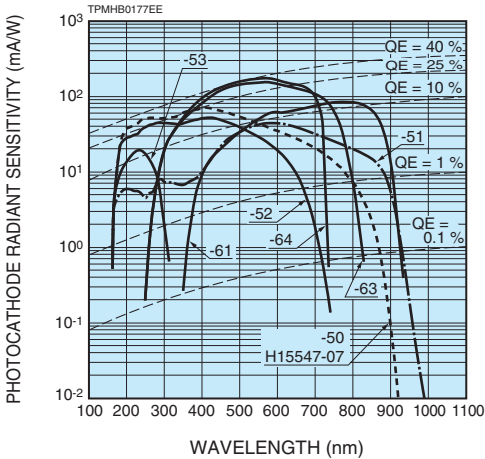
(at 25 °C)

Anode to cathode supply voltage (V)	Luminous		Radiant <sup>(K)</sup>	Luminous	Gain	Dark current (After 30 min.) Max. (nA)	Time response			Notes	Type No.
	Min. (μA/lm)	Typ. (μA/lm)	Typ. (mA/W)	Typ. (A/lm)	Typ.		Rise time Typ. (ns)	Transit time Typ. (ns)	T.T.S. <sup>(A)</sup> (FWHM) Typ. (ns)		
-3000	100	180	70	36	$3.0 \times 10^5$	10	0.16	0.55	0.045	Transit time spread: 0.025 ns	R3809U-50
-3000	20	50	50	10	$3.0 \times 10^5$	0.5	0.16	0.55	0.045	Transit time spread: 0.025 ns	R3809U-52
-3000	—	—	20	—	$3.0 \times 10^5$	0.1	0.16	0.55	0.045	Transit time spread: 0.025 ns	R3809U-53
-3000	400	700	85	140	$3.0 \times 10^5$	25	0.2	0.55	0.15		R3809U-61
-3000	450	750	160	150	$3.0 \times 10^5$	15	0.18	0.55	0.08		R3809U-63
-3000	400	700	180	140	$3.0 \times 10^5$	15	0.18	0.55	0.08		R3809U-64
-1900	100	180	70	100	$5.6 \times 10^5$	10	0.19	0.75	0.04		H15547-07*
-3000	100	150	52	30	$3.0 \times 10^5$	10	0.18	1.0	0.095		R5916U-50
-3000	20	45	45	9	$3.0 \times 10^5$	0.5	0.18	1.0	0.095		R5916U-52
-3000	—	—	20	—	$3.0 \times 10^5$	0.1	0.18	1.0	0.095		R5916U-53

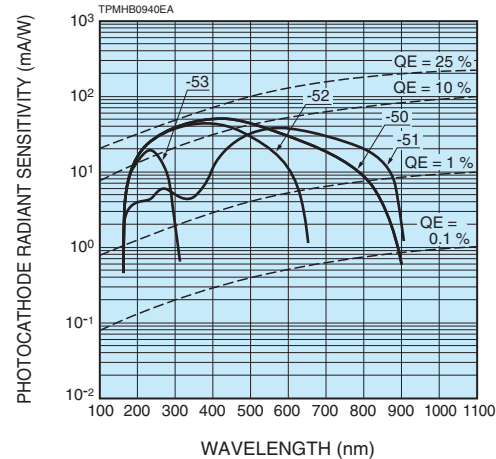
NOTE: (A) At the single photon state and the full illumination on photocathode, specified as FWHM (Full Width at Half Maximum)

**Spectral response**

● R3809U series, H15547-07

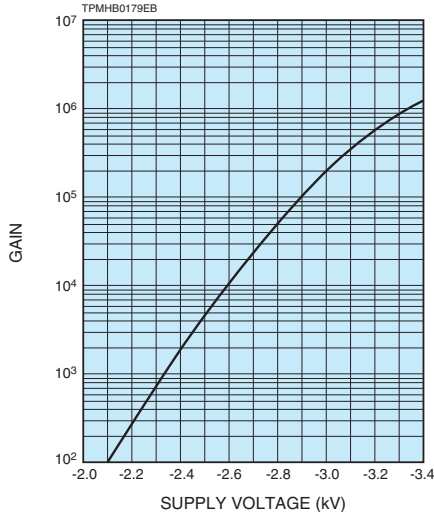


● R5916U series

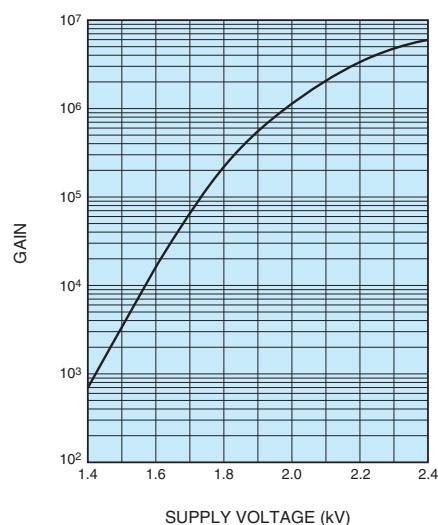


**Gain**

● R3809U series, R5916U series



● H15547-07



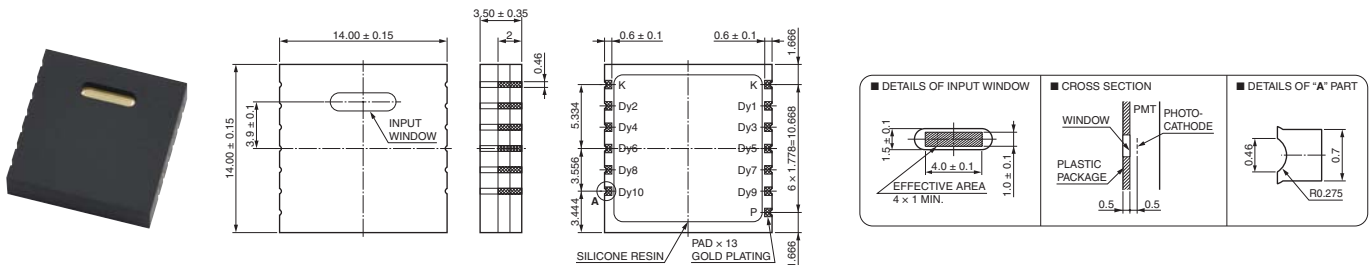
# Micro PMT / Micro PMT assemblies

Type No.	Spectral response										Remarks			Max. ratings					
	Effective area (mm)		Wavelength (nm)								Spectral response range (nm)	Peak wave-length (nm)	Photo-cathode material	Win-dow material	Out-line No.	Dynode structure / Stages	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)
*R12900U	4 × 1		300 400 500 600 700 800 900 1000 1100 1200								300 to 650	420	BA	K	①	SC/10	1150	0.005	900
*R12900U-01	4 × 1		300 400 500 600 700 800 900 1000 1100 1200								300 to 850	420	MA	K	①	SC/10	1150	0.005	900

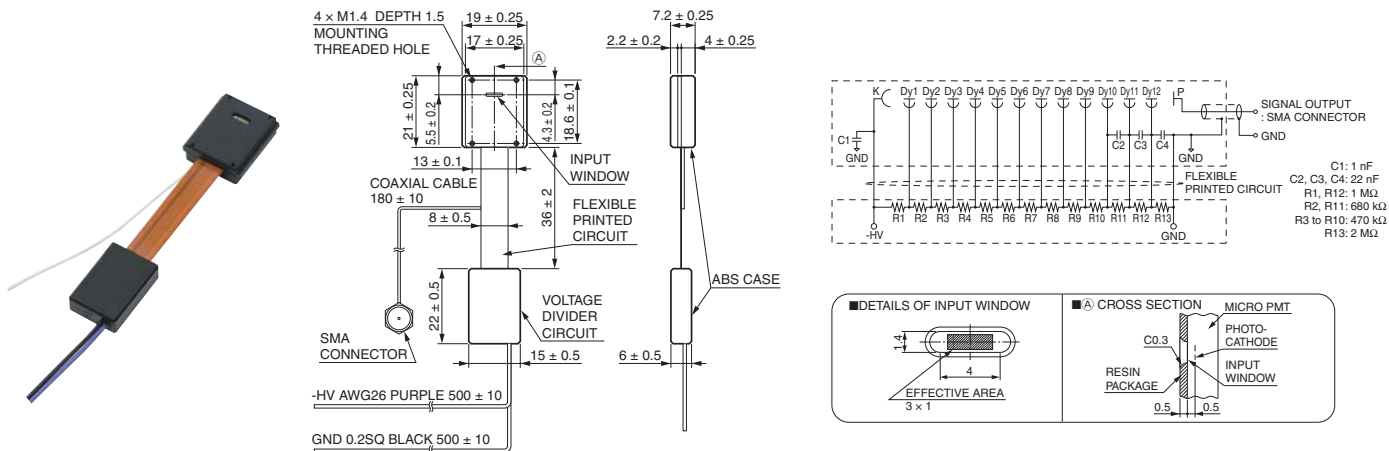
Type No.	Spectral response										Remarks			Max. ratings					
	Effective area (mm)		Wavelength (nm)								Spectral response range (nm)	Peak wave-length (nm)	Photo-cathode material	Win-dow material	Out-line No.	Dynode structure / Stages	Anode to cathode voltage (V)	Average anode current (mA)	Anode to cathode supply voltage (V)
H12400-00-01	3 × 1		300 400 500 600 700 800 900 1000 1100 1200								300 to 650	420	BA	K	②	SC/12	-1150	0.005	-900
H12400-01-01	3 × 1		300 400 500 600 700 800 900 1000 1100 1200								300 to 850	420	MA	K	②	SC/12	-1150	0.005	-900
*H12400-20-01	3 × 1		300 400 500 600 700 800 900 1000 1100 1200								300 to 920	630	ERMA	K	②	SC/12	-1150	0.005	-900

## Dimensional outlines (Unit: mm)

### ① R12900U, R12900U-01



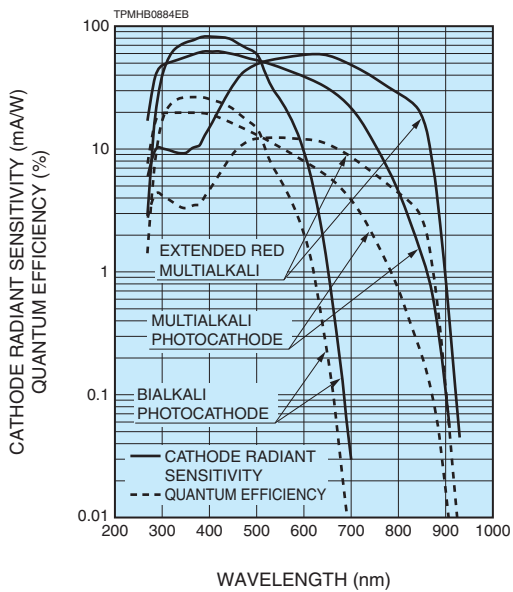
### ② H12400-00-01, H12400-01-01



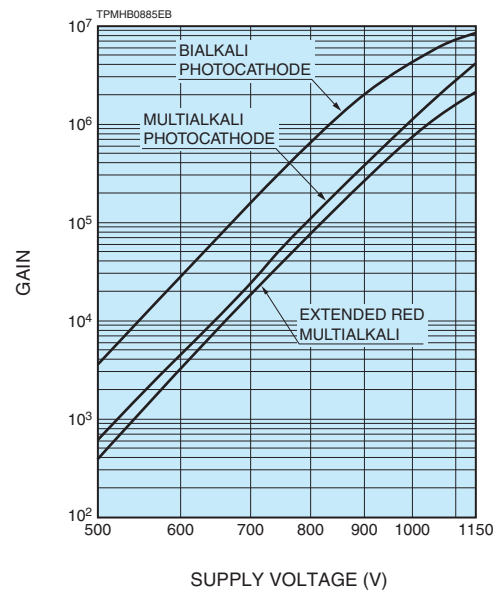
Cathode characteristics					Anode characteristics <sup>M</sup>								(at 25 °C)	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
70	100	11.5	—	93	30	200	$1.8 \times 10^5$	$2.0 \times 10^6$	0.3	3	1.2	8.0		R12900U*
100	200	—	0.2	62	15	70	$2.1 \times 10^4$	$3.5 \times 10^5$	0.3	3	1.2	8.0		R12900U-01*

Cathode characteristics					Anode characteristics <sup>M</sup>								(at 25 °C)	
Luminous		Blue sensitivity index (CS 5-58) Typ.	Red / White ratio (R-68) Typ.	Radiant <sup>K</sup> Typ. (mA/W)	Luminous		Radiant Typ. (A/W)	Gain Typ.	Dark current (After 30 min.)		Time response		Notes	Type No. <sup>A</sup>
Min. (μA/lm)	Typ. (μA/lm)				Min. (A/lm)	Typ. (A/lm)			Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)		
50	80	8.0	—	80	30	160	$1.6 \times 10^5$	$2.0 \times 10^6$	0.3	3	1.2	8.0		H12400-00-01
100	200	—	0.2	62	15	70	$2.1 \times 10^4$	$3.5 \times 10^5$	0.3	3	1.2	8.0		H12400-01-01
300	400	—	0.45	60	30	100	$1.5 \times 10^4$	$2.5 \times 10^5$	0.6	6	1.2	8.0		H12400-20-01*

### ■ Spectral response



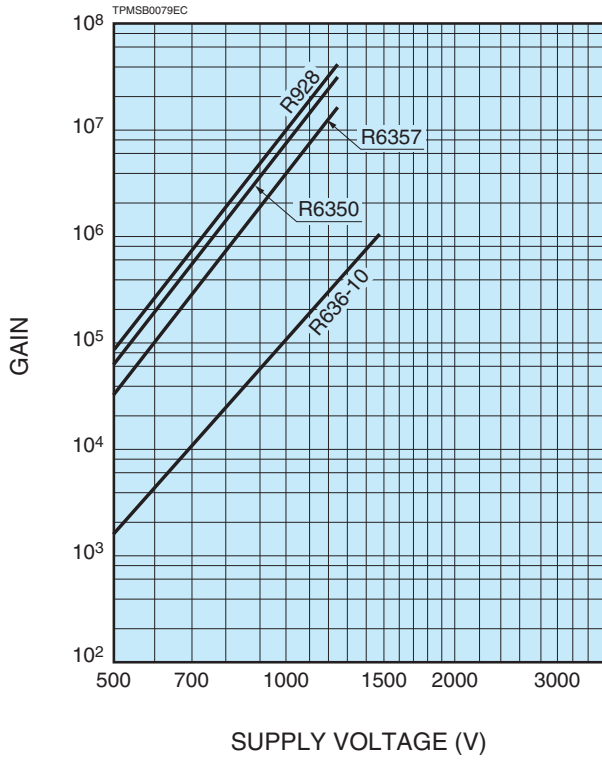
### ■ Gain



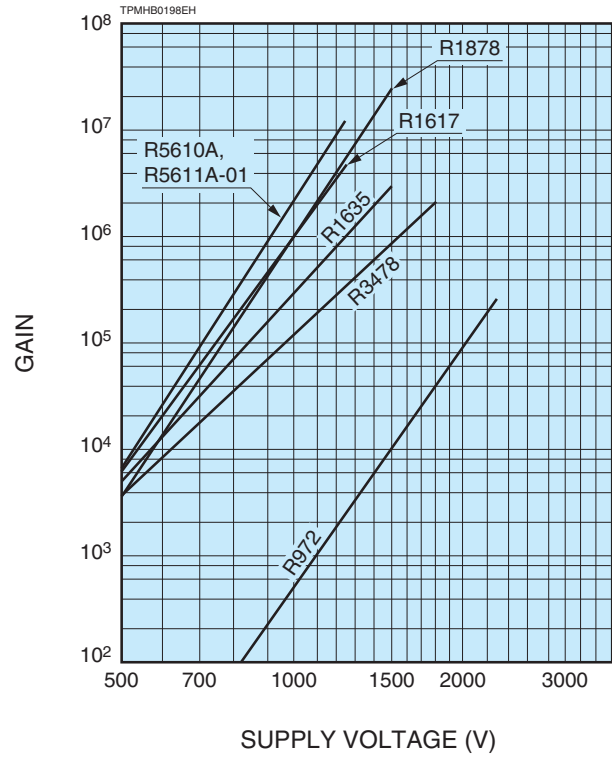
# Gain characteristics

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

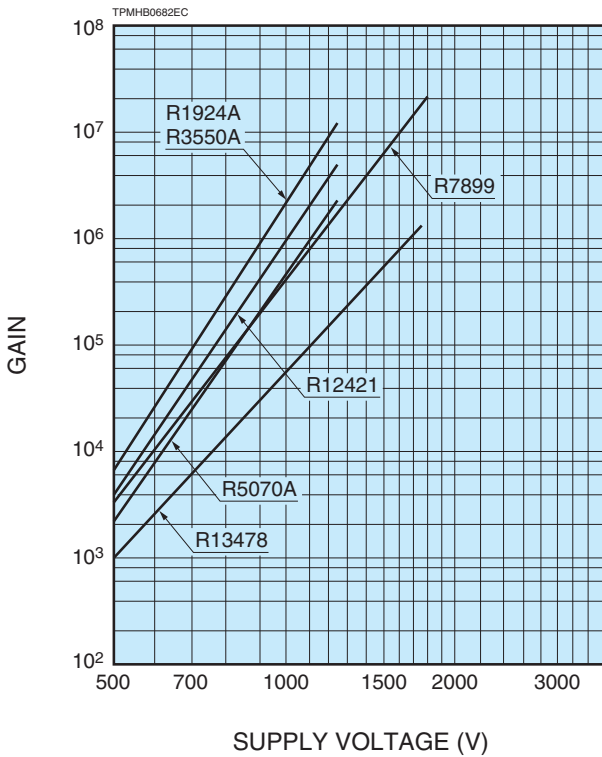
## Side-on types



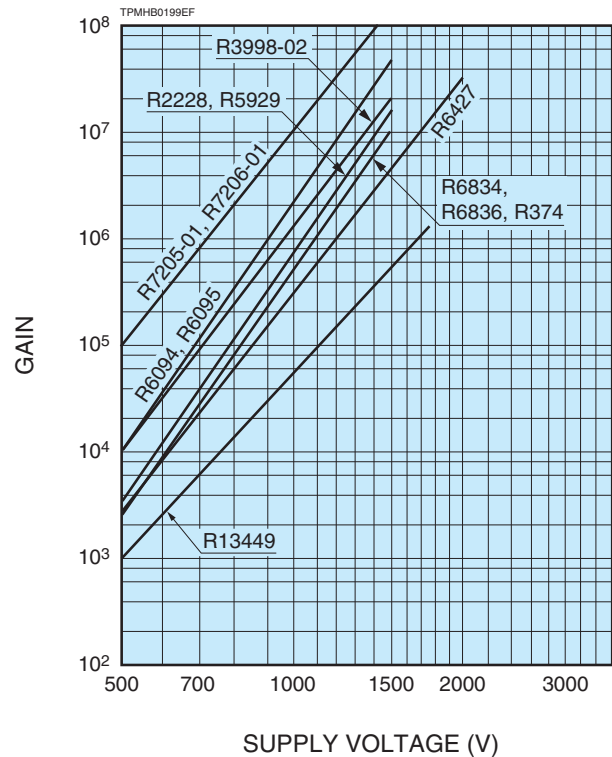
## Head-on types (10 mm and 19 mm Dia.)



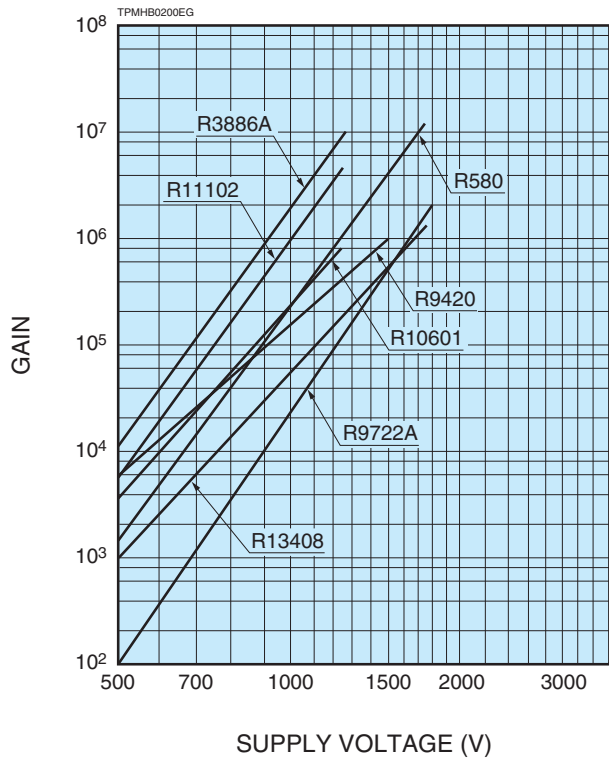
## Head-on types (13 mm and 25 mm Dia.)



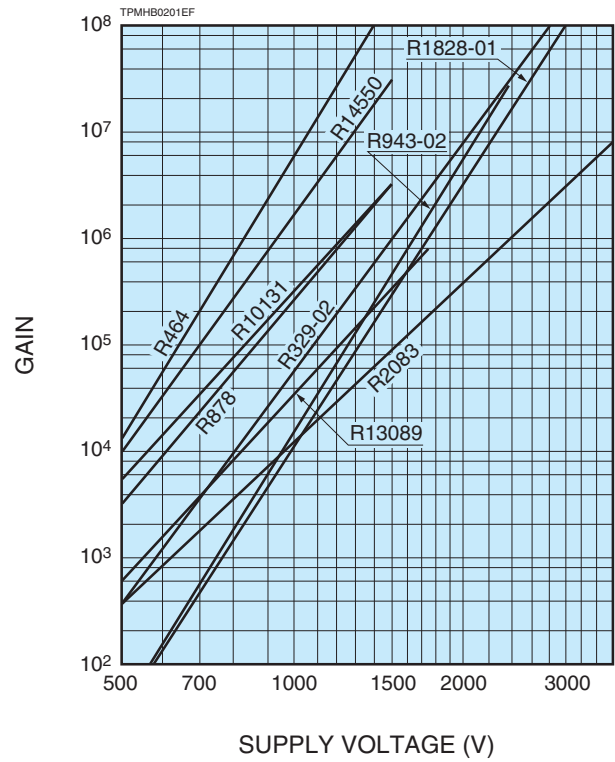
## Head-on types (28 mm Dia.)



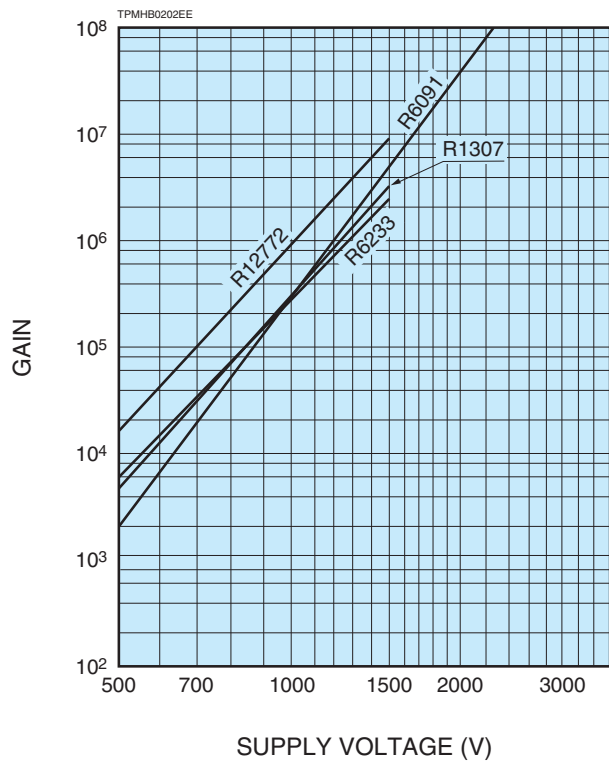
**Head-on types (38 mm Dia.)**



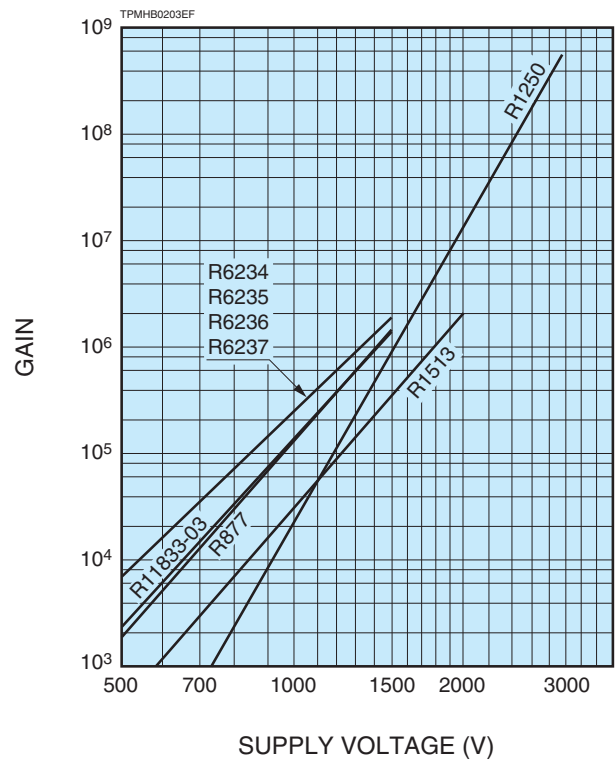
**Head-on types (51 mm Dia.)**



**Head-on types (76 mm Dia.)**



**Head-on types (127 mm Dia.) and special types**



# Voltage distribution ratio

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

Distribution ratio codes	Number of stage	Voltage distribution ratio																		
		K: Photocathode Dy: Dynode P: Anode G: Grid Acc: Accelerating electrode GR: Guard ring																		
① ② ③ ④ ⑤ ⑥ ⑦ ⑧	8	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	P								
		2	—	2	1	1	1	1	1	1	1	1								
		1	1	1	1	1	1	1	1	1	1	1								
		3	—	1.5	1.5	1	1	1	1	1	1	1								
		7	—	1	1.5	1	1	1	1	1	1	1								
		2	2	1	1	1	1	1	1	1	1	1								
		4	—	1.5	1.5	1	1	1	1	1	1	1								
		4	0	1.2	1.5	1	1	1	1	1	1	1								
0.4	1.8	2	2	1	1	1	1	1	1	1										
⑨	8	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8(Acc)	P	(Note 1)							
		1.3	4.8	1.5	1.5	1	1	1	1	1	1	1								
⑩	8	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Acc	Dy7	Dy8	P								
		1.3	4.8	1.2	1.8	1	1	1	1	0.5	3	2.5								
⑪ ⑫	9	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	P							
		1	—	1	1	1	1	1	1	1	1	1	1							
		3	1	1	1	1	1	1.5	1	1	1	1								
⑬ ⑭ ⑮ ⑯ ⑰ ⑱ ⑲ ⑳ ㉑ ㉒ ㉓ ㉔ ㉕	10	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P						
		1	—	1	1	1	1	1	1	1	1	1	1	0.5						
		1	—	1	1	1	1	1	1	1	1	1	1	1						
		1	1	1	1	1	1	1	1	1	1	1	1	1						
		1.5	—	1	1	1	1	1	1	1	1	1	1	1						
		2	—	1	1	1	1	1	1	1	1	1	1	1						
		2	—	1	1.5	1	1	1	1	1	1	1	1	0.75						
		3	—	1	1	1	1	1	1	1	1	1	1	1						
		3	—	1	1.5	1	1	1	1	1	1	1	1	1						
		3	—	1.5	1	1	1	1	1	1	1	1	1	1						
		4	—	1	1.5	1	1	1	1	1	1	1	1	1						
		4	—	1	2	1	1	1	1	1	1	1	2	1						
		1.3	4.8	1.2	1.8	1	1	1	1	1	1	1.5	3	2.5						
1.5	—	1.5	1.5	1	1	1	1	1	1	1	1	1								
⑳ ㉑ ㉒	11	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	P					
		1	—	1	1	1	1	1	1	1	1	1	1	1	1					
		0.5	1.5	2	1	1	1	1	1	1	1	1	1	1	0.5					
		2	—	1	1	1	1	1	1	1	1	1	1	1						
㉓ ㉔ ㉕ ㉖ ㉗ ㉘	12	K	G	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	GR	P			
		1.2	2.8	1.2	1.8	1	1	1	1	1	1	1	1.5	1.5	3	—	2.5			
		4	0	1	1.4	1	1	1	1	1	1	1	1	1	1	—	1	(Note 2)		
		4	0	2.5	1.5	1	1	1	1	1	1	1	1	1	1	—	1			
		2	—	2	2	1	1	1	1	1	1	1	1	1	1	—	1			
		3	—	2	2	1	1	1	1	1	1	1	1	1	2	—	5			
		2.5	—	1.3	0.8	0.8	1	1	1	1	1	1	1	1	1	—	0.5			
2.3	—	1.2	1	1	1	1	1	1	1	1	1	1	1	1	0.5					
㉙	14	K	G1	G2	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	Dy11	Dy12	Dy13	Dy14	P	
		2.5	7.5	0	1.2	1.8	1	1	1	1	1	1	1	1	1	1	1.5	1.5	3	2.5

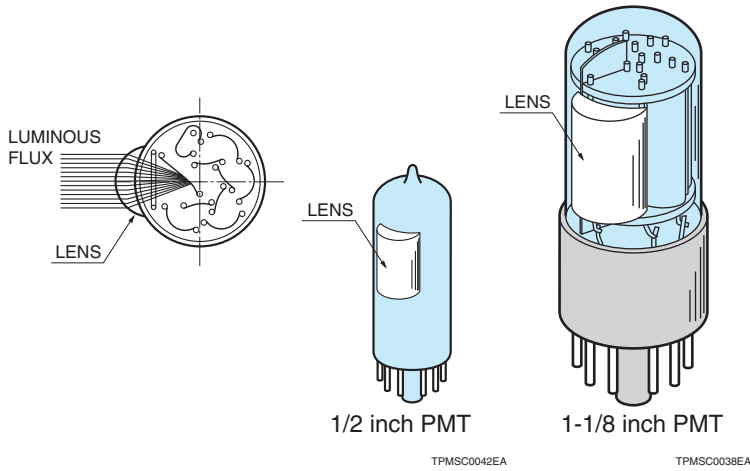
Note 1: The Acc should be connected to Dy8.

2: The shield pin should be connected to Dy5.

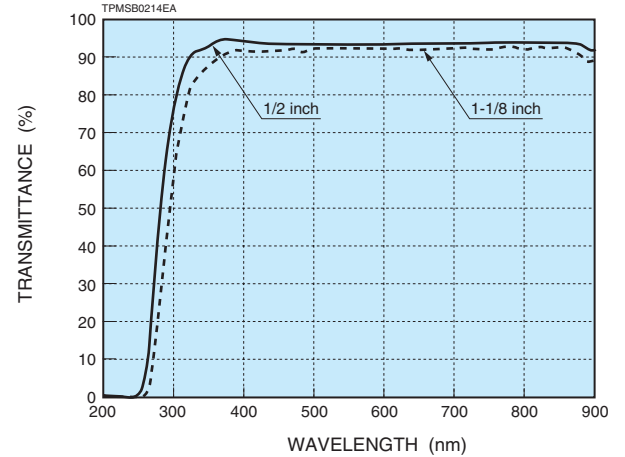


# Lens for side-on type photomultiplier tubes

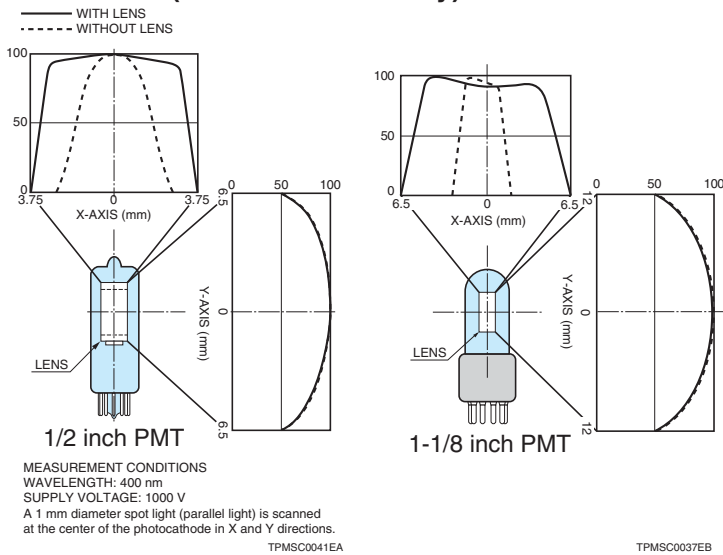
The optimized cylindrical lens which can be attached at the entrance window of 1-1/8 inch side-on photomultiplier tube. This lens helps the incident light reaches the photocathode efficiently. With these lenses, the effective area widens by the factor of three in case of 1-1/8" PMT (13 mm width) or the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



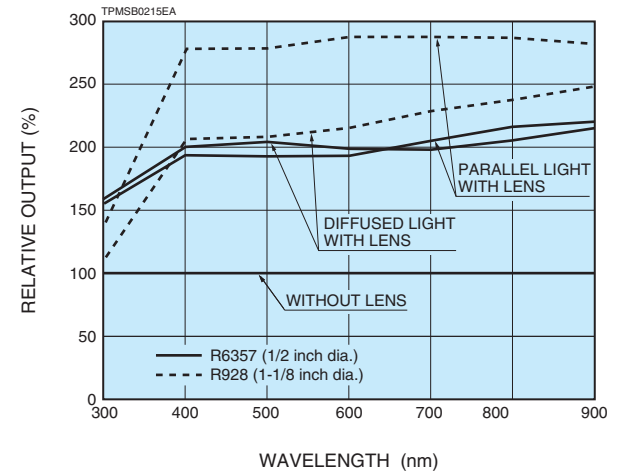
## Transmittance of lens



## Lens effect (at anode sensitivity)



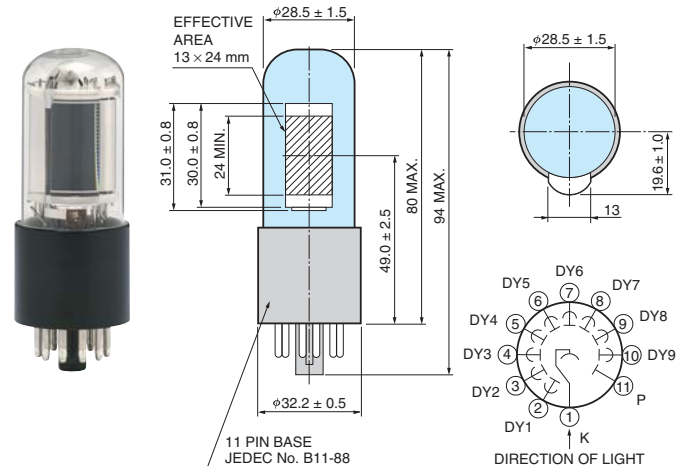
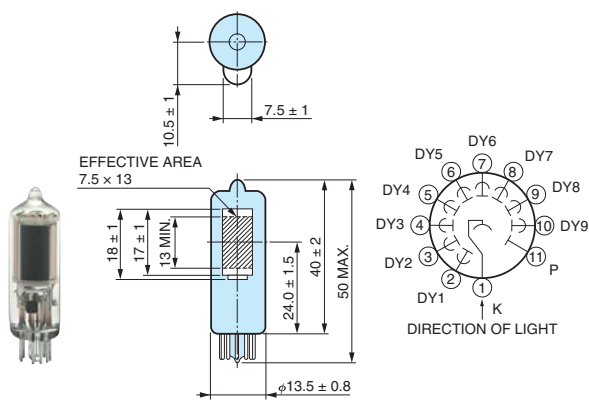
## Lens effect



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

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

## Dimensional outlines (Unit: mm)



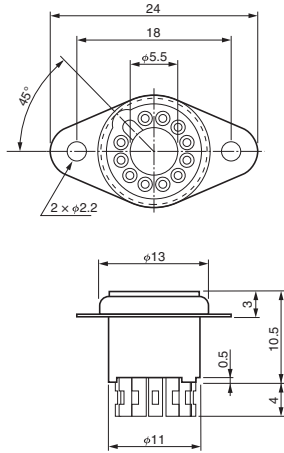
TPMSA0041EA

TPMSA0036EB

# Photomultiplier tube socket

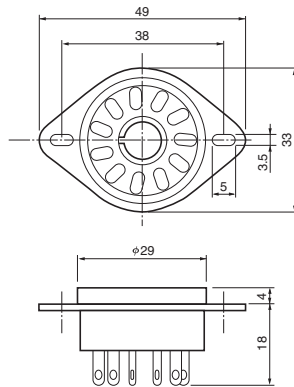
Dimensional outline (Unit: mm)

**E678-11U**



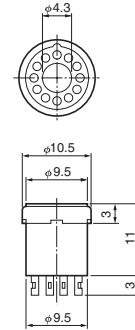
TACCA0181EC

**E678-11A**



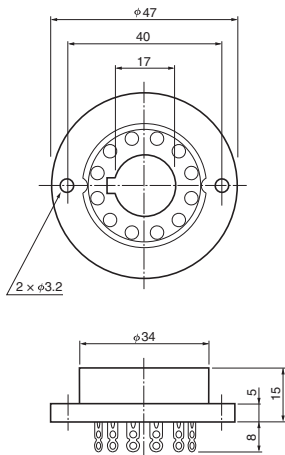
TACCA0064EA

**E678-11N**



TACCA0043EB

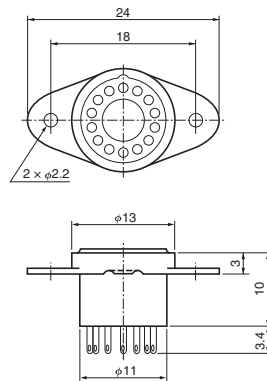
**E678-12A, E678-12R\***



\* Gold Plating type

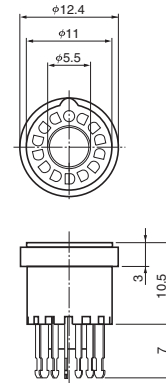
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**E678-13F**



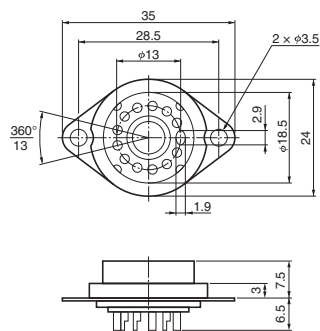
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**E678-13E**



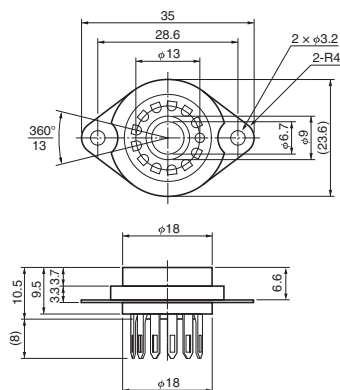
TACCA0013EB

**E678-12T**



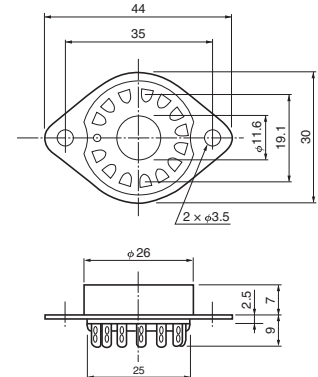
TACCA0275EA

**E678-12L**



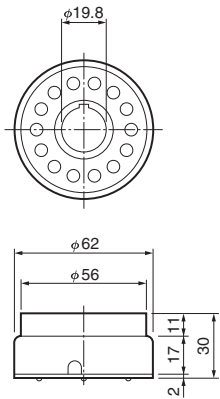
TACCA0047EB

**E678-14C**



TACCA0004EA

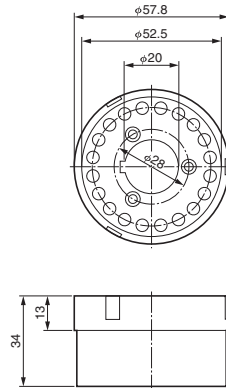
**E678-14W**



\* Pins are housed in the socket.

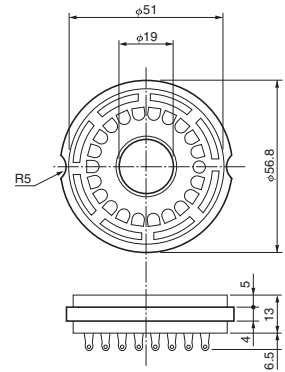
TACCA0200EA

**E678-20B**



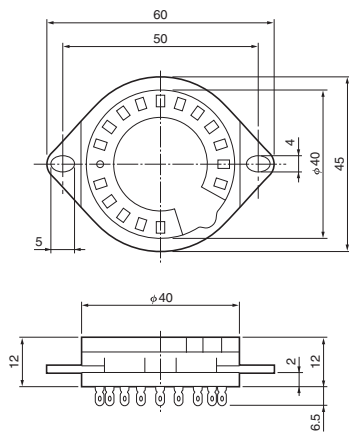
TACCA0309EB

**E678-21C**



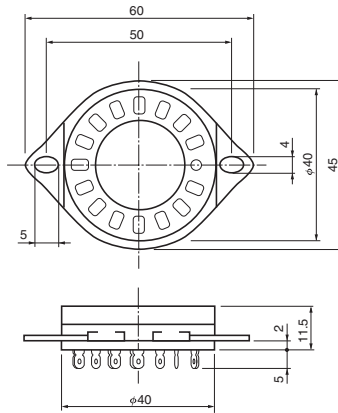
TACCA0068EC

**E678-19J**



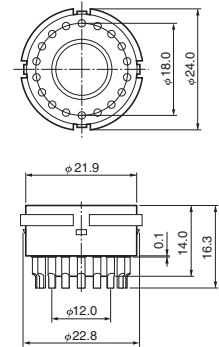
TACCA0203EB

**E678-15C**



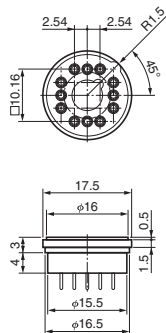
TACCA0201EA

**E678-17A**



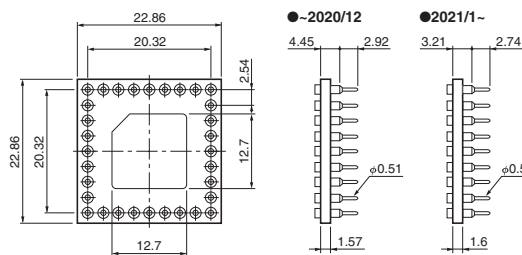
TACCA0048EC

**E678-12-01**



TACCA0304EA

**E678-32B**



MATERIAL: Glass Epoxy

TACCA0094ED

# Photomultiplier tube assemblies





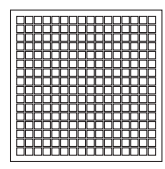


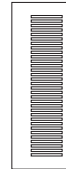
## Photomultiplier tube assemblies

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

Type No.	Assembly Dia. (mm)	PMT Dia. mm (inch)	Built-in PMT (Type No. for referring)	Curve code	Spectral response range wavelength (nm)	Out-line No.	Dynode structure / Stages	Max. rating		Cathode sensitivity		
								Anode to cathode voltage Max. (V)	Divider current Max. (mA)	Anode to cathode supply voltage (V)	Luminous Typ. (μA/lm)	Blue sensitivity index (CS 5-58) Typ.
H3164-10	φ10.5	10 (3/8)	R1635	400K	300 to 650	1	L/8	-1500	0.41	-1250	100	10.0
H3695-10	φ11.3	10 (3/8)	R2496	400S	160 to 650	2	L/8	-1500	0.37	-1250	100	10.0
H3165-10	φ14.3	13 (1/2)	R647-01	400K	300 to 650	3	L/10	-1250	0.34	-1000	110	10.0
H12690	φ14.3	13 (1/2)	R12421	400K	300 to 650	4	L/10	-1250	0.31	-1000	110	10.0
H6520	φ23.5	19 (3/4)	R1166	400K	300 to 650	5	L/10	-1250	0.33	-1000	110	10.5
H6524	φ23.5	19 (3/4)	R1450	400K	300 to 650	6	L/10	-1800	0.43	-1500	115	11.0
H6612	φ23.5	19 (3/4)	R3478	400K	300 to 650	7	L/8	-1800	0.35	-1700	115	11.0
H6533	φ31.0	25 (1)	R4998	400K	300 to 650	8	L/10	-2500	0.36	-2250	80	9.5
H7415	φ33.0 (1-1/8)	28	R6427	400K	300 to 650	9	L/10	-2000	0.42	-1500	100	11.0
H10828	φ47.0	38 (1-1/2)	R9420	400K	300 to 650	10	L/8	-1500	0.39	-1300	95	11.0
H3178-51	φ47.0	38 (1-1/2)	R580	400K	300 to 650	11	L/10	-1750	0.63	-1500	95	11.0
H1949-51	φ60.0	51 (2)	R1828-01	400K	300 to 650	12	L/12	-3000	0.70	-2500	90	10.5
H6410	φ60.0	51 (2)	R329	400K	300 to 650	13	L/12	-2700	0.67	-2000	90	10.5
H7195	φ60.0	51 (2)	R329	400K	300 to 650	14	L/12	-2700	1.23	-2000	90	10.5
H2431-50	φ60.0	51 (2)	R2083	400K	300 to 650	15	L/8	-3500	0.61	-3000	80	10.0
H6559	φ83.0	76 (3)	R6091	400K	300 to 650	16	L/12	-2500	0.62	-2000	90	10.5
H6527	φ142.0	127 (5)	R1250	400K	300 to 650	17	L/14	-3000	1.02	-2000	70	9.0
H9530-20	□35 × 16	—	—	—	300 to 920	18	MC/12	-1200	0.42	-1000	500	—
H8711	□30	—	R7600-00-M16	—	300 to 650	19	MC/12	-1000	0.35	-800	80	9.5
H8711-20	□30	—	R7600-20-M16	—	300 to 920	19	MC/12	-1000	0.35	-800	500	—
H7546B	□30	—	R7600-00-M64	—	300 to 650	20	MC/12	-1000	0.45	-800	80	9.5
H7546B-20	□30	—	R7600-20-M64	—	300 to 920	20	MC/12	-1000	0.45	-800	500	—
*H11934-20	□30	—	R11265-20	—	300 to 920	21	MC/12	-1000	0.36	-900	500	—
H10515B-20	□30	—	R5900-20-L16	—	300 to 920	22	MC/10	-900	0.37	-800	500	—
H7260-20	□52 × 24	—	R7259-20	—	300 to 920	23	MC/10	-900	0.37	-800	500	—
*H9500	□52	—	R8400-00-M256	—	300 to 650	24	MC/12	-1100	0.18	-1000	75	10.5
H12700A	□52	—	R12699-00-M64	—	300 to 650	25	MC/10	-1100	0.225	-1000	75	12.0
*H13700	□52	—	R12699-00-M256	—	300 to 650	26	MC/10	-1100	0.185	-1000	75	12.0
*H13974-00-1616	□106	—	R12699-00-M64	—	300 to 650	27	MC/10	-1100	0.9	-1000	95	12.0

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

### Channel patterns for multianode photomultiplier tubes assemblies

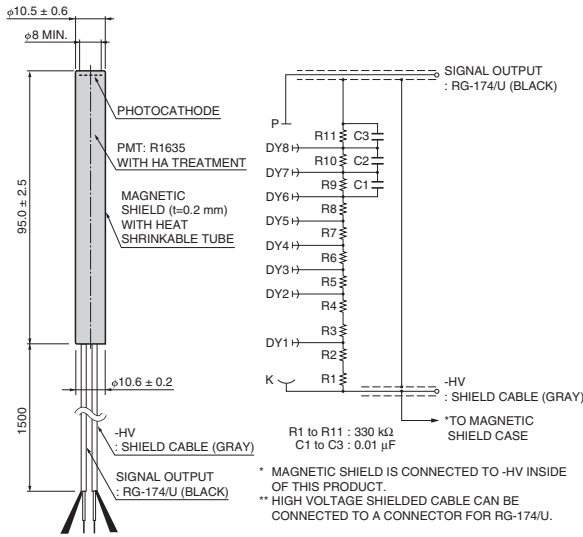
Type	Multianode photomultiplier tubes					
	Matrix			Linear		
	M16	M64	M256	L8	L16	L32
Channel pattern						
Number of channels	16	64	256	8	16	32

### Anode characteristics

Luminous Typ. (A/lm)	Gain Typ.	Dark current		Time response			Pulse linearity		Notes	Type No.
		Typ. (nA)	Max. (nA)	Rise time Typ. (ns)	Transit time Typ. (ns)	Transit time spread Typ. (ns)	2 % Typ. (mA)	5 % Typ. (mA)		
100	$1.0 \times 10^6$	1	50	0.8	9.0	0.5	3	7	H3164-12: SHV, BNC connector type H3164-14: SHV, LEMO connector type	<a href="#">H3164-10</a>
100	$1.0 \times 10^6$	2	50	0.7	9.0	0.5	3	7		<a href="#">H3695-10</a>
150	$1.4 \times 10^6$	1	2	2.1	22	2.0	3	7	H3165-12: SHV, BNC connector type	<a href="#">H3165-10</a>
220	$2.0 \times 10^6$	0.5	2	1.2	14	1.4	3	12	H12690-00-01: SHV, BNC connector type H12690-00-02: SHV, LEMO connector type	<a href="#">H12690</a>
110	$1.0 \times 10^6$	1	5	2.5	27	2.8	4	7		<a href="#">H6520</a>
200	$1.7 \times 10^6$	3	50	1.8	19	0.76	4	8		<a href="#">H6524</a>
200	$1.7 \times 10^6$	10	300	1.3	14	0.36	4	8		<a href="#">H6612</a>
400	$5.0 \times 10^6$	10	200	0.7	10	0.16	40	70	H6610 (R5320)	<a href="#">H6533</a>
500	$5.0 \times 10^6$	10	200	1.7	16	0.5	10	30	H7415-01 (with 50 Ω) H7416 (R7056)	<a href="#">H7415</a>
47	$5.0 \times 10^5$	10	100	1.6	17	0.55	30	50		<a href="#">H10828</a>
75	$7.9 \times 10^5$	2	15	2.7	40	4.5	150	200		<a href="#">H3178-51</a>
1800	$2.0 \times 10^7$	50	400	1.3	28	0.55	100	200	H3177-51 (R2059)	<a href="#">H1949-51</a>
270	$3.0 \times 10^6$	10	100	2.7	40	1.1	100	200	H6521 (R2256)	<a href="#">H6410</a>
270	$3.0 \times 10^6$	10	100	2.7	40	1.1	80	110		<a href="#">H7195</a>
200	$2.5 \times 10^6$	100	800	0.8	16	0.37	100	150	H3378-50 (R3377)	<a href="#">H2431-50</a>
900	$1.0 \times 10^7$	30	120	2.7	40	1.5	100	200		<a href="#">H6559</a>
1000	$1.4 \times 10^7$	50	300	2.5	54	1.2	100	150		<a href="#">H6527</a>
1500	$3.0 \times 10^6$	1/ch	10/ch	0.7	6.0	0.25	0.9/ch	1/ch	8 ch linear multianode	<a href="#">H9530-20</a>
280	$3.5 \times 10^6$	0.8/ch	4/ch	0.83	12	0.33	0.5/ch	1/ch	16 ch matrix multianode H8711-10 (Taper divider type)	<a href="#">H8711</a>
250	$5.0 \times 10^5$	0.8/ch	4/ch	0.83	12	0.33	0.5/ch	1/ch		<a href="#">H8711-20</a>
50	$6.0 \times 10^5$	0.2/ch	2/ch	1.0	12	0.38	0.3/ch	0.6/ch	64 ch matrix multianode	<a href="#">H7546B</a>
250	$5.0 \times 10^5$	0.2/ch	2/ch	1.0	12	0.38	0.3/ch	0.6/ch	64 ch matrix multianode	<a href="#">H7546B-20</a>
1200	$2.4 \times 10^6$	30	200	1.3	5.8	0.27	20	60		<a href="#">H11934-20*</a>
500	$1.0 \times 10^6$	1/ch	10/ch	0.6	7.4	0.23	0.8/ch	1/ch	16 ch linear multianode	<a href="#">H10515B-20</a>
500	$1.0 \times 10^6$	1/ch	10/ch	0.6	6.8	0.23	0.6/ch	0.8/ch	32 ch linear multianode H7260A-20 (-HV cable input type)	<a href="#">H7260-20</a>
105	$1.5 \times 10^6$	0.02/ch	30/in total	0.8	6.0	0.4	0.2/ch	0.5/ch	H9500-03 (UV glass type)	<a href="#">H9500</a>
110	$1.5 \times 10^6$	0.1/ch	50/in total	0.52	4.9	0.35	0.8/ch	—	H12700A-03 (UV glass type) H12700B (HV pin input type)	<a href="#">H12700A*</a>
110	$1.5 \times 10^6$	5	50	0.45	5.2	0.38	0.15	—	H13700-03 (UV glass type)	<a href="#">H13700*</a>
110	$1.5 \times 10^6$	5	50	0.52	4.9	0.35	0.8/ch	—	H13974-03-1616 (UV glass type)	<a href="#">H13974-00-1616*</a>

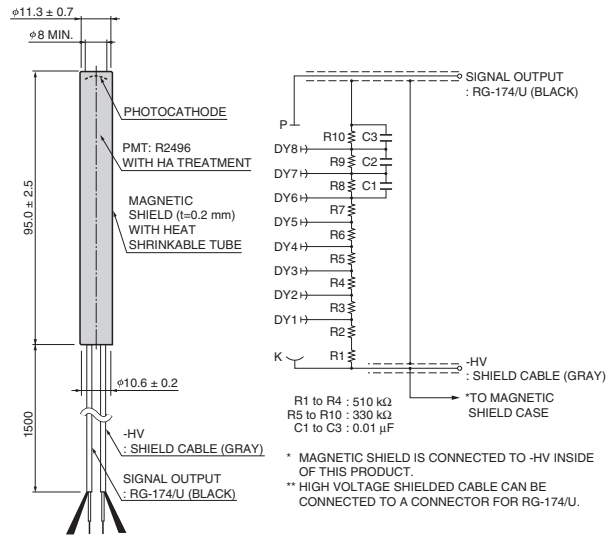
# Photomultiplier tube assemblies dimensional outlines and diagrams (Unit: mm)

## 1 H3164-10



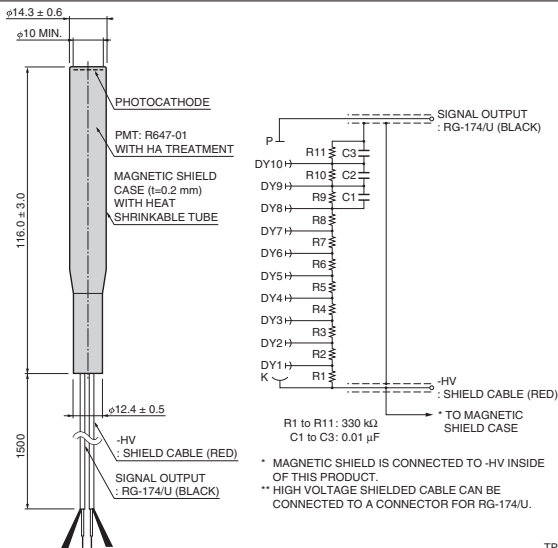
TPMHA0309ED

## 2 H3695-10



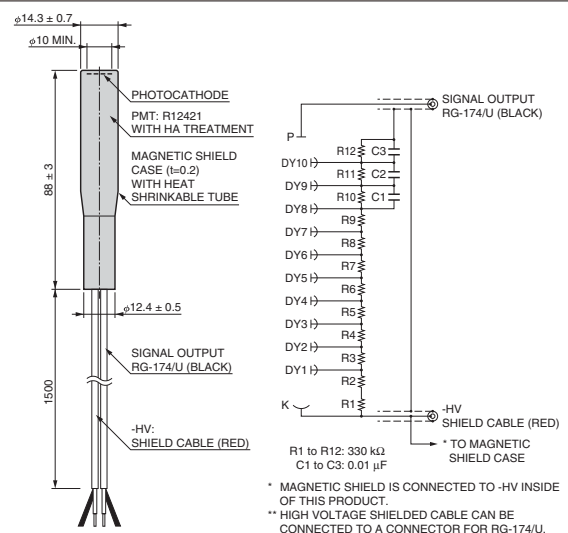
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## 3 H3165-10



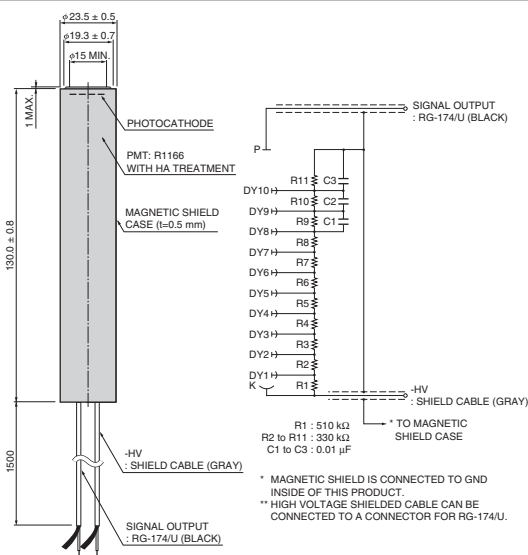
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## 4 H12690



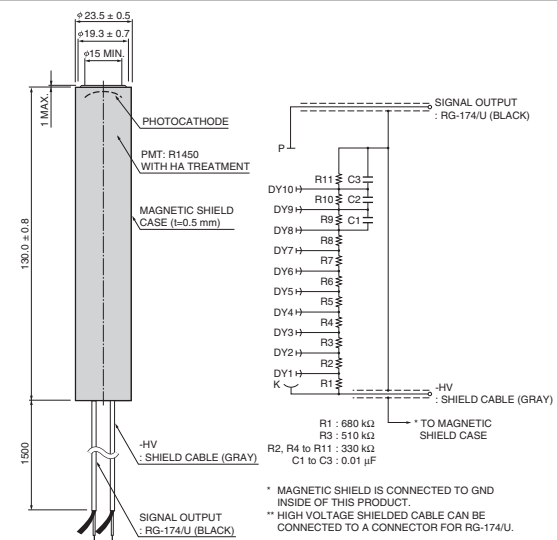
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## 5 H6520



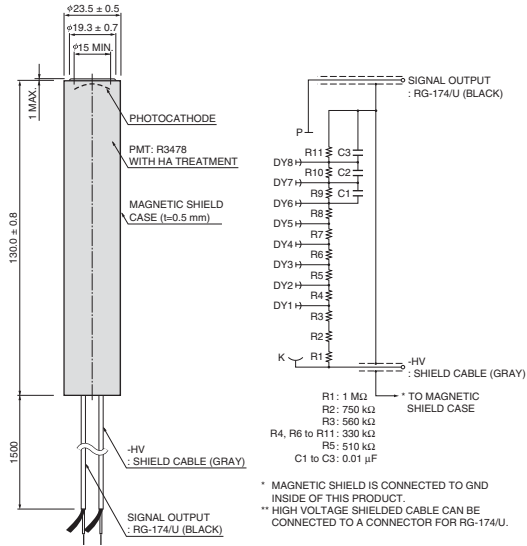
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## 6 H6524



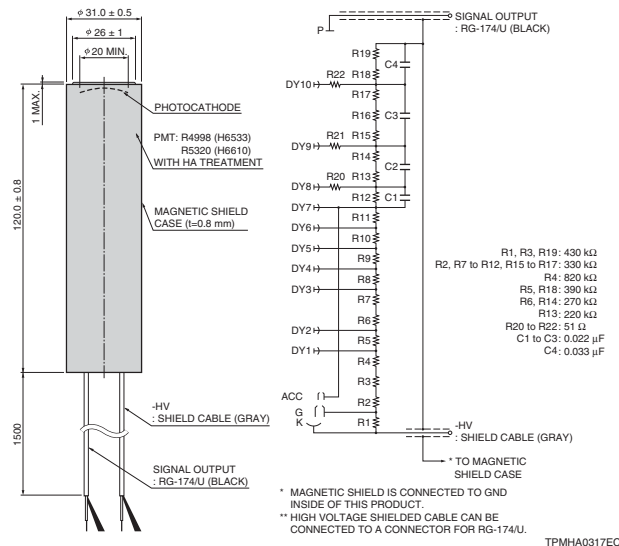
TPMHA0313EB

### 7 H6612



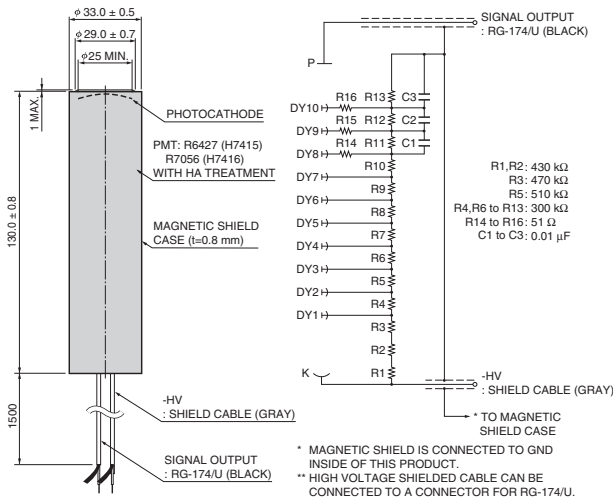
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### 8 H6533



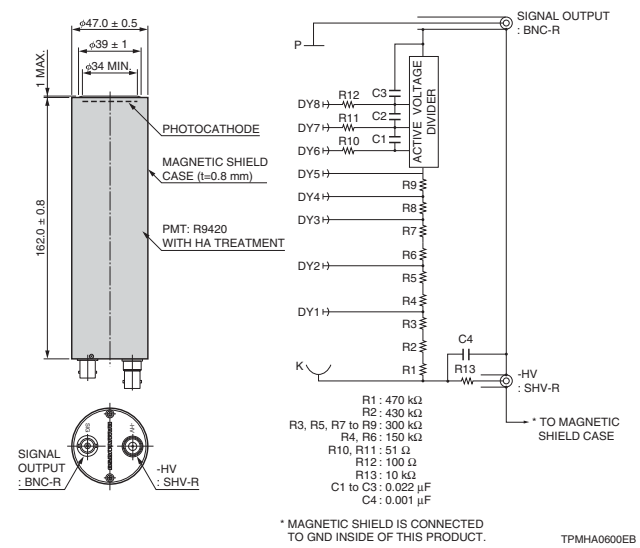
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### 9 H7415



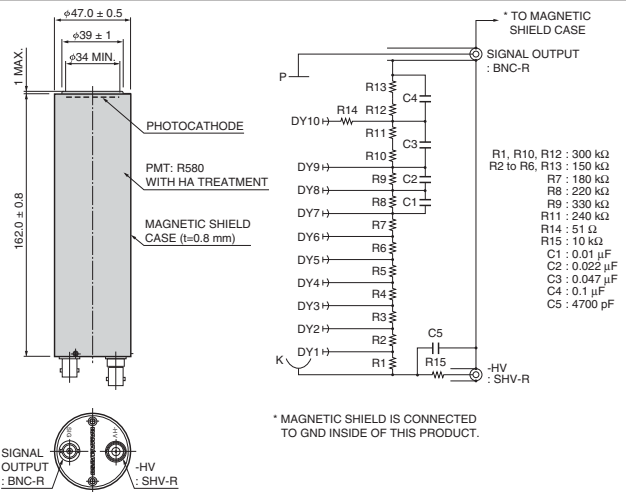
TPMHA0318EC

### 10 H10828



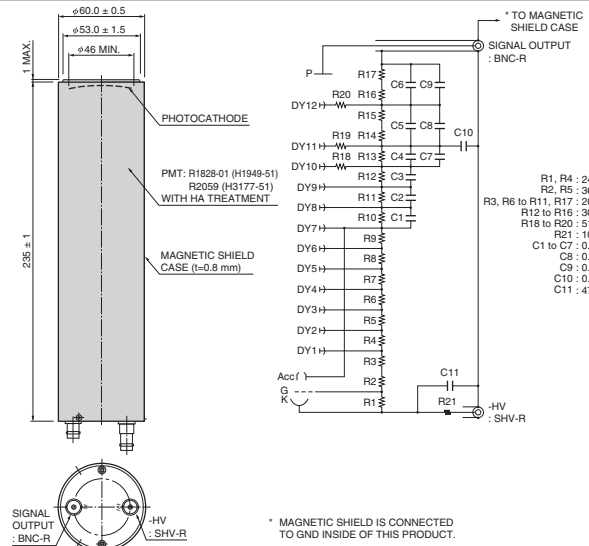
TPMHA0600EB

### 11 H3178-51



TPMHA0320EC

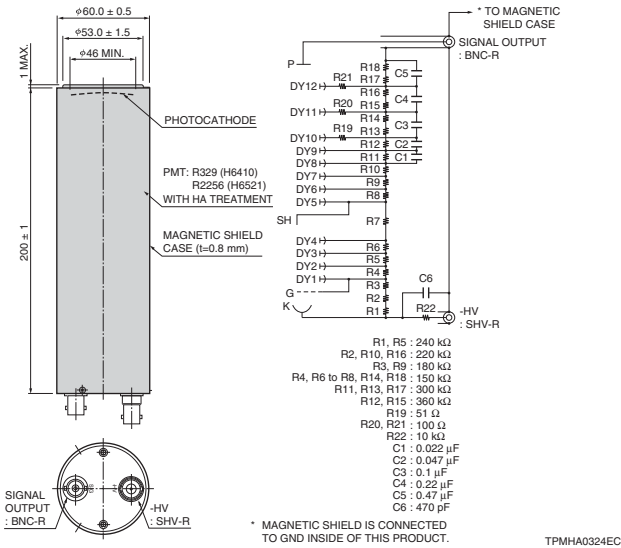
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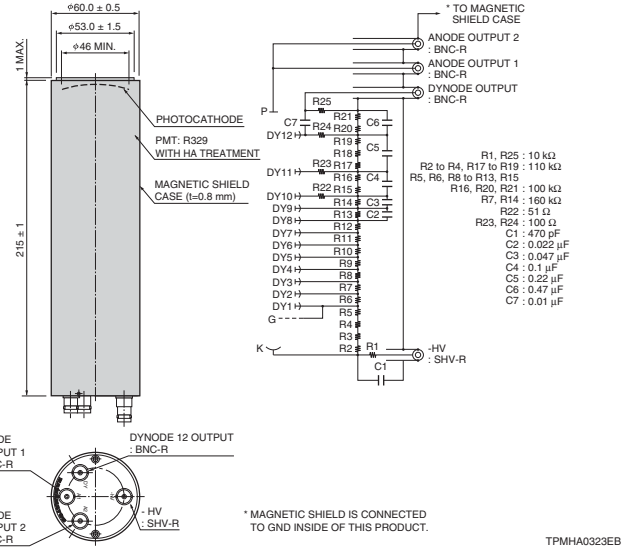
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# Photomultiplier tube assemblies dimensional outlines and diagrams (Unit: mm)

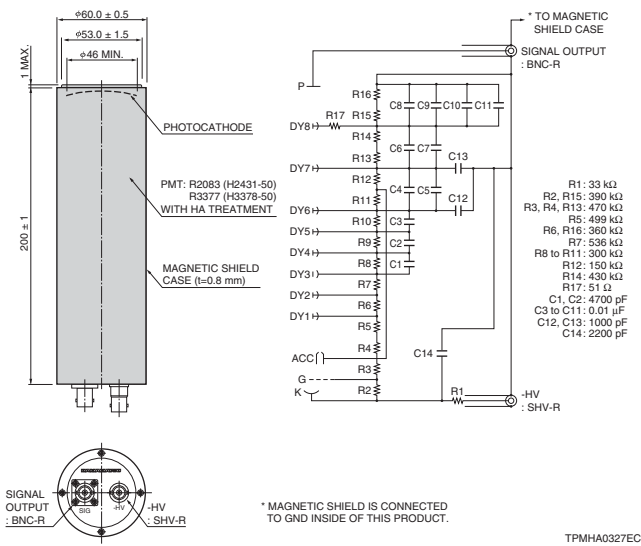
## 13 H6410



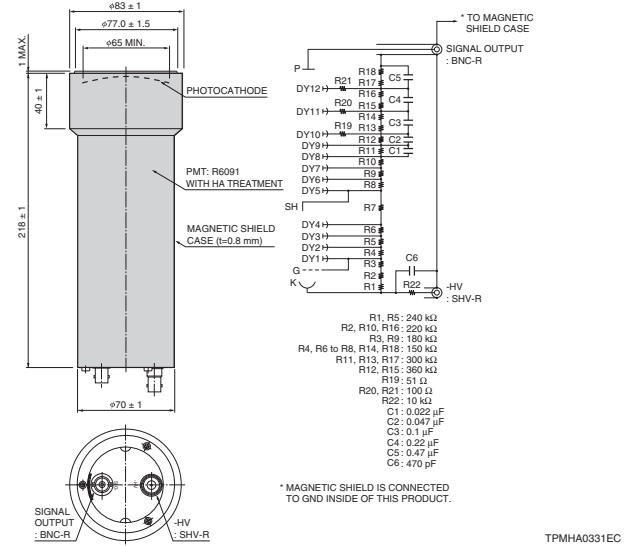
## 14 H7195



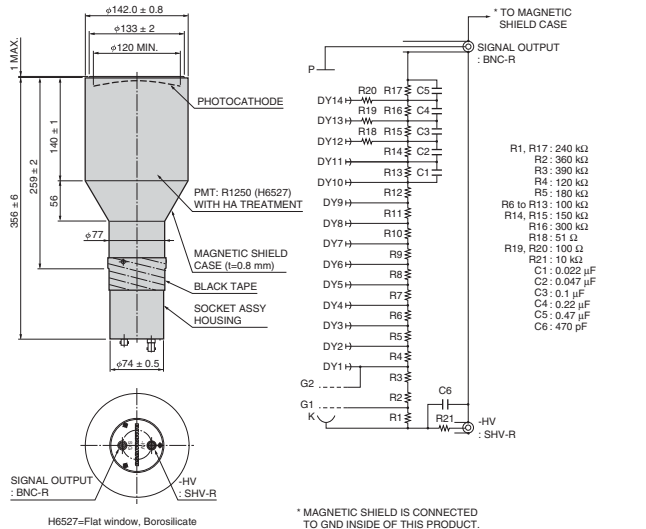
## 15 H2431-50



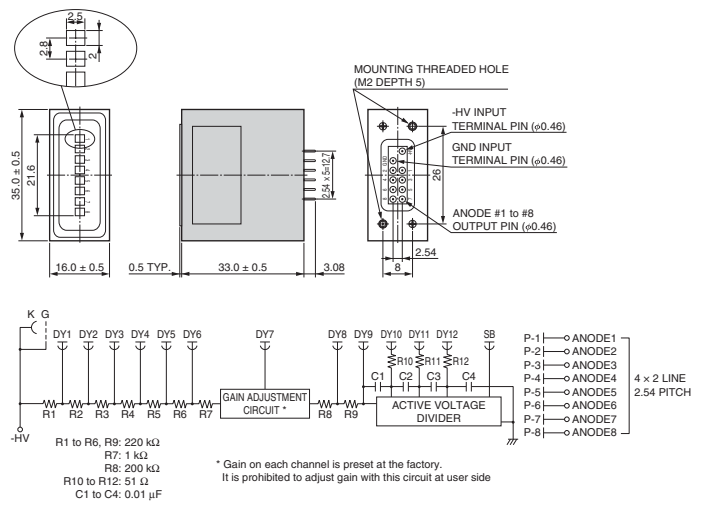
## 16 H6559



## 17 H6527

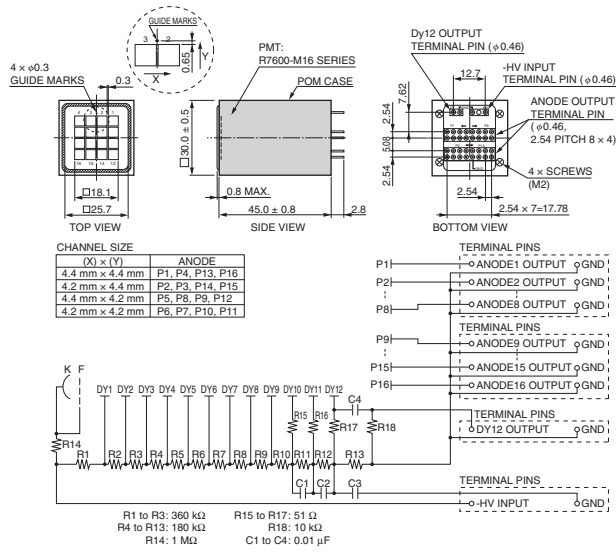


## 18 H9530-20



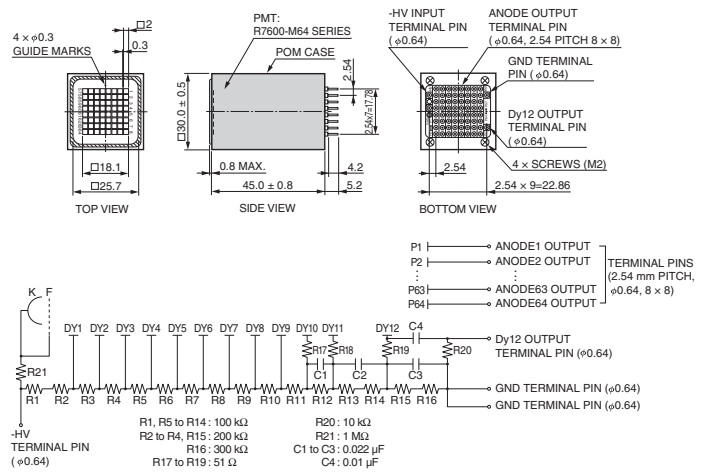


19 H8711, H8711-20, H8711-100, H8711-200, H8711-300



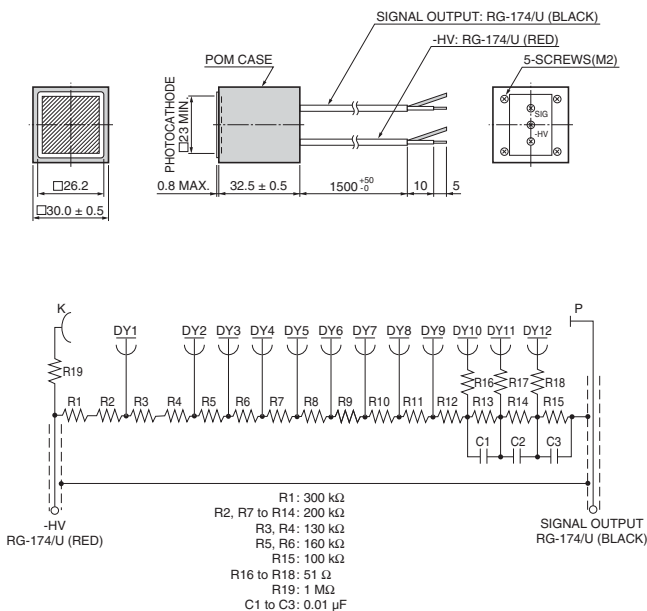
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20 H7546B, H7546B-20, H7546B-100, H7546B-200, H7546B-300



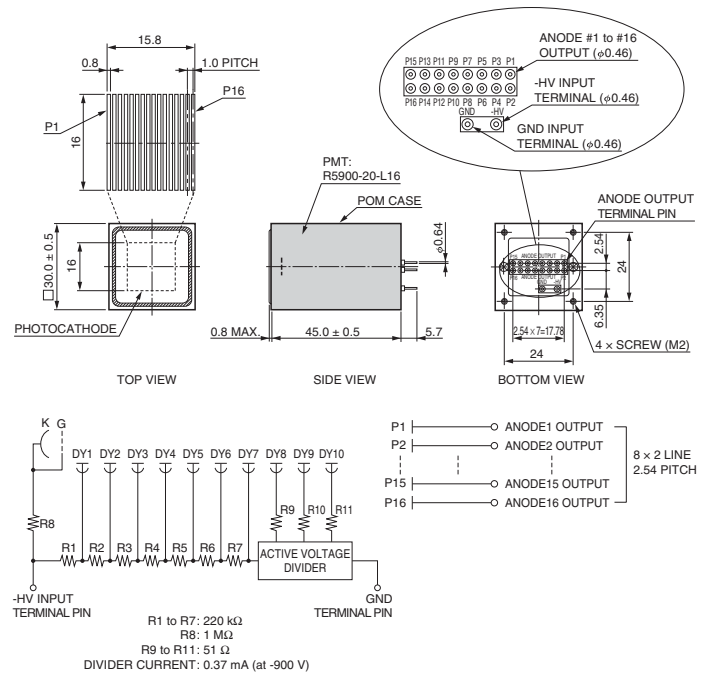
TPMHA0488ED

21 H11934-20



TPMHA0586EA

22 H10515B-20

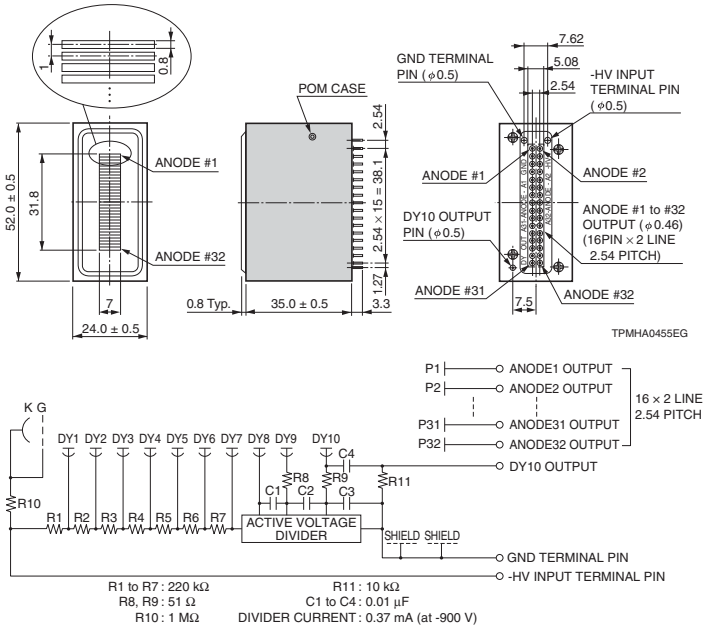


TPMHA0534EC

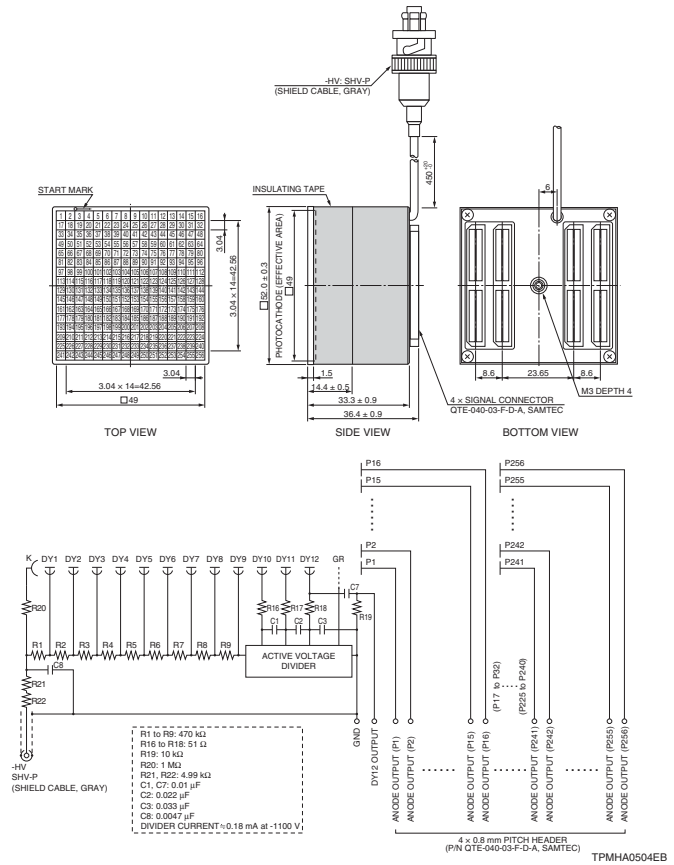
NOTE: DIVIDER RATIO=2.5: 1.3: 0.8: 0.8: 1: 1: .....1: 0.5  
TOTAL RESISTANCE=2.78 MΩ, DIVIDER CURRENT=359.7 μA at -1000 V (MAX.)

# Photomultiplier tube assemblies dimensional outlines and diagrams (Unit: mm)

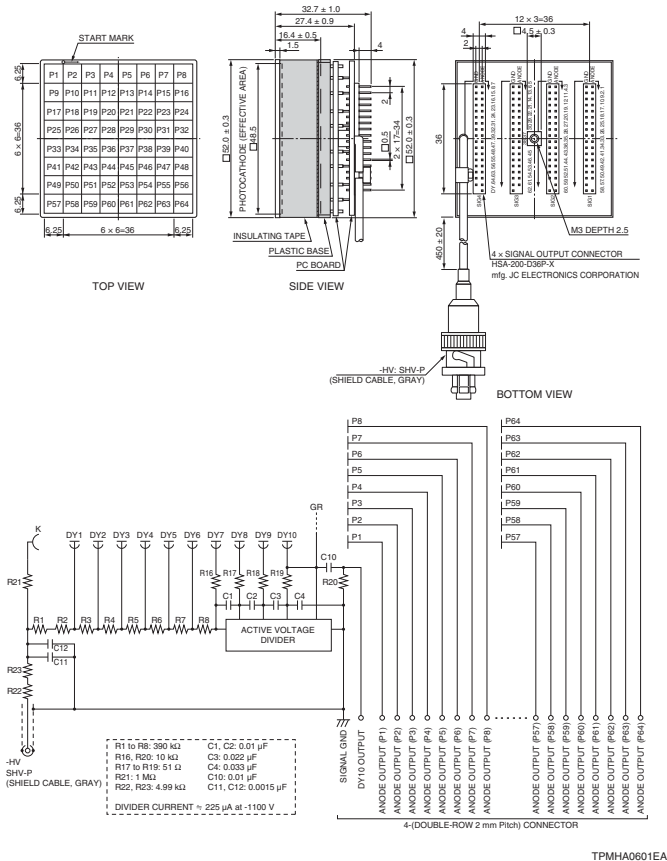
## 23 H7260-20, H7260-100, H7260-200



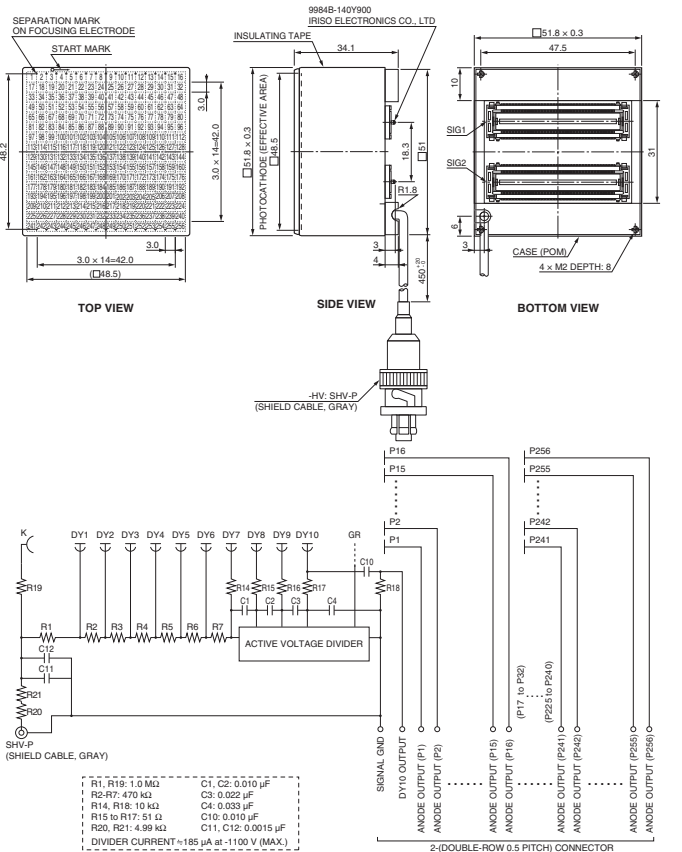
## 24 H9500



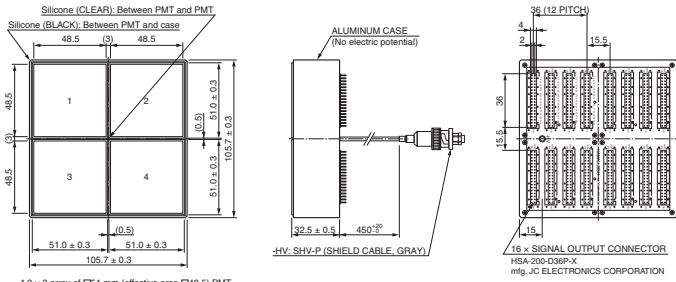
## 25 H12700A



## 26 H13700

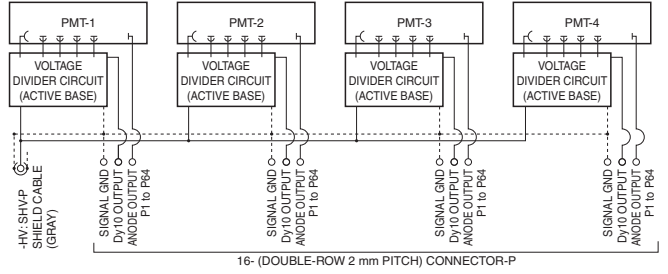


27 H13974-00-1616



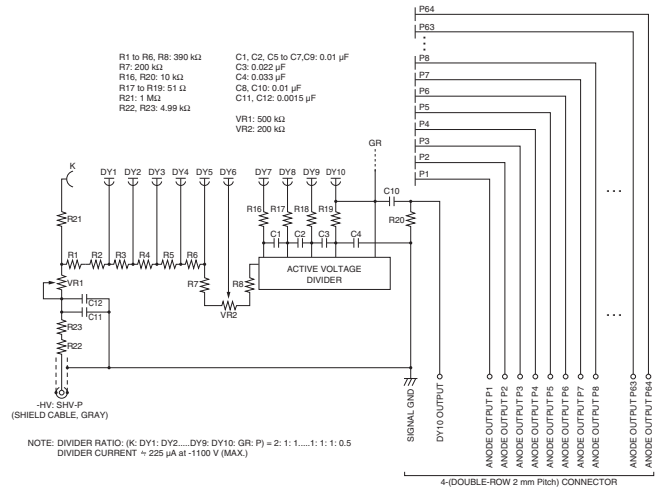
\* 2 x 2 array of □51 mm (effective area □48.5) PMT

TPMHA0625EA



16-(DOUBLE-ROW 2 mm PITCH) CONNECTOR-P

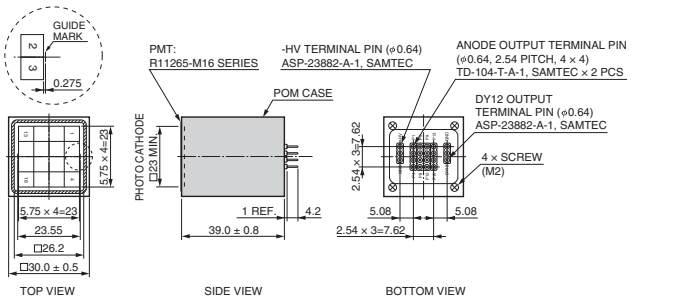
TPMHC0269EA



NOTE: DIVIDER RATIO: (K: DY1: DY2...DY9: DY10: GR: P) = 2: 1: 1...1: 1: 1: 0.5  
DIVIDER CURRENT = 225 μA at -1100 V (MAX.)

TPMHC0272EA

28 H12445-100, H12445-200 \*P.62

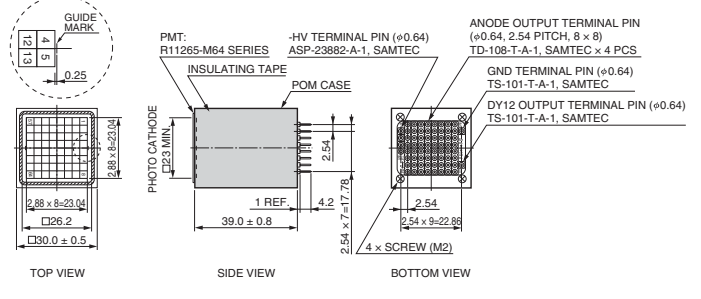


TOP VIEW

SIDE VIEW

BOTTOM VIEW

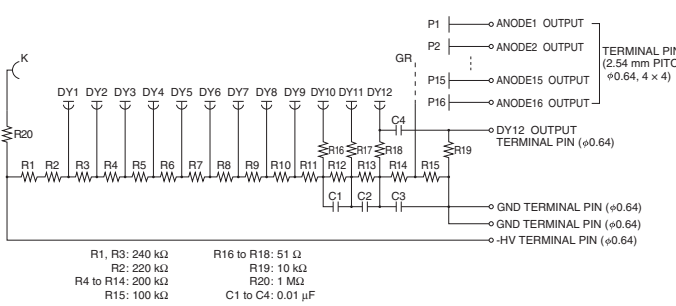
29 H12428-100, H12428-200 \*P.62



TOP VIEW

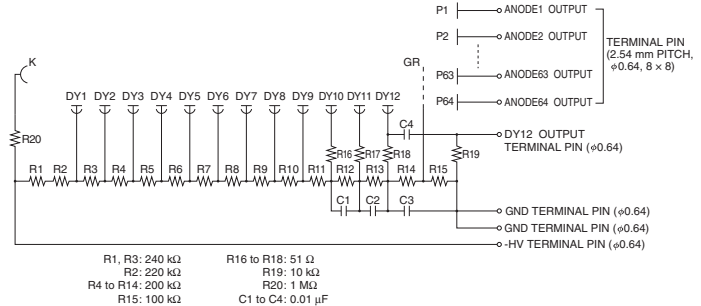
SIDE VIEW

BOTTOM VIEW



R1, R3: 240 kΩ  
R2: 220 kΩ  
R4 to R14: 200 kΩ  
R15: 100 kΩ  
R16 to R18: 51 Ω  
R19: 10 kΩ  
R20: 1 MΩ  
C1 to C4: 0.01 μF

TPMHA0591EA



R1, R3: 240 kΩ  
R2: 220 kΩ  
R4 to R14: 200 kΩ  
R15: 100 kΩ  
R16 to R18: 51 Ω  
R19: 10 kΩ  
R20: 1 MΩ  
C1 to C4: 0.01 μF

TPMHA0592EA

# Photomultiplier tube socket assemblies



## Photomultiplier tube socket assemblies

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

### Types of socket assemblies

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

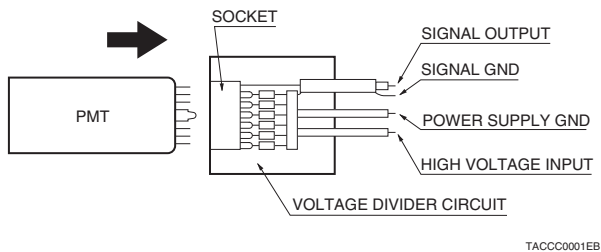
- D : Voltage Divider
- A : Amplifier
- P : High Voltage Power Supply

#### D-type socket assemblies (E717, E990 series, etc.)

The D-type socket assemblies contain a voltage divider circuit along with a socket in a compact metallic or plastic case.

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

Figure 40: D-type socket assembly

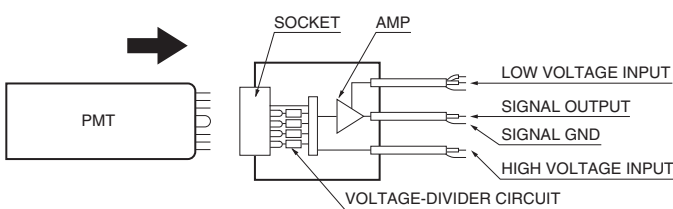


TACCC0001EB

#### DA-type socket assemblies (C7246, C7247 series)

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

Figure 41: DA-type socket assembly

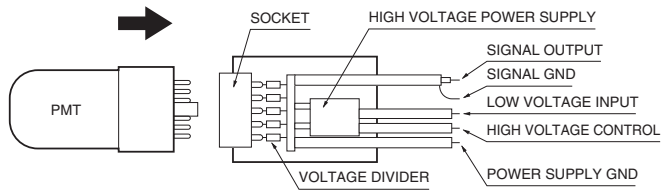


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#### DP-type socket assemblies (C12597-01, etc.)

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

Figure 42: DP-type socket assembly

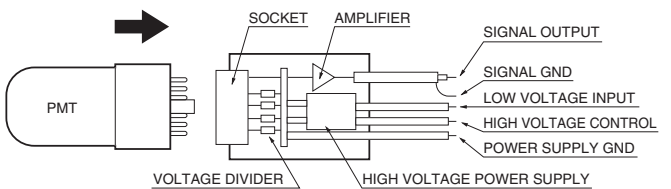


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#### DAP-type socket assemblies (C13654-01, C14019-01, etc.)

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

Figure 43: DAP-type socket assembly



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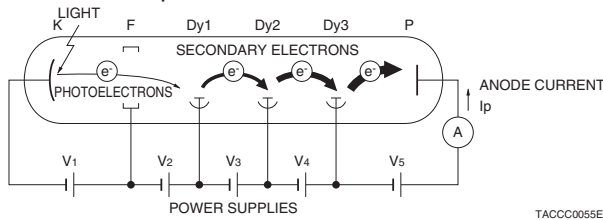
### Basics of voltage dividers

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

#### Voltage divider circuits

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

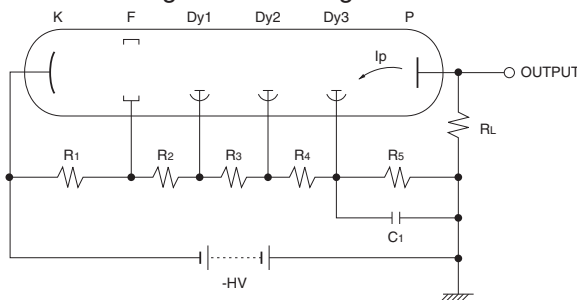
Figure 44: Schematic representation of photomultiplier tube operation



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

Figure 45: Anode grounded voltage divider circuit



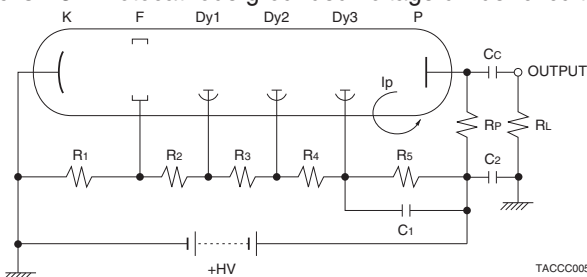
TACCC0056EB

### Anode grounding and photocathode grounding

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

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

Figure 46: Photocathode grounded voltage divider circuit

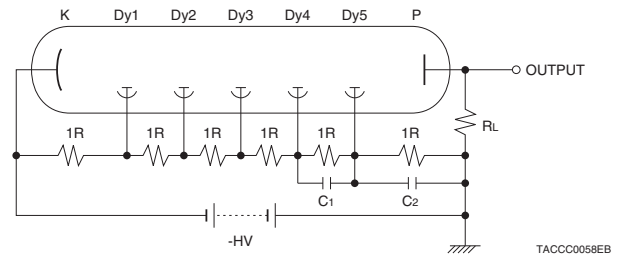


TACCC0057EB

### Standard voltage divider circuits

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

Figure 47: Equally divided voltage divider circuit



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### Tapered voltage divider circuits

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

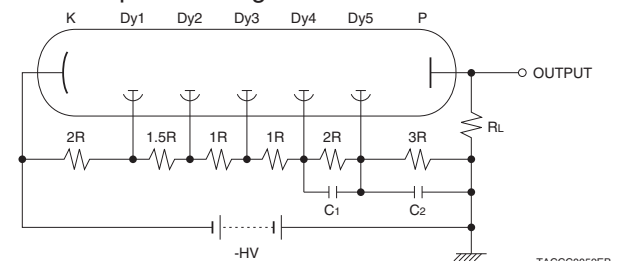
#### Tapered circuit at the first few stages (resistance: large $\rightarrow$ small)

- Photon counting (improvement in pulse height distribution)
- Low-light-level detection (S/N ratio enhancement)
- High-speed pulsed light detection (improvement in timing properties)
- Other applications requiring better magnetic characteristics and uniformity

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

- High pulsed light detection (improvement in output linearity)
- High-speed pulsed light detection (improvement in timing properties)
- Other applications requiring high output across the load resistor

Figure 48: Tapered voltage divider circuit



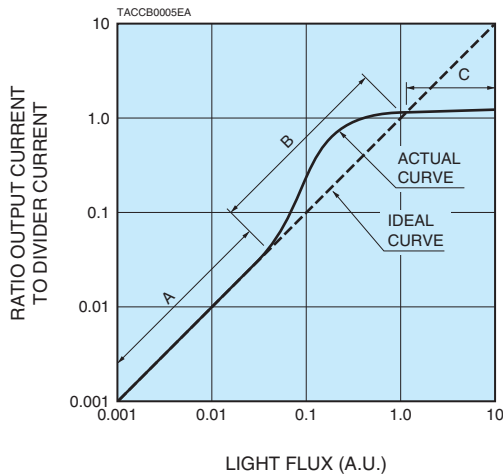
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### Voltage divider circuit and photomultiplier tube output linearity

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

# Photomultiplier tube socket assemblies

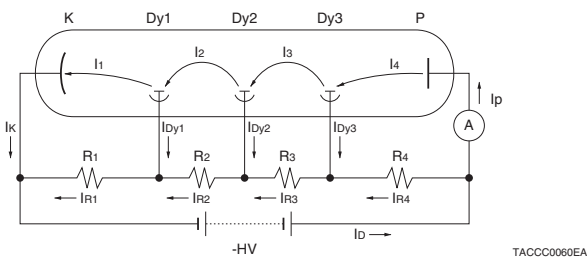
Figure 49: Output linearity of photomultiplier tube



## Output linearity in DC mode

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

Figure 50: Basic operation of photomultiplier tube and voltage divider circuit



## [When light is not incident on the tube]

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

### Interelectrode current of photomultiplier tube

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

### Electrode current of photomultiplier tube

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

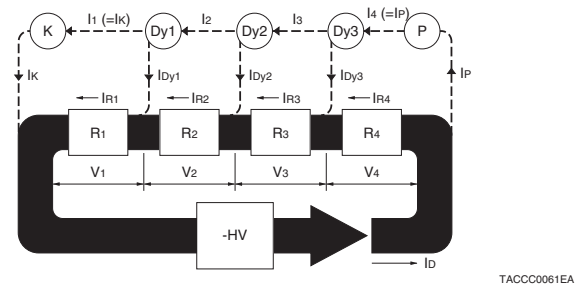
### Voltage divider circuit current

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

### Voltage divider circuit voltage

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

Figure 51: Operation without light input



## [When light is incident on the tube]

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

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

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

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

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

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

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

Figure 52: Operation with light input

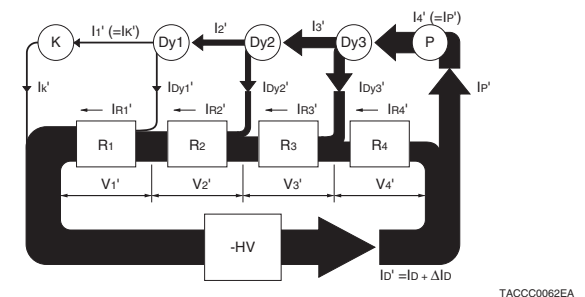
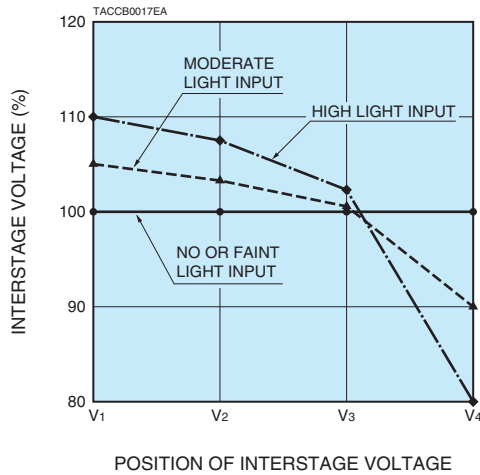


Figure 53 shows changes in the interstage voltages as the incident light level varies. The interstage voltage  $V_4'$  with light input drops significantly compared to  $V_4$  in dark state operation. This voltage loss is redistributed to the other stages, resulting in increases in  $V_1'$ ,  $V_2'$  and  $V_3'$  which are higher than those in dark state operation. The interstage voltage  $V_4'$  is only required to collect the secondary electrons emitted from the last dynode to the anode, so it has little effect on the anode current even if dropped to 20 or 30 volts. In contrast, the increases in  $V_1'$ ,  $V_2'$  and  $V_3'$  directly raise the secondary emission ratios ( $\delta_1$ ,  $\delta_2$  and  $\delta_3$ ) at the dynodes  $Dy_1$ ,  $Dy_2$  and  $Dy_3$ , and thus boost the overall gain  $m (= \delta_1 \cdot \delta_2 \cdot \delta_3)$ . This is the cause of overlinearity in region B in Figure 49. As the incident light level further increases so that  $V_4'$  approaches 0 volts, output saturation occurs in region C.

Figure 53: Changes in interstage voltages at different incident light levels



**Linearity improvement in DC output mode**

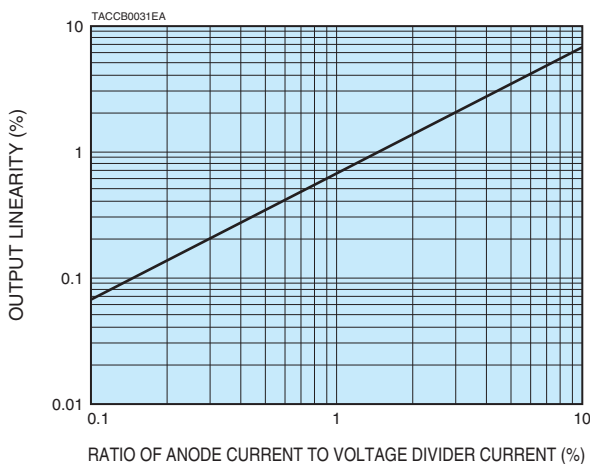
To improve the linearity in DC output mode, it is important to minimize the changes in the interstage voltage when photocurrent flows through the photomultiplier tube. There are several specific methods for improving the linearity, as discussed below.

**① Increasing the voltage divider current**

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

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

Figure 54: Output linearity vs. Anode current to voltage divider current ratio

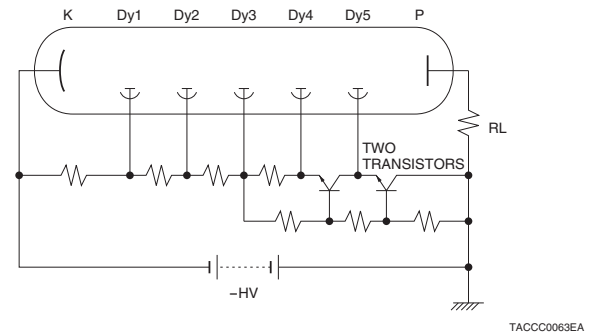


As stated above, good output linearity can be obtained simply by increasing the voltage divider current. However, this is accompanied by heat emanating from the voltage divider. If this heat is conducted to the photomultiplier tube, it may cause problems such as an increase in the dark current, and variation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

**② Using the active voltage divider circuit**

Use of a voltage divider circuit having transistors in place of the dividing resistors in last few stages (for example, Hamamatsu C12597 series using FETs) is effective in improving the output linearity. This type of voltage divider circuit ensures good linearity up to an output current equal to 60 % to 70 % of the voltage divider current, since the interstage voltage is not affected by the interelectrode current inside the photomultiplier tube. A typical active voltage divider circuit is shown in Figure 55.

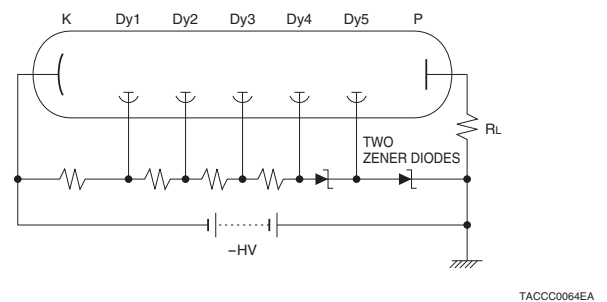
Figure 55: Active voltage divider circuit



**③ Using zener diodes**

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

Figure 56: Voltage divider circuit using zener diodes



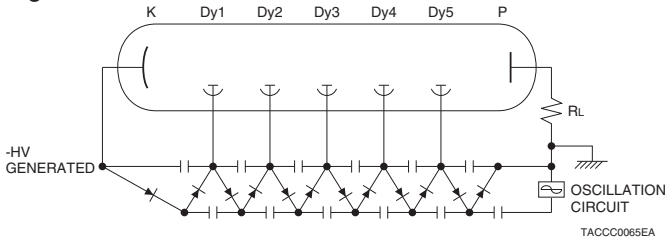
# Photomultiplier tube socket assemblies

## ④ Using Cockcroft-Walton circuit

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

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

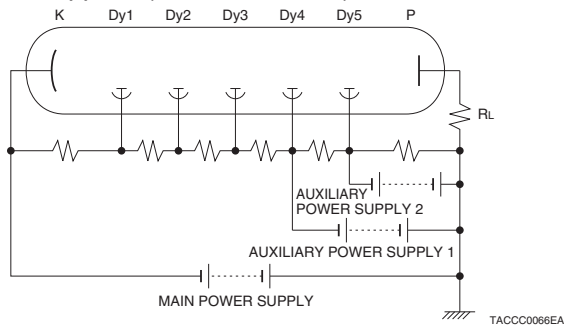
Figure 57: Cockcroft-Walton circuit



## ⑤ Using multiple high voltage power supplies

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

Figure 58: Voltage divider circuit using multiple power supplies (Booster method)



## Output linearity in pulsed mode

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

## Improving linearity in pulsed output mode

### ① Using storage capacitors

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

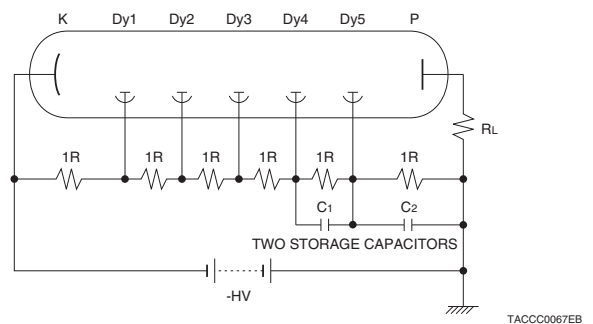
$$C > 100 \cdot Q/V$$

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

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

The active voltage divider circuit and the booster method using multiple power supplies discussed previously, provide superior pulse output linearity even at a higher duty factor.

Figure 59: Equally divided voltage divider circuit and storage capacitors

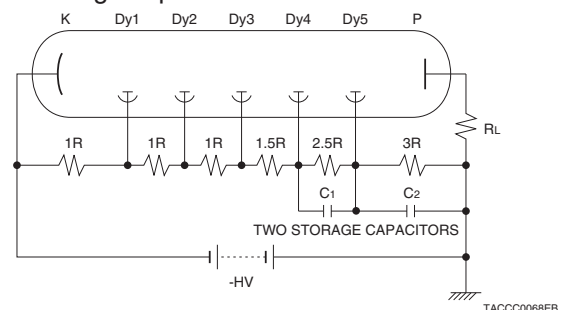


### ② Using tapered voltage divider circuit with storage capacitors

Use of the above voltage divider circuit having storage capacitors is effective in improving pulse linearity. However, when the pulse current increases further, the electron density also increases, particularly in last stages. This may cause a space charge effect which prevents interelectrode current from flowing adequately and leading to output saturation. A commonly used technique for extracting a higher pulse current is the tapered voltage divider circuit in which the voltage distribution ratios in the latter stages are enhanced as shown in Figure 60. Care should be taken in this case regarding loss of the gain and the breakdown voltages between electrodes.

Since use of a tapered voltage divider circuit allows an increase in the voltage between the last dynode and the anode, it is possible to raise the voltage across the load resistor when it is connected to the anode. It should be noted however, that if the output voltage becomes excessively high, the voltage between the last dynode and the anode may drop, causing a degradation in output linearity.

Figure 60: Tapered voltage divider circuit using storage capacitors





### D-type socket assemblies

The D-type socket assemblies are grouped as follows:

- (a) For DC output (-HV supply)  
Available only upon request
- (b) For DC or pulsed output (-HV supply)  
ex. E717-63, E10679-02
- (c) For pulsed output (+HV supply)  
ex. E990-08

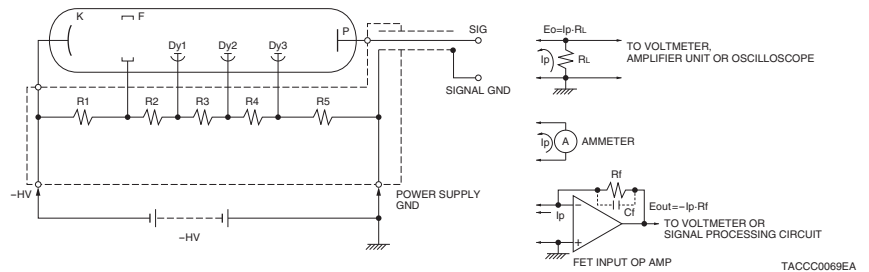
- (d) For DC or pulsed output (-HV supply), or pulsed output (+HV supply)  
ex. E717-74, E10679-51

### Connection of D-type socket assemblies to external circuits

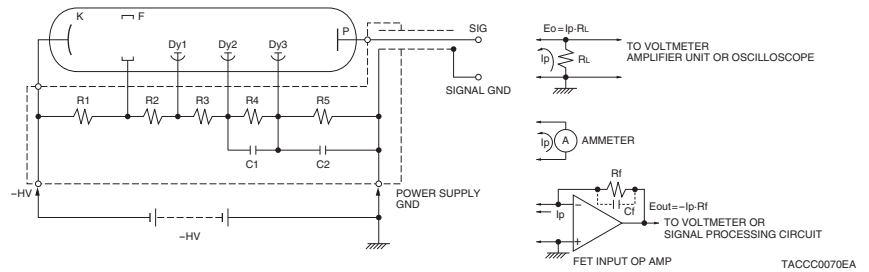
Figure 61 shows typical examples of connecting various D-type socket assemblies to external circuits.

Figure 61: Connection of D-type socket assemblies to external circuits

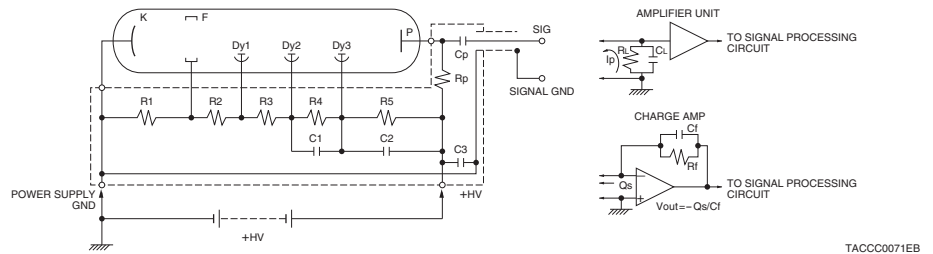
- (a) For DC output (-HV supply)



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

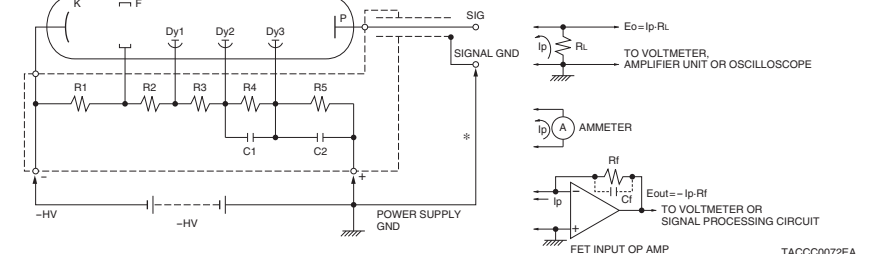


- (c) For pulsed output (+HV supply)



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

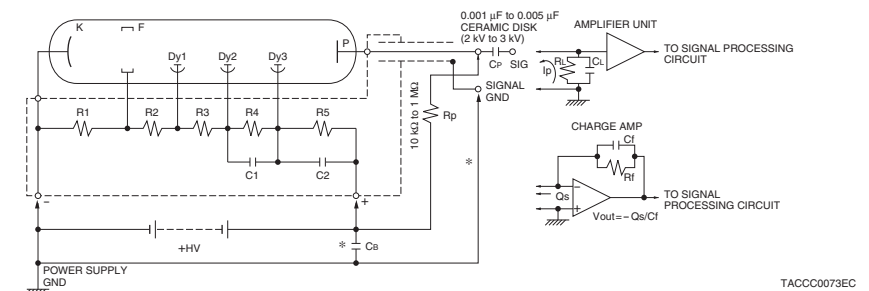
\* GND should be connected externally.



- d-2. For pulsed output (+HV supply)

For general scintillation counting and photon counting applications, recommended values for  $C_P$  and  $R_P$  are  $0.001 \mu\text{F}$  to  $0.005 \mu\text{F}$  and  $10 \text{ k}\Omega$  to  $1 \text{ M}\Omega$ . Since a high voltage is supplied to these parts, care must be taken when handling this circuit.

\* GND and  $C_B$  should be connected externally.



# D-type socket assemblies

Socket assembly Type No.	Applicable PMT diameter	Out-line and diagram	Grounded electrode / Supply voltage polarity	Maximum ratings			Leakage current in signal Max. (A)	Total voltage divider resistance (MΩ)	Maximum linear output in DC mode (μA)	Signal output	Note	
				Insulation voltage between case and pins (V)	Supply voltage (V)	Voltage divider current (mA)						
<b>For side-on types</b>												
E850-13	13 mm (1/2")	①	Anode / -	1500	1250	0.38	$1 \times 10^{-10}$	3.30	18 (at 1250 V)	DC / Pulse	Mounting flange E5038 (P.90) supplied. E850-13 with connector E5038 not supplied	
E850-22		②	Anode / -	1500	1250	0.38	$1 \times 10^{-10}$	3.30	18 (at 1250 V)	DC / Pulse		
E717-63	28 mm (1-1/8")	③	Anode / -	1500	1500	0.46	$1 \times 10^{-10}$	3.30	22 (at 1500 V)	DC / Pulse		
E717-74		④	Anode-Cathode / +-	1500	1500	0.46	$1 \times 10^{-10}$	3.30	22 (at 1500 V)	DC / Pulse	Pin output	
E717-500A		⑤	Anode / -	1500	1500	0.46	$1 \times 10^{-10}$	3.30	22 (at 1500 V)	DC / Pulse	E717-63 with connector	
<b>For head-on types</b>												
E1761-04	10 mm (3/8")	⑥	Anode / -	1500	1500	0.41	$1 \times 10^{-10}$	3.63	20 (at 1500 V)	DC / Pulse		
E1761-05		⑦	Anode / -	1500	1500	0.37	$1 \times 10^{-10}$	4.02	19 (at 1500 V)	DC / Pulse	For R2496	
E849-35	13 mm (1/2")	⑧	Anode / -	1250	1250	0.34	$1 \times 10^{-10}$	3.63	17 (at 1250 V)	DC / Pulse	E5038 (P.90) supplied	
E849-90		⑨	Anode / -	1250	1250	0.34	$1 \times 10^{-10}$	3.63	17 (at 1250 V)	DC / Pulse	E849-35 with connector E5038 not supplied	
E849-99		⑩	Anode / -	1250	1250	0.32	$1 \times 10^{-10}$	3.96	16 (at 1250 V)	DC / Pulse	For R12421, E5038 (P.90) supplied	
E974-13	19 mm (3/4")	⑪	Anode / -	1800	1800	0.48	$1 \times 10^{-10}$	3.81	23 (at 1800 V)	DC / Pulse		
E974-14		⑫	Cathode / +	1800	1800	0.48	—	3.81	—	Pulse	For scintillation counting	
E974-17		⑬	Anode / -	1800	1800	0.48	$1 \times 10^{-10}$	3.81	23 (at 1800 V)	DC / Pulse	E974-13 with connector	
E974-22		⑭	Anode / -	1800	1800	0.44	$1 \times 10^{-10}$	4.16	21 (at 1800 V)	DC / Pulse	For R1450, with connector	
E2253-05		⑮	Anode / -	1800	1800	0.36	$1 \times 10^{-10}$	5.13	17 (at 1800 V)	DC / Pulse	For R3478, with connector	
E2253-08		⑯	Cathode / +	1800	1800	0.36	—	5.13	—	Pulse	For R3478, for scintillation counting	
E974-29		⑰	Anode / -	1250	1250	0.30	$1 \times 10^{-10}$	4.30	14 (at 1250 V)	DC / Pulse	For R5610A, R5611A, with connector	
E974-18		⑱	Anode / -	1500	1500	0.38	$1 \times 10^{-10}$	3.98	18 (at 1500 V)	DC / Pulse	For R1878, with connector	
E2924-11		25 mm (1")	⑲	Anode / -	1800	1800	0.41	$1 \times 10^{-10}$	4.47	20 (at 1800 V)	DC / Pulse	For R7899
E2924			⑳	Anode / -	1500	1250	0.30	$1 \times 10^{-10}$	4.29	14 (at 1250 V)	DC / Pulse	
E2924-500	㉑		Anode / -	1500	1250	0.30	$1 \times 10^{-10}$	4.29	14 (at 1250 V)	DC / Pulse	E2924 with connector	
E2924-05	㉒		Cathode / +	1500	1250	0.30	—	4.30	—	Pulse	For scintillation counting	
E990-07	28 mm (1-1/8")	㉓	Anode / -	1500	1500	0.38	$1 \times 10^{-10}$	3.96	18 (at 1500 V)	DC / Pulse		
E990-08		㉔	Cathode / +	1500	1500	0.38	—	3.96	—	Pulse	For scintillation counting	
E990-501		㉕	Anode / -	1500	1500	0.38	$1 \times 10^{-10}$	3.96	18 (at 1500 V)	DC / Pulse	E990-07 with connector	
E2624		㉖	Anode / -	2500	2500	0.53	$1 \times 10^{-10}$	4.80	26 (at 2500 V)	DC / Pulse	For R6427,	
E2624-05		㉗	Cathode / +	2500	2500	0.53	—	4.80	—	Pulse	For R6427, for scintillation counting	
E2624-14		㉘	Anode / -	2500	2500	0.53	$1 \times 10^{-10}$	4.80	26 (at 2500 V)	DC / Pulse	E2624 with connector	

NOTE: (A) Measured with the maximum supply voltage

(B) Measured with a supply voltage of 1000 V except for E5996, E7083 and E6736 (900 V)

(C) The current at which the output linearity is kept within  $\pm 5\%$

Socket assembly Type No.	Applicable PMT diameter	Out-line and diagram	Grounded electrode / Supply voltage polarity	Maximum ratings			Leakage current in signal Max. (A)	Total voltage divider resistance (MΩ)	Maximum linear output in DC mode (μA)	Signal output	Note
				Insulation voltage between case and pins (V)	Supply voltage (V)	Voltage divider current (mA)					
<b>For head-on types</b>											
E990-500	28 mm (1-1/8")	29	Anode / -	1500	1500	0.35	$1 \times 10^{-10}$	4.29	17 (at 1500 V)	DC / Pulse	With connector
E990-29		30	Anode / -	1500	1500	0.34	$1 \times 10^{-10}$	4.48	16 (at 1500 V)	DC / Pulse	For R3998-02
E2183-500	38 mm (1-1/2")	31	Anode / -	2000	1750	0.45	$1 \times 10^{-10}$	3.97	22 (at 1750 V)	DC / Pulse	With connector
E2183-502		32	Cathode / +	2000	1750	0.45	—	3.96	—	Pulse	With connector, for scintillation counting
E1198-26	51 mm (2") 76 mm (3")	33	Anode / -	1500	1500	0.38	$1 \times 10^{-10}$	4.01	18 (at 1500 V)	DC / Pulse	
E1198-27		34	Cathode / +	1500	1500	0.38	—	4.01	—	Pulse	For scintillation counting
E1198-05		35	Anode / -	1500	1500	0.46	$1 \times 10^{-10}$	3.30	22 (at 1500 V)	DC / Pulse	
E1198-20		36	Cathode / +	1500	1500	0.46	—	3.30	—	Pulse	For scintillation counting
E1198-07	51 mm (2")	37	Anode / -	1750	1750	0.44	$1 \times 10^{-10}$	3.98	22 (at 1750 V)	DC / Pulse	For R2154-02
E2979-500		38	Anode / -	3000	3000	0.70	$1 \times 10^{-10}$	4.31	34 (at 3000 V)	DC / Pulse	For R1828-01, with rear panel connector, with magnetic shield
E1198-23	51 mm (2") 76 mm (3") 127 mm (5")	39	Cathode / +	2200	2000	0.51	—	3.97	—	Pulse	For scintillation counting
E1198-22		40	Anode / -	2200	2000	0.51	$1 \times 10^{-10}$	3.97	25 (at 2000 V)	DC / Pulse	
E6316		41	Cathode / +	2200	2000	0.51	—	3.97	—	Pulse	E1198-23, with rear panel connector, for scintillation counting
E6316-01		42	Anode / -	2200	2000	0.51	$1 \times 10^{-10}$	3.97	25 (at 2000 V)	DC / Pulse	E1198-22, with rear panel connector
E5859-05	51 mm (2") 76 mm (3")	43	Anode / -	1500	1500	0.38	$1 \times 10^{-10}$	3.98	18 (at 1500 V)	DC / Pulse	With rear panel connector
E5859-19		44	Anode / -	2000	2000	0.57	$1 \times 10^{-10}$	3.53	28 (at 2000 V)	DC / Pulse	For R7724 with rear panel connector
E5859		45	Anode / -	2700	2700	0.67	$1 \times 10^{-10}$	4.06	33 (at 2700 V)	DC / Pulse	With rear panel connector
E5859-01		46	Anode / -	2700	2700	0.75	$1 \times 10^{-10}$	3.62	37 (at 2700 V)	DC / Pulse	With rear panel connector
E5859-03		47	Cathode / +	2700	2700	0.75	—	3.62	—	Pulse	With rear panel connector, for scintillation counting
E1435-02	51 mm (2")	48	Anode / -	1500	1500	0.38	$1 \times 10^{-10}$	3.96	18 (at 1500 V)	DC / Pulse	
E7693	127 mm (5")	49	Anode / -	3000	3000	1.03	$1 \times 10^{-10}$	2.94	51 (at 3000 V)	DC / Pulse	For R1250, with rear panel connector
E10679-02	Metal package PMT R9880U series	50	Anode / -	1100	1100	0.32	$1 \times 10^{-10}$	3.46	16 (at 1100 V)	DC / Pulse	
E10679-51	Metal package PMT R9880U series	51	Anode-Cathode / +-	1100	1100	0.32	$1 \times 10^{-10}$	3.46	16 (at 1100 V)	DC / Pulse	Pin output
E5996	Metal package PMT R7600U series	52	Anode / -	900	900	0.33	$1 \times 10^{-10}$	2.75	16 (at 900 V)	DC / Pulse	
E7083	Metal package PMT R7600U-M4 series	53	Anode / -	900	900	0.33	$1 \times 10^{-10}$	2.75	4 <sup>Ⓓ</sup> (at 900 V)	DC / Pulse	
E6736	Metal package PMT R5900U-L16	54	Anode / -	900	900	0.38	$1 \times 10^{-10}$	2.42	1.16 <sup>Ⓓ</sup> (at 900 V)	DC / Pulse	
E7514	Metal package PMT R8900U-C12	55	Anode / -	1000	1000	0.34	$1 \times 10^{-10}$	2.97	1.4 <sup>Ⓓ</sup> (at 1000 V)	DC / Pulse	
E11807	Metal package PMT R11265U series	56	Anode / -	1000	1000	0.36	$1 \times 10^{-10}$	2.78	17 (at 1000 V)	DC / Pulse	
E11807-01	Metal package PMT R11265U series	56	Anode / -	1000	1000	0.36	$1 \times 10^{-10}$	2.69	18 (at 1000 V)	DC / Pulse	E11807, with tapered voltage divider circuit

NOTE: Ⓓ Current of one anode

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

Temperature ranges of D-type socket assemblies are as follows (except for some products):

Operating: 0 °C to +50 °C Storage: -15 °C to +60 °C

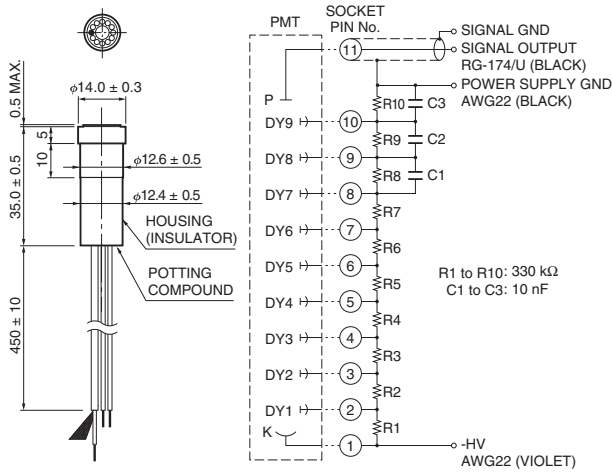
Do not use the socket assemblies if condensation occurs, since a high voltage is output from the socket.

Insert the photomultiplier tube all the way into the socket.

Insert the photomultiplier tube straight into the socket, or pull the photomultiplier tube straight out of the socket when removing it.

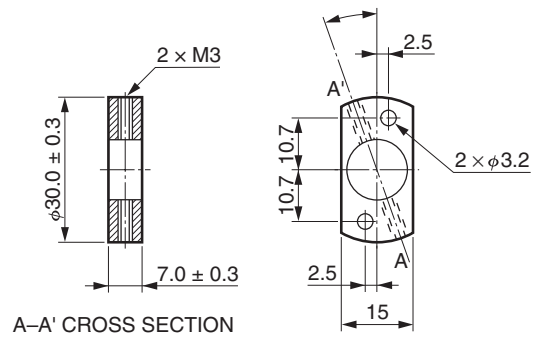
# D-type socket assemblies dimensional outlines and diagrams (Unit: mm)

## 1 E850-13



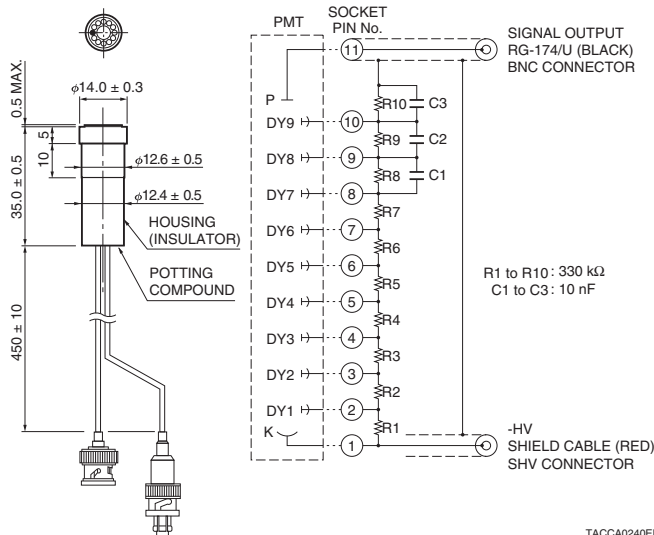
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## Mounting flange: E5038 (For E850 series, E849 series)



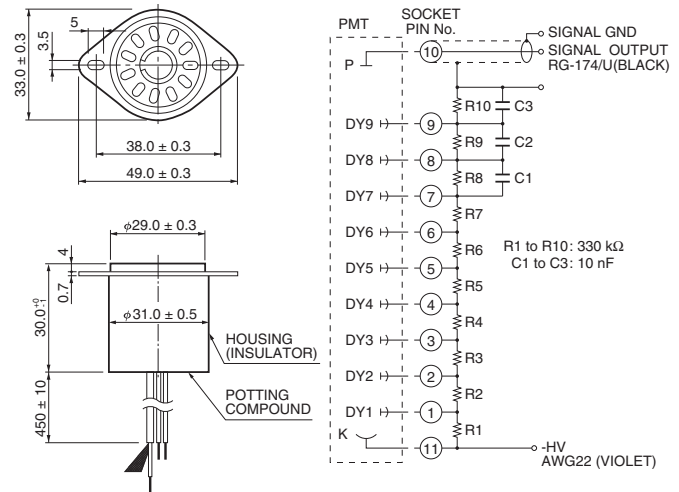
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## 2 E850-22



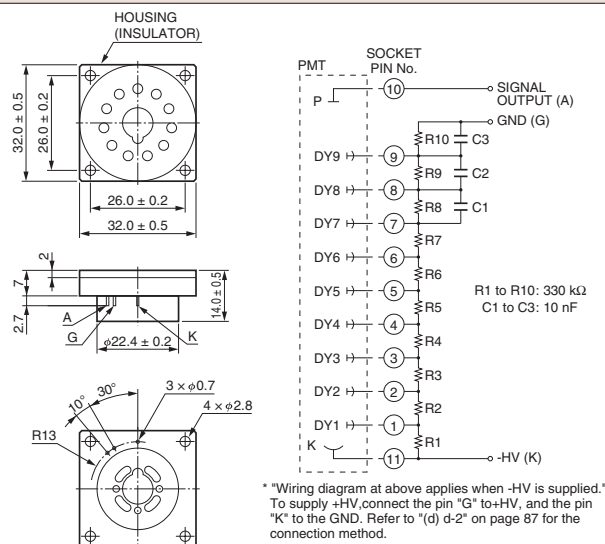
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## 3 E717-63



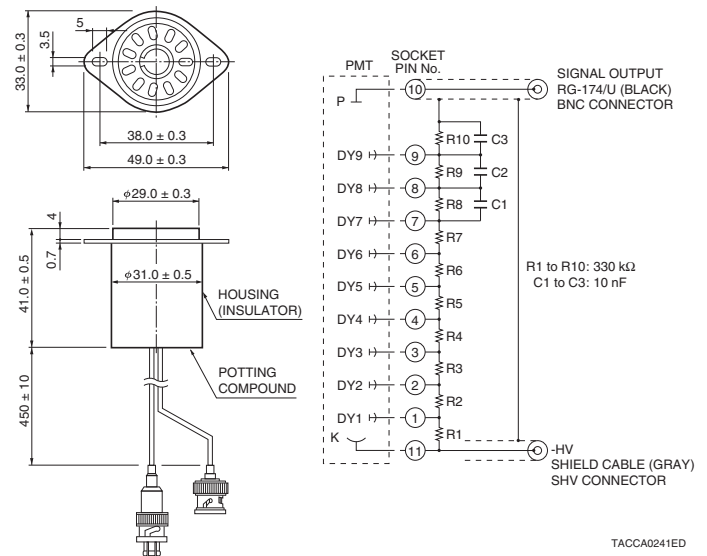
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## 4 E717-74



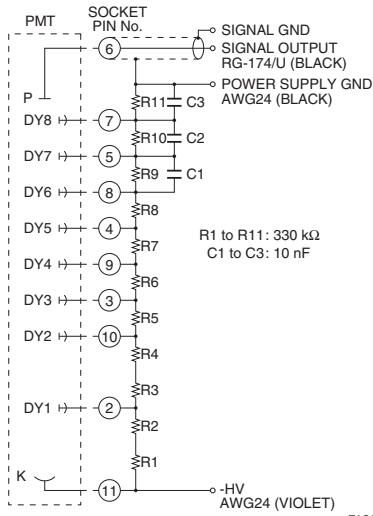
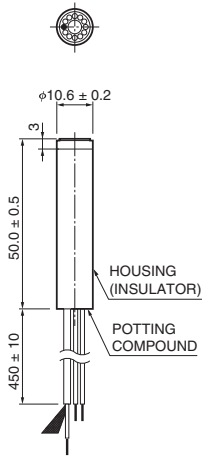
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## 5 E717-500A



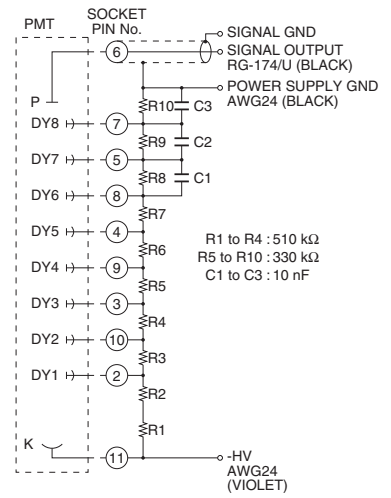
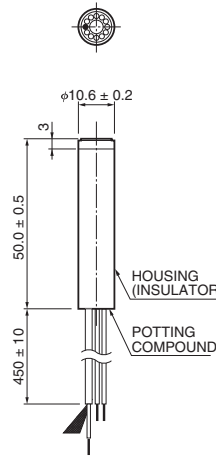
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**6 E1761-04**



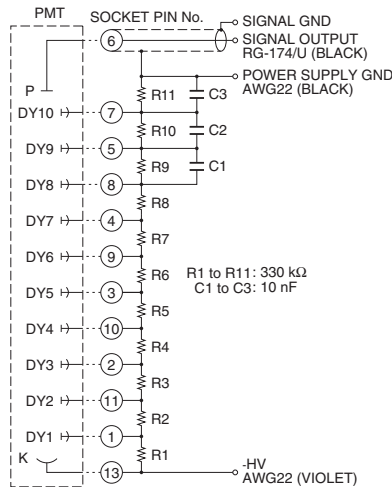
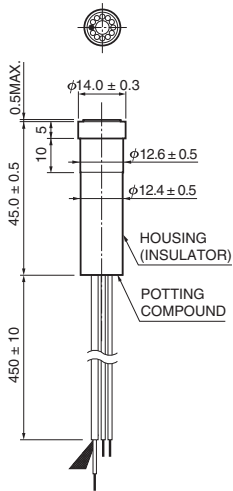
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**7 E1761-05**



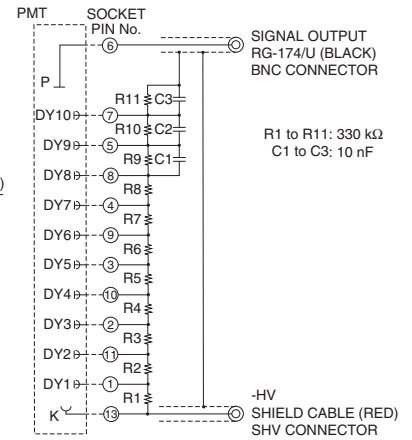
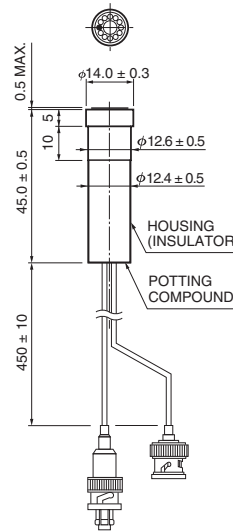
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**8 E849-35**



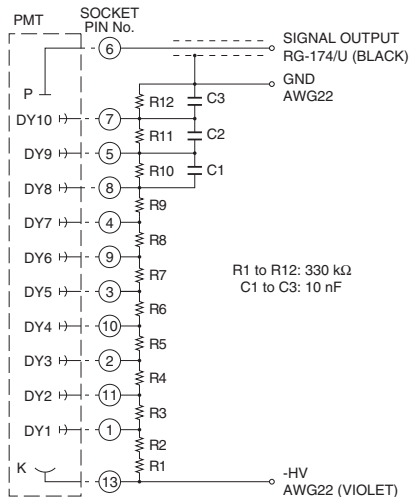
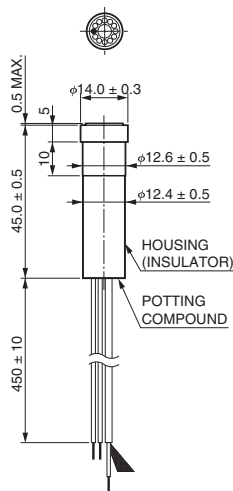
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**9 E849-90**



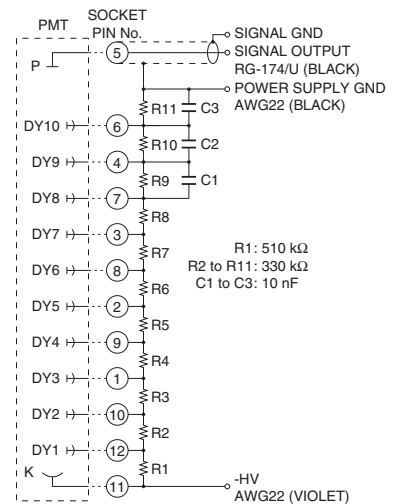
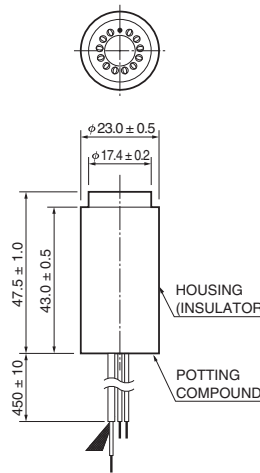
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**10 E849-99**



TACCA00324EA

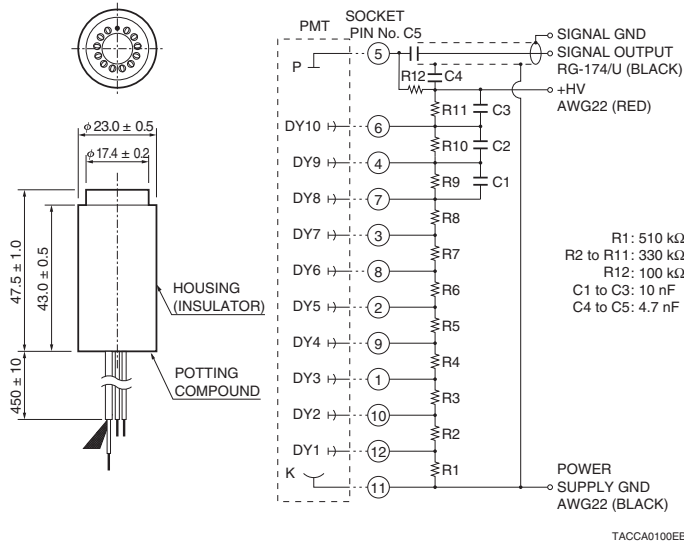
**11 E974-13**



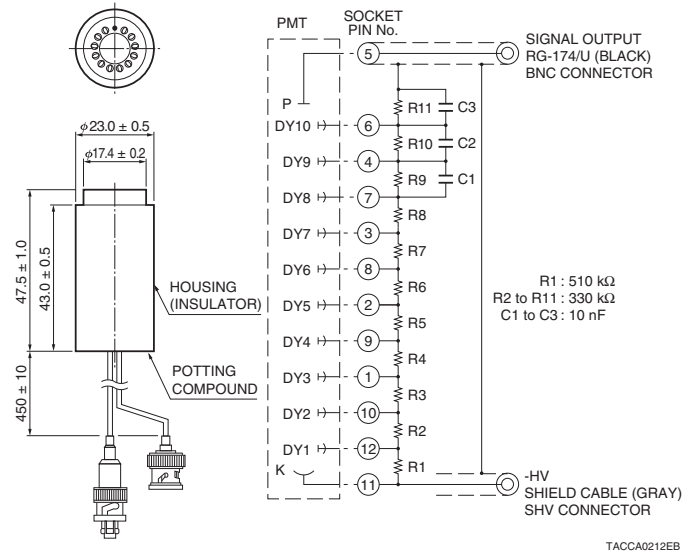
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# D-type socket assemblies dimensional outlines and diagrams (Unit: mm)

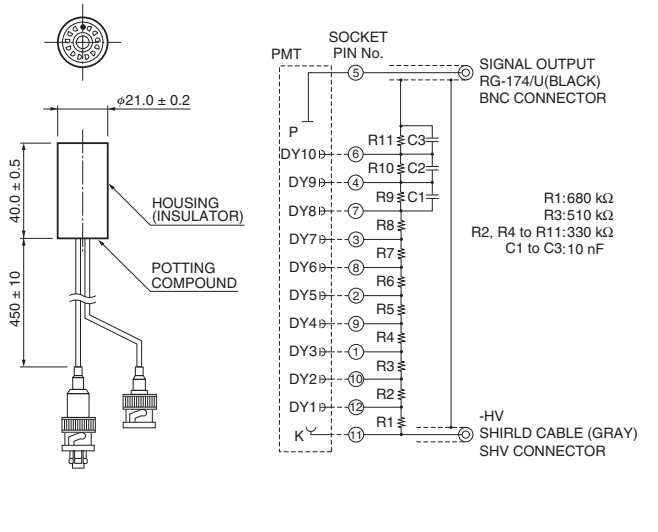
12 E974-14



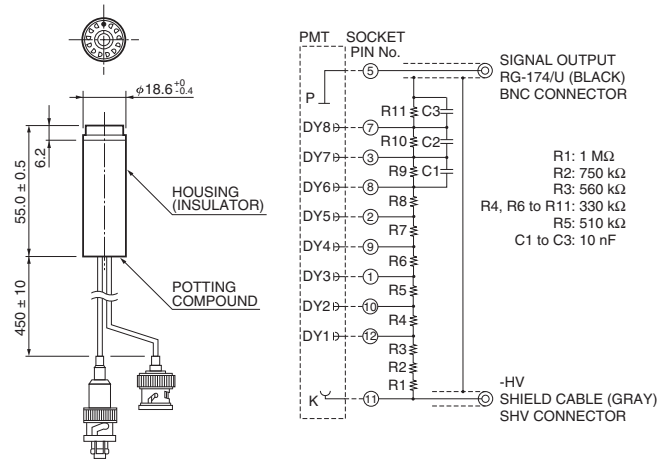
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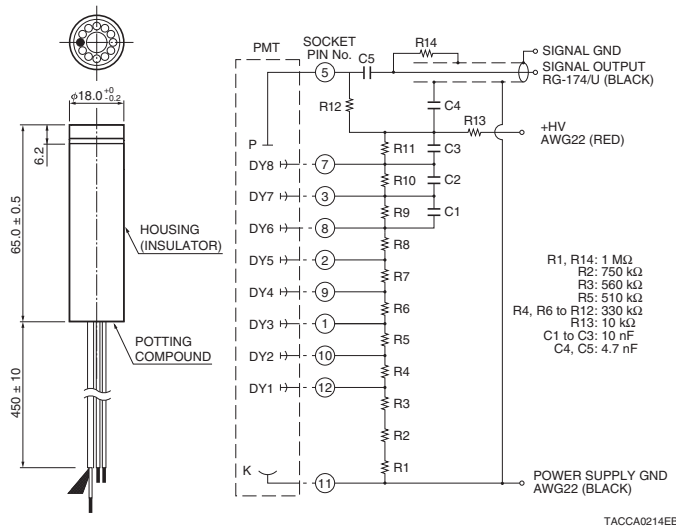
14 E974-22



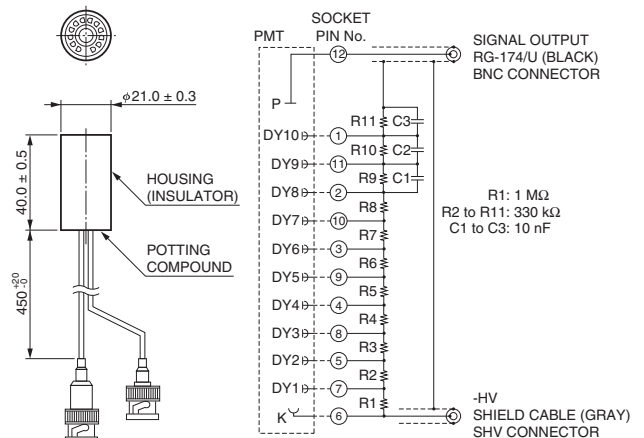
15 E2253-05



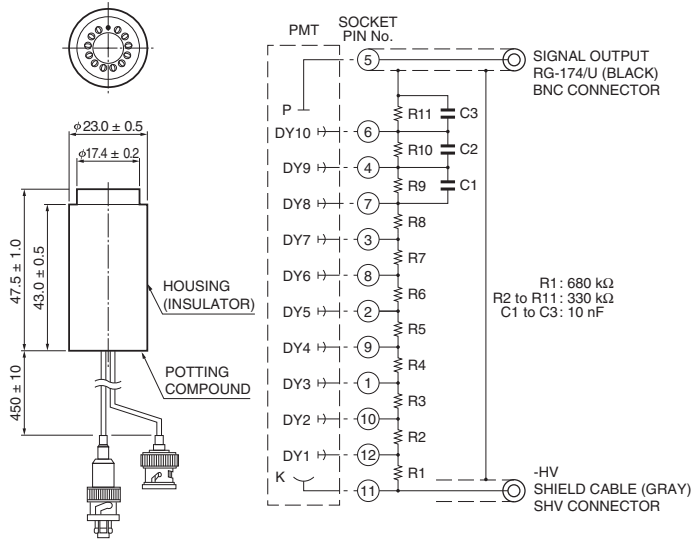
16 E2253-08



17 E974-29

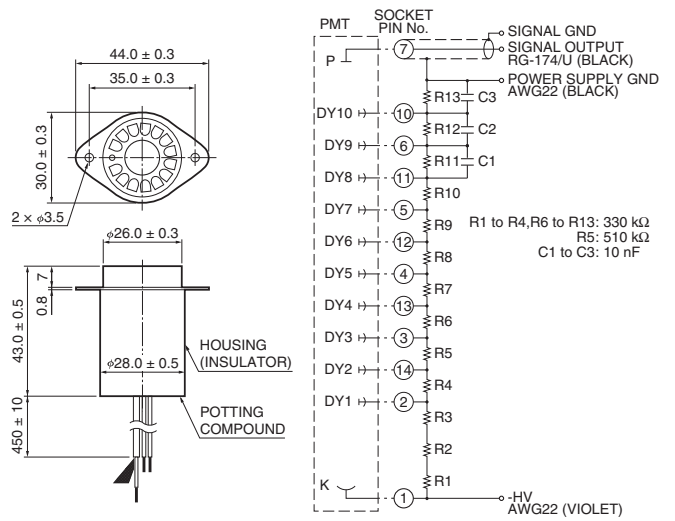


**18 E974-18**



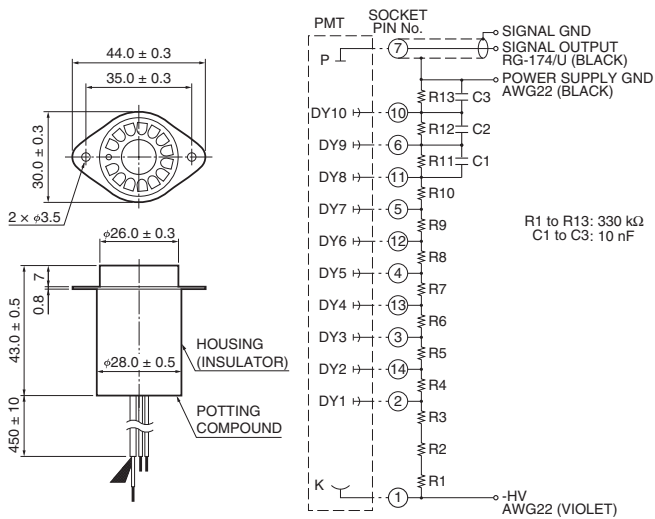
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**19 E2924-11**



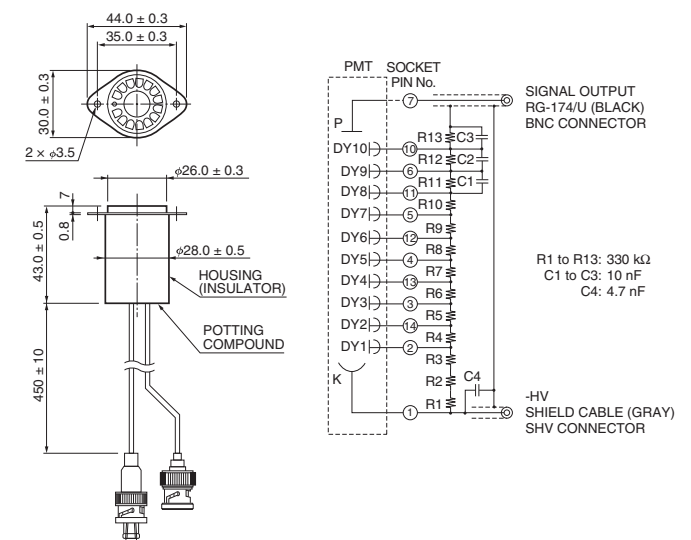
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**20 E2924**



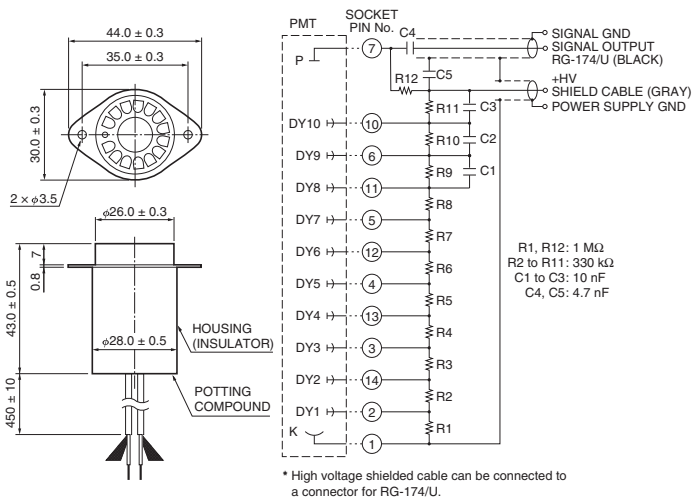
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**21 E2924-500**



TACCA0081EC

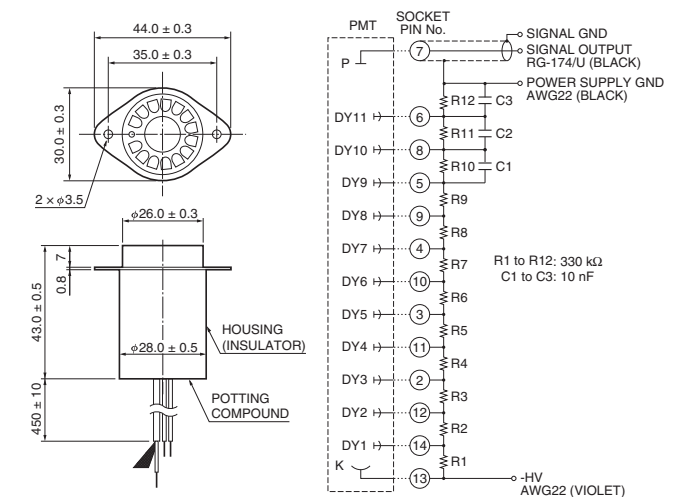
**22 E2924-05**



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

TACCA0102EA

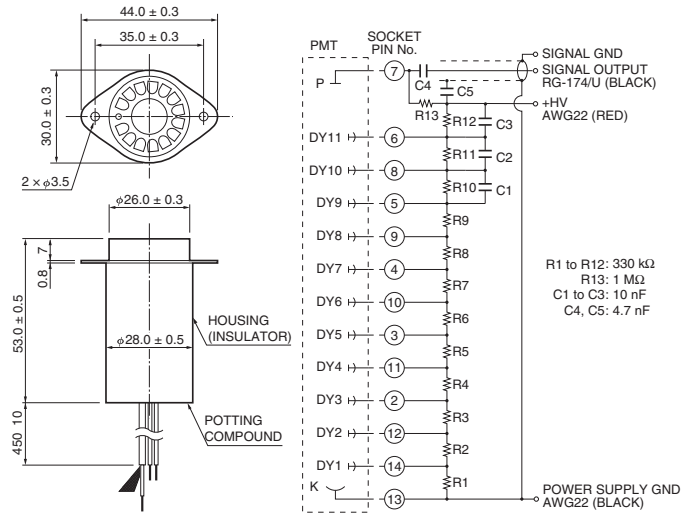
**23 E990-07**



TACCA0101EB

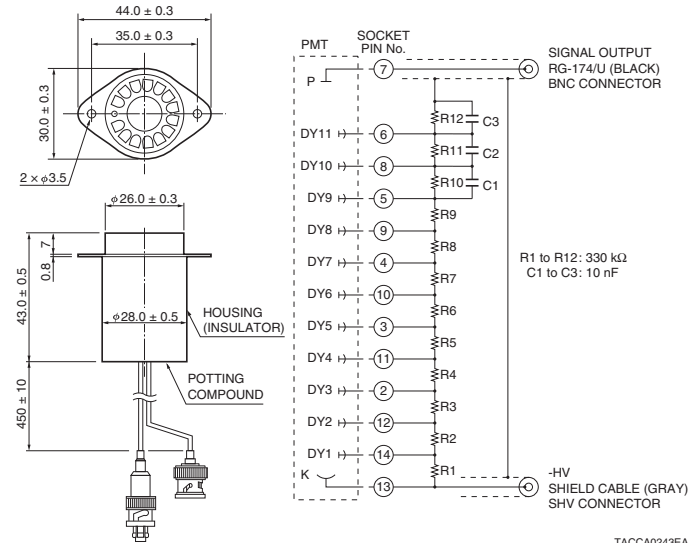
# D-type socket assemblies dimensional outlines and diagrams (Unit: mm)

24 E990-08



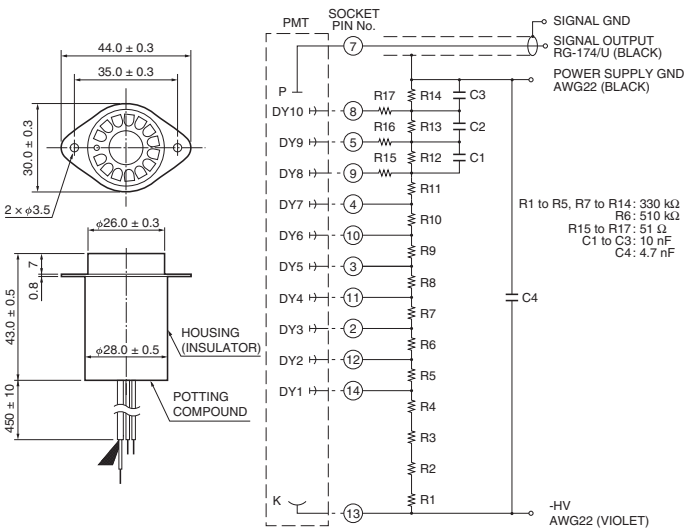
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25 E990-501



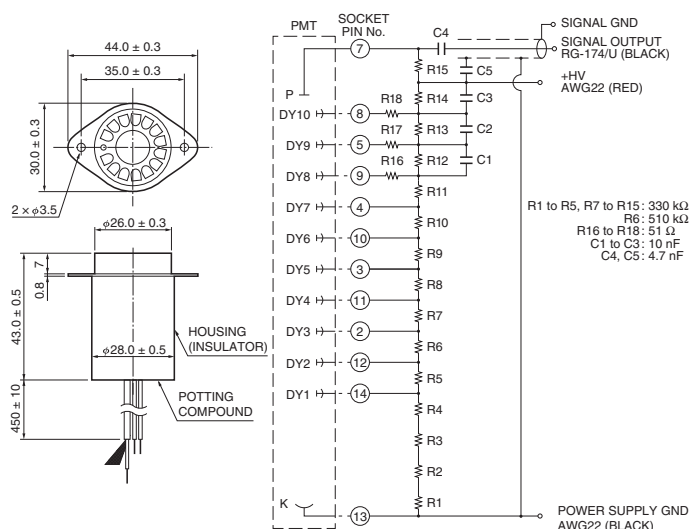
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26 E2624



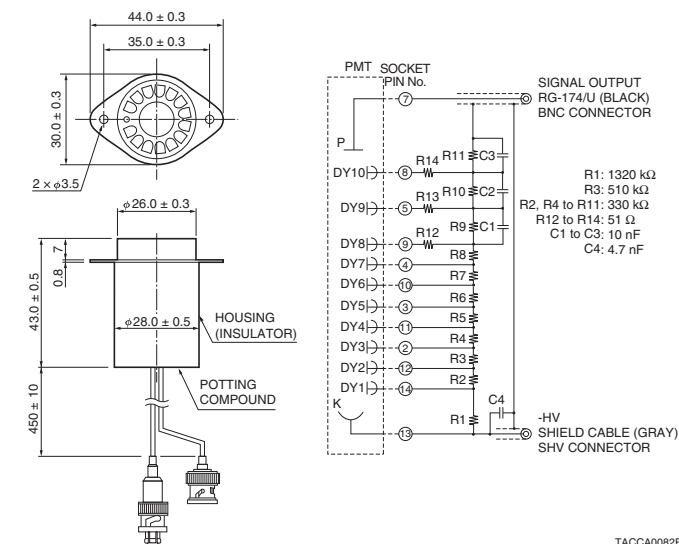
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27 E2624-05



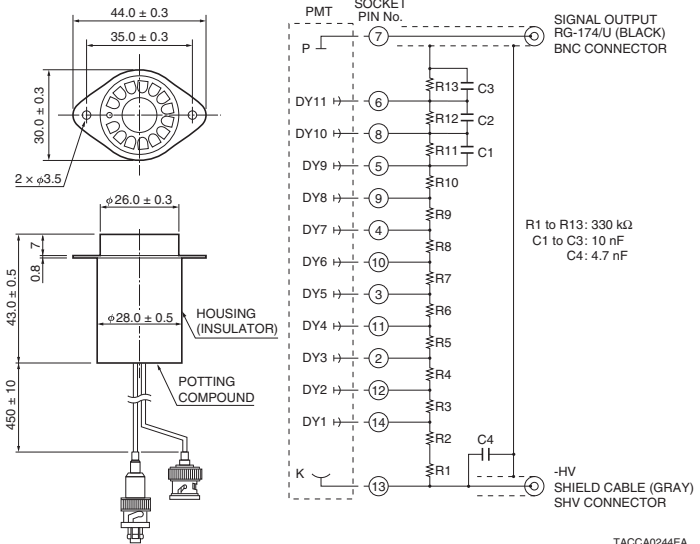
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28 E2624-14



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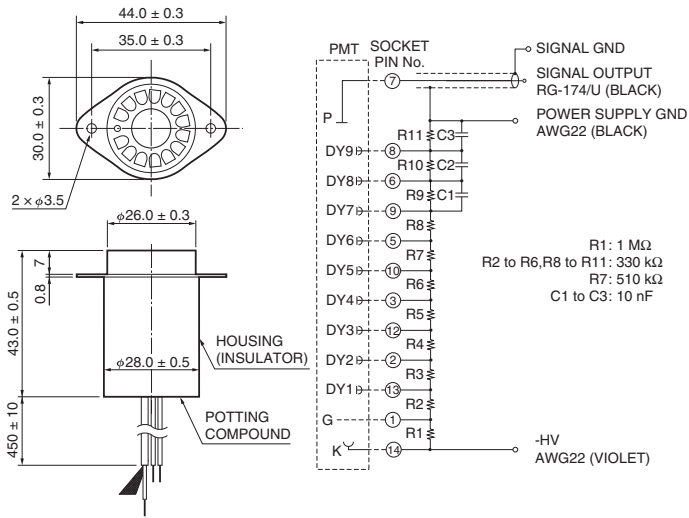
29 E990-500



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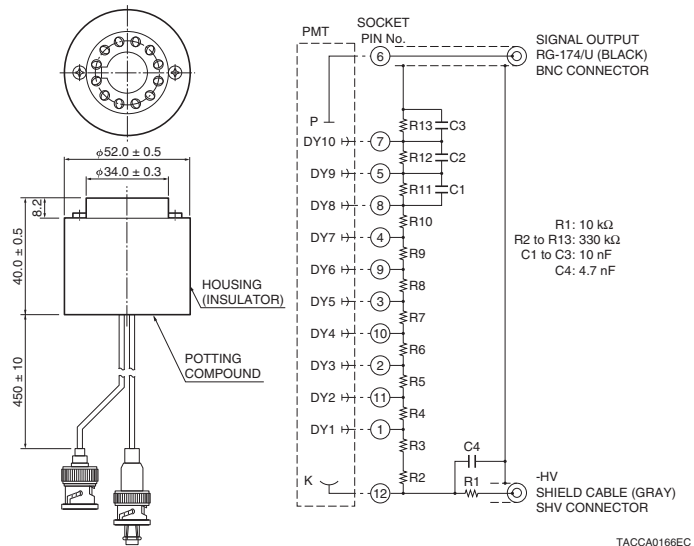


### 30 E990-29



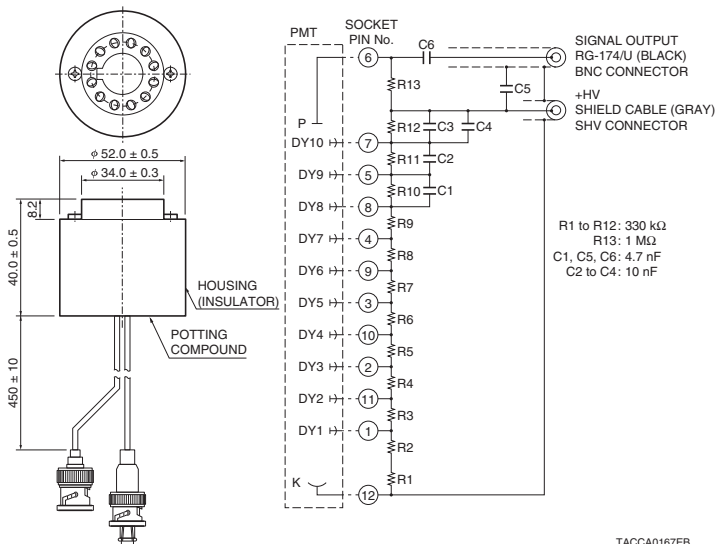
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### 31 E2183-500



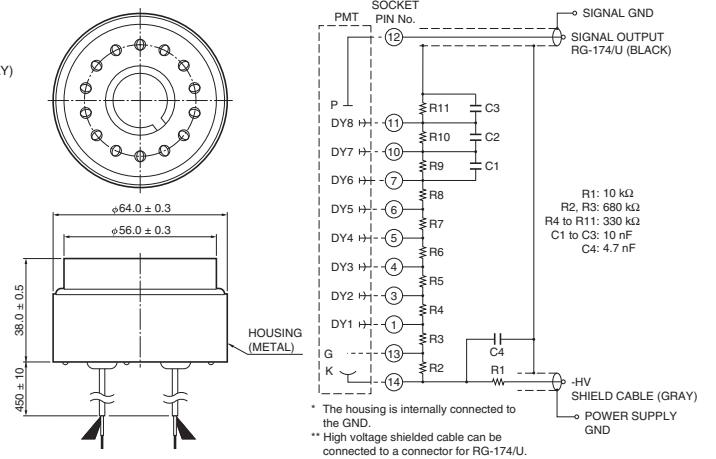
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### 32 E2183-502



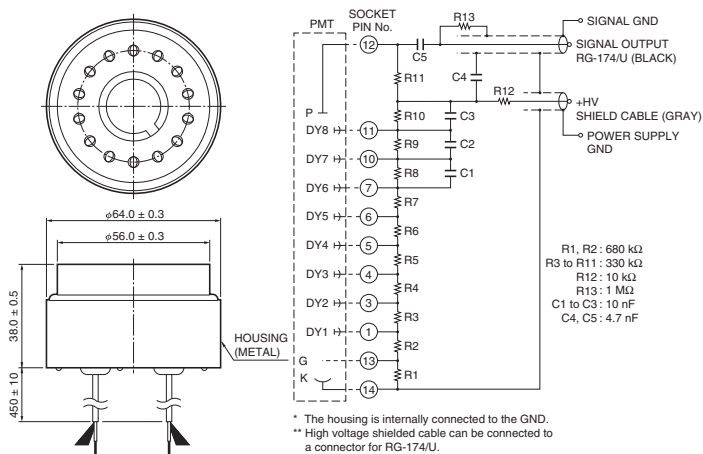
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### 33 E1198-26



TACCA0224EC

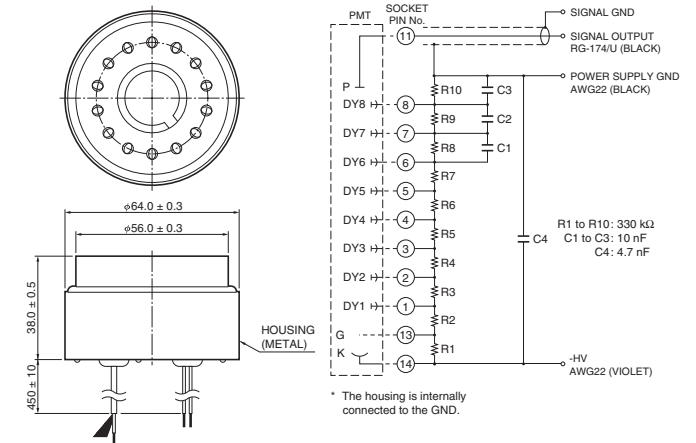
### 34 E1198-27



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

TACCA0225EB

### 35 E1198-05

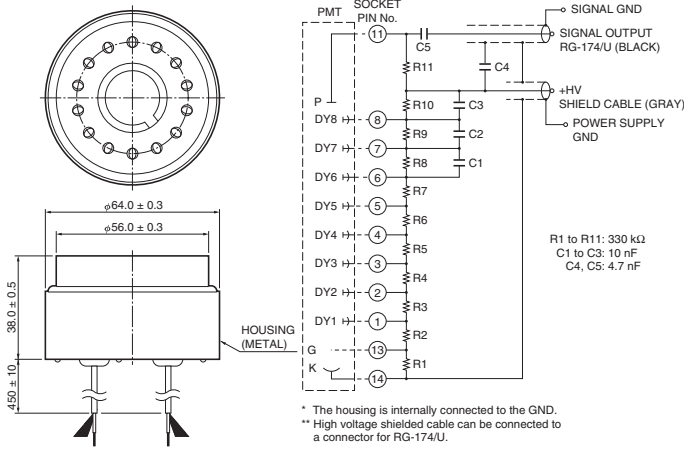


\* The housing is internally connected to the GND.

TACCA0221EB

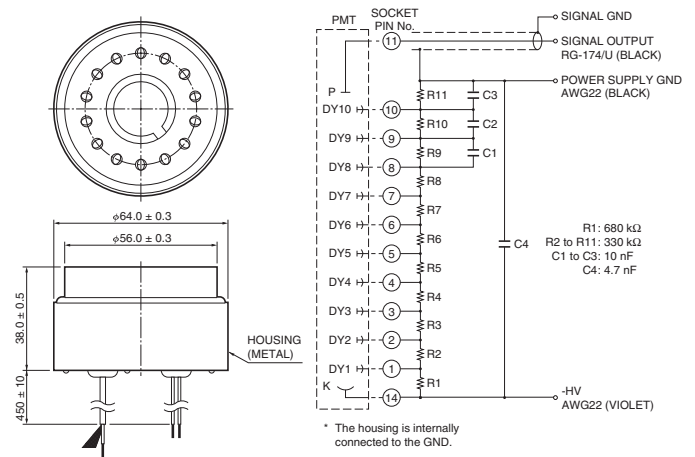
# D-type socket assemblies dimensional outlines and diagrams (Unit: mm)

36 E1198-20



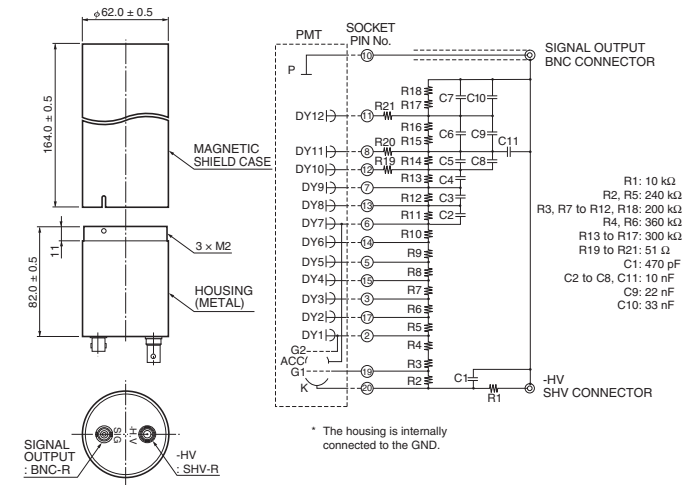
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37 E1198-07



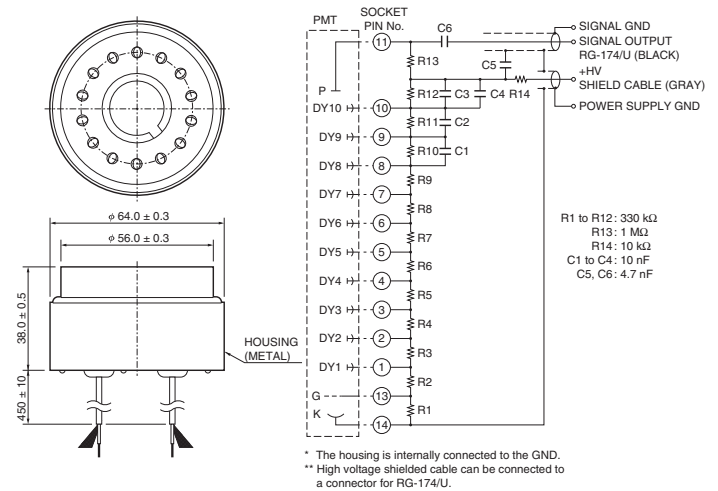
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38 E2979-500



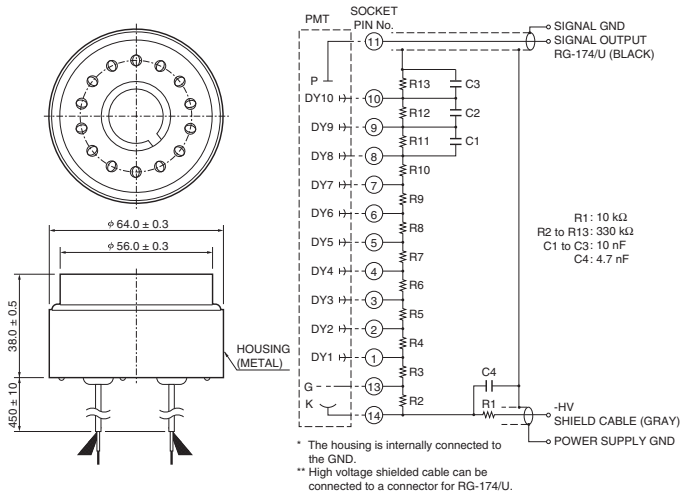
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39 E1198-23



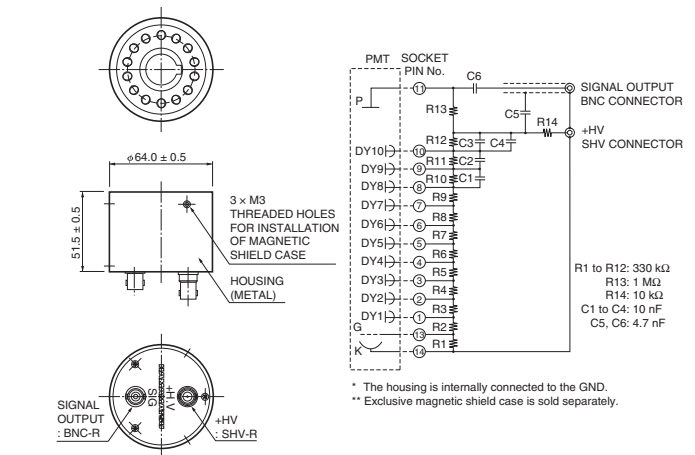
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40 E1198-22



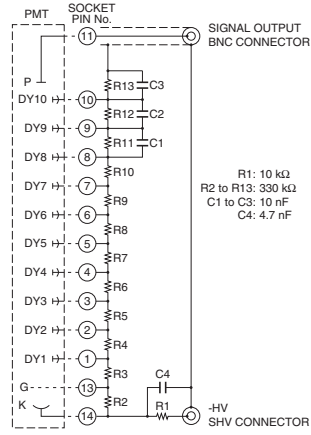
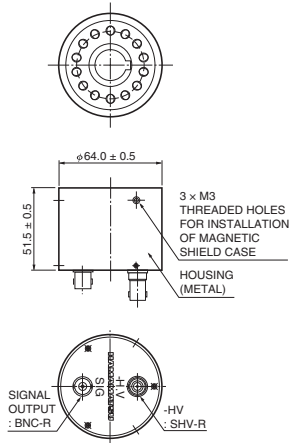
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41 E6316



TACCA0226EC

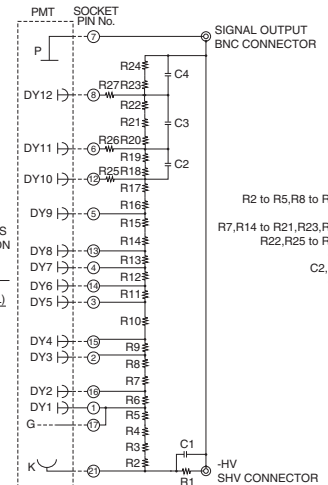
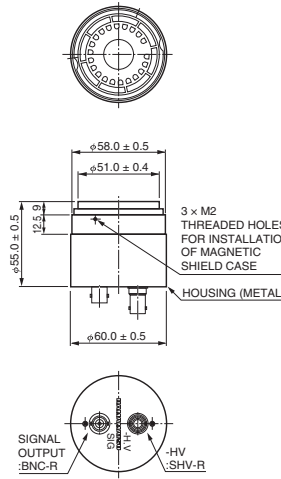
42 E6316-01



\* The housing is internally connected to the GND.  
\*\* Exclusive magnetic shield case is sold separately

TACCA0245EB

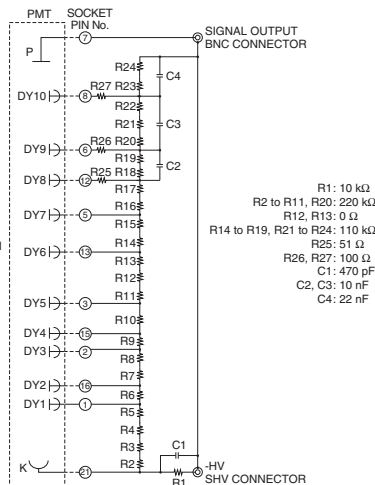
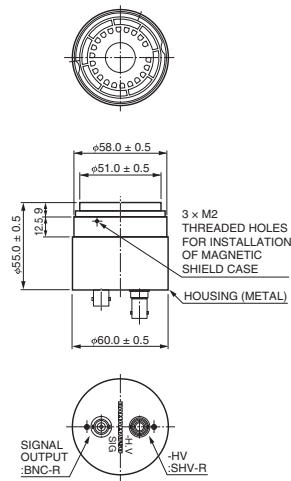
43 E5859-05



\* The housing is internally connected to the GND.  
\*\* Magnetic shield case E989-62 is sold separately.

TACCA0219EC

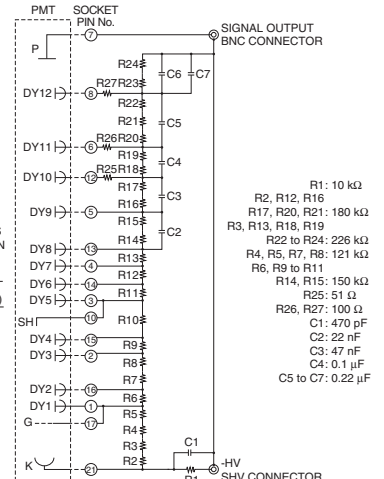
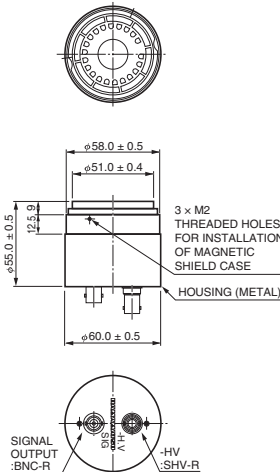
44 E5859-19



\* The housing is internally connected to the GND.  
\*\* Exclusive magnetic shield case is sold separately

TACCA0305EA

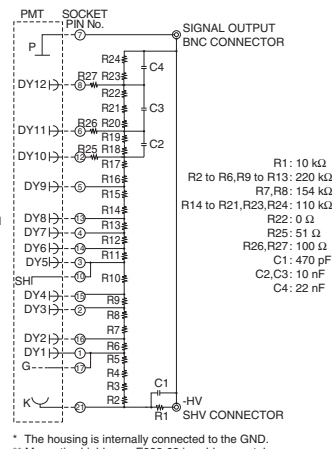
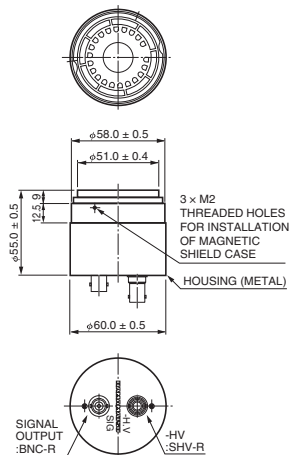
45 E5859



\* The housing is internally connected to the GND.  
\*\* Magnetic shield case E989-62 is sold separately.

TACCA0176ED

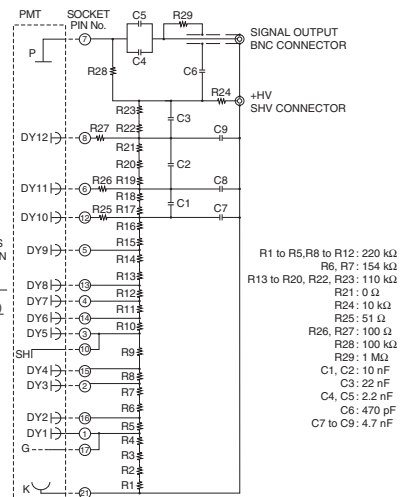
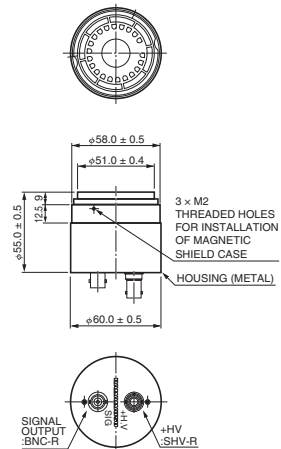
46 E5859-01



\* The housing is internally connected to the GND.  
\*\* Magnetic shield case E989-62 is sold separately.

TACCA0178EC

47 E5859-03

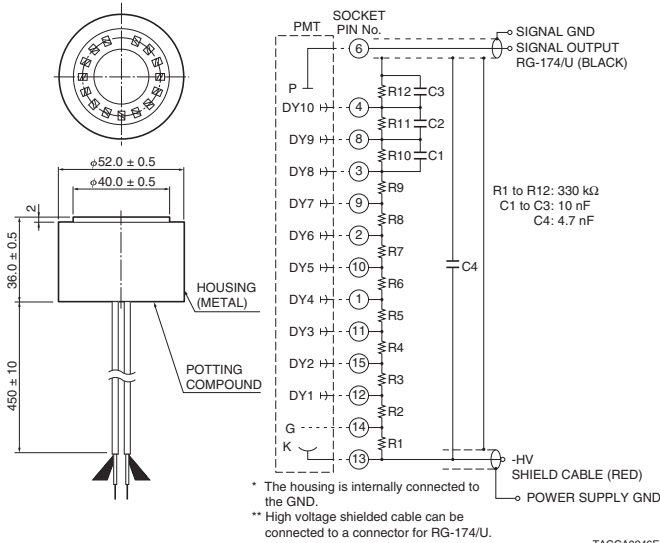


\* The housing is internally connected to the GND.  
\*\* Magnetic shield case E989-62 is sold separately.

TACCA0218EE

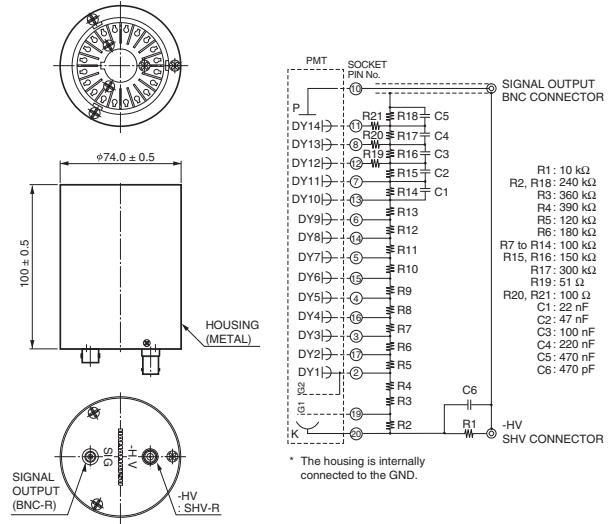
# D-type socket assemblies dimensional outlines and diagrams (Unit: mm)

48 E1435-02



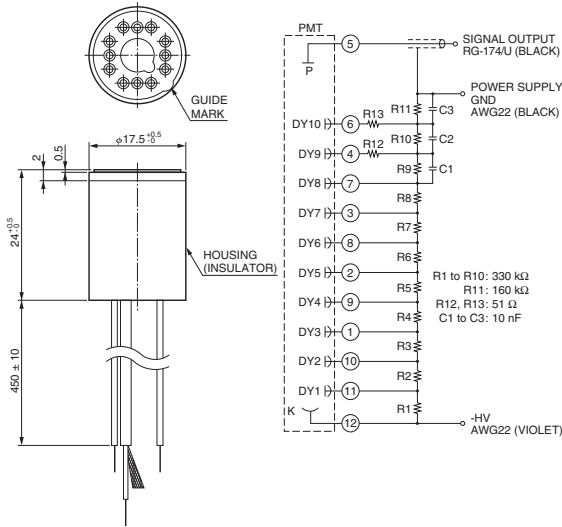
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49 E7693



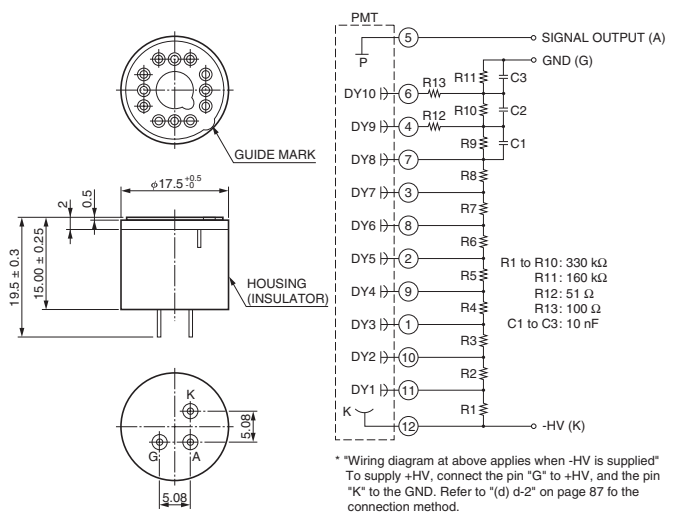
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50 E10679-02



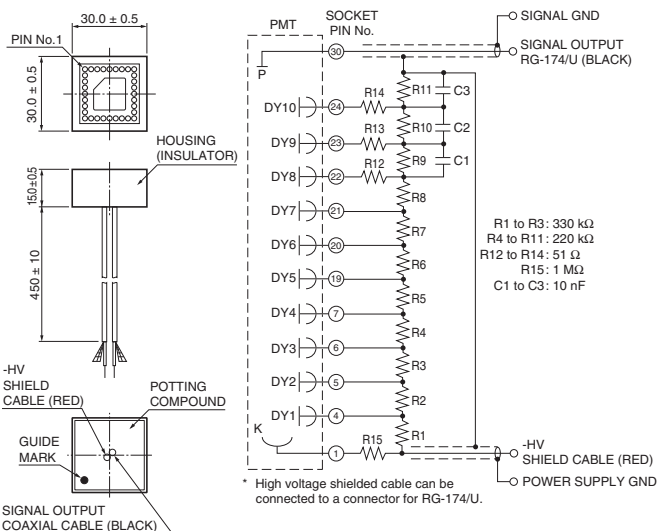
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51 E10679-51



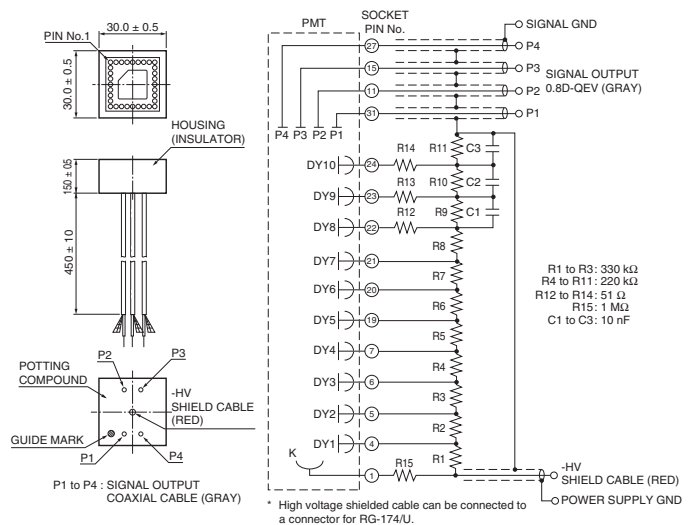
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52 E5996



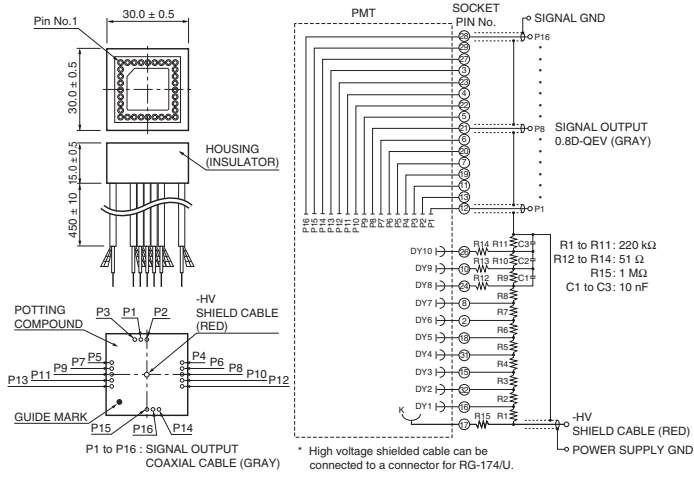
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53 E7083



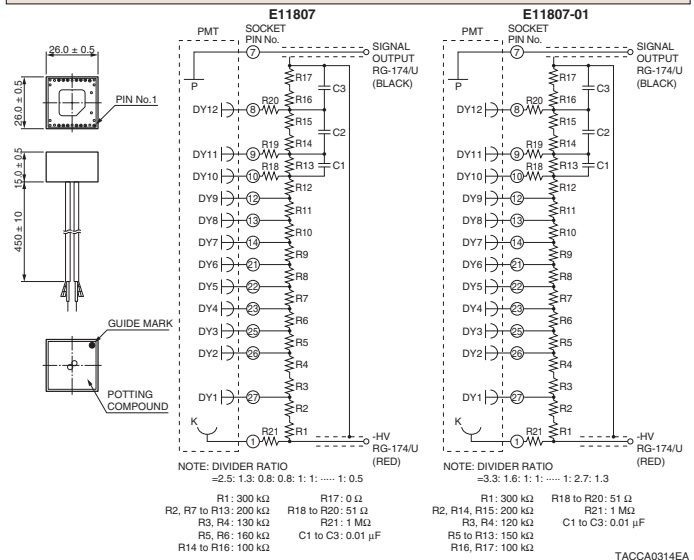
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54 E6736



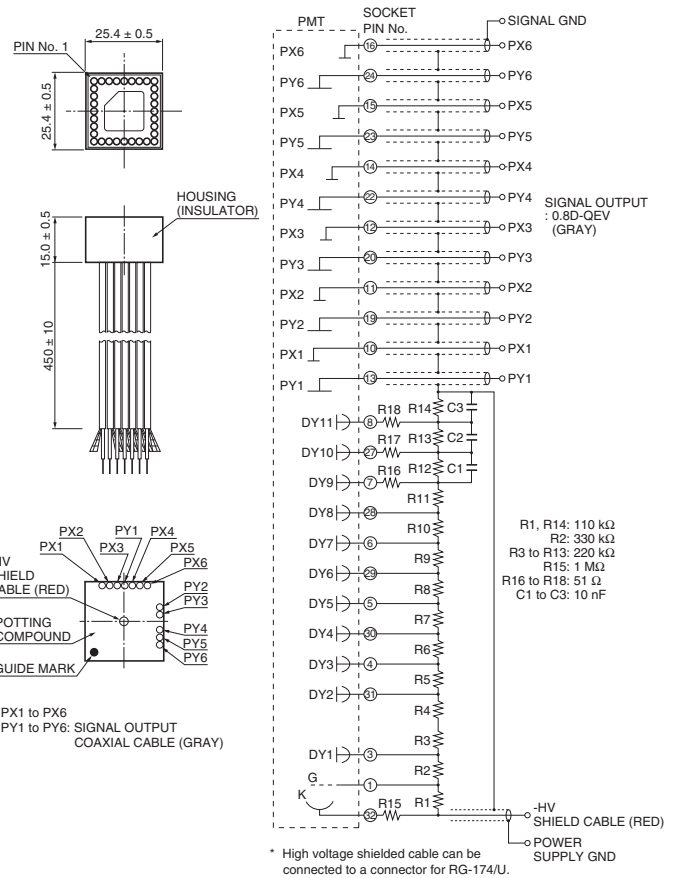
TACCA0158ED

56 E11807/E11807-01



TACCA0314EA

55 E7514



TACCA0236ED

# DA-type socket assemblies

## Socket assemblies with transimpedance amplifier (DA type)

DA type socket assemblies contain an active voltage-divider circuit and an amplifier that converts high impedance current signals from the photomultiplier tube into low impedance voltage signals. These socket assemblies ensure stable photomultiplier operation with excellent output linearity.

### Features

- Active voltage divider
- Superior DC output linearity
- Photomultiplier tube gain adjustment function (C7246 series)
- Wide frequency bandwidth (C7247 series)
- Input/output connectors (C7246-22, C7246-23, C7247-22, C7247-23)

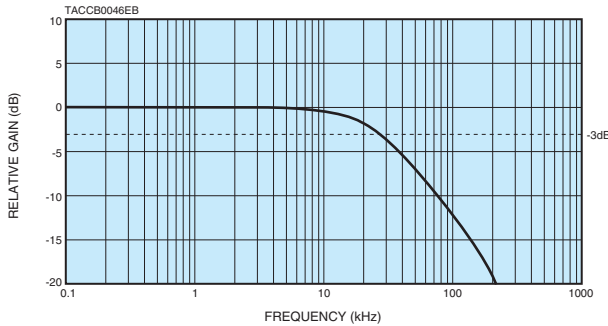
### Specifications

Type No.	Applicable PMTs	Amplifier							
		Input voltage (V)	Maximum input voltage (V)	Maximum supply voltage (mA)	Frequency bandwidth (-3 dB)	Current to voltage conversion factor (V/μA)	Maximum output signal voltage (V)	Offset voltage Max. (mV)	
C7246-01	φ28 mm side-on type	±12 to ±15	±18	+20/-0.53	DC to 20 kHz	0.3 (load resistance 10 kΩ)	+10 (load resistance 10 kΩ)	±1	
C7246-23									
C7247-01				+140/-50	DC to 5 MHz	0.15 (load resistance 50 Ω)	+3 (load resistance 50 Ω)	±3	
C7247-23									
C7246	φ28 mm head-on type R374, R2228, R5929, R6094, R6095, etc.	±12 to ±15	±18	+20/-0.53	DC to 20 kHz	0.3 (load resistance 10 kΩ)	+10 (load resistance 10 kΩ)	±1	
C7246-22									
C7247				+140/-50	DC to 5 MHz	0.15 (load resistance 50 Ω)	+3 (load resistance 50 Ω)	±3	
C7247-22									

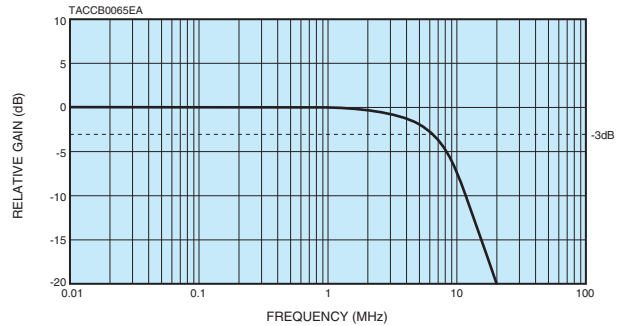
NOTE: (A) If the output signal voltage is 3 V or higher (with 10 kΩ load), the divider circuit input voltage should be -600 V to -1000 V.

### Frequency response of built-in amplifier

C7246/-01/-22/-23

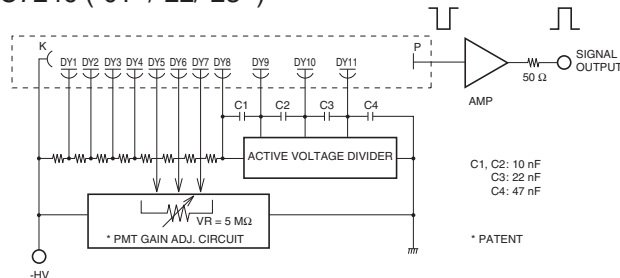


C7247/-01/-22/-23

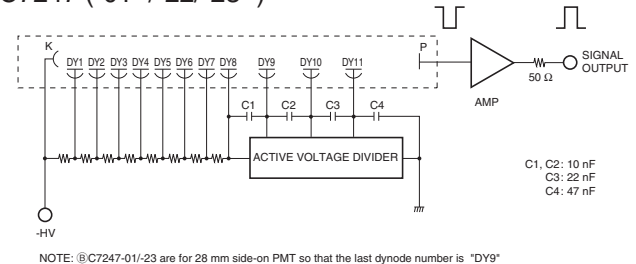


### Circuit diagrams

C7246 (-01®/-22/-23®)



C7247 (-01®/-22/-23®)



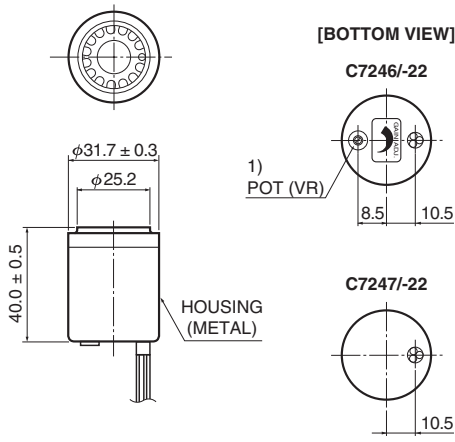
NOTE: (B) C7247-01/-23 are for 28 mm side-on PMT so that the last dynode number is "DY9"



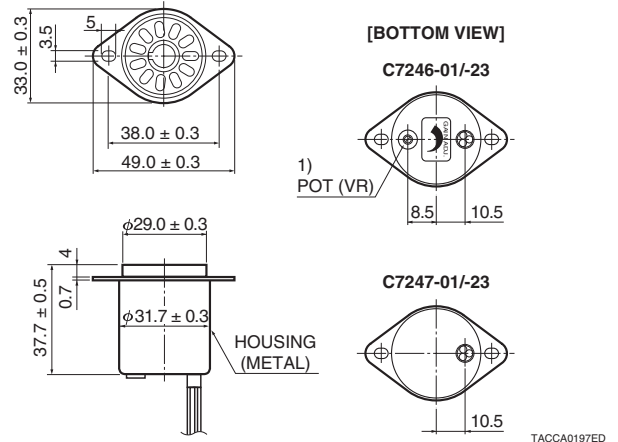
Amplifier Output noise voltage Typ. (mV rms)	Voltage-divider circuit				Operating ambient temperature (°C)	Storage temperature (°C)	Weight (g)	Type No.
	Recommended supply voltage (V)	Maximum supply voltage (V)	Divider current (μA)	PMT gain adjustable range (dB)				
0.09 (load resistance 10 kΩ)	-300 to -1000 <sup>A</sup>	-1500	211 (HV = -1000 V)	30	0 to +40	-15 to +60	50	C7246-01
							170 (With connectors)	C7246-23
4.5 (load resistance 50 Ω)	-300 to -600		166 (HV = -600 V)	—			50	C7247-01
							170 (With connectors)	C7247-23
0.09 (load resistance 10 kΩ)	-400 to -1000 <sup>A</sup>	174 (HV = -1000 V)	10	55	C7246			
				170 (With connectors)	C7246-22			
4.5 (load resistance 50 Ω)	-400 to -900	219 (HV = -900 V)	—	55	C7247			
				170 (With connectors)	C7247-22			

## Dimensional outlines (Unit : mm)

C7246/-22, C7247/-22



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



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

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

\* See page 121 for details on flanges and housing contains a magnetic shield case.

# DP-type socket assemblies

## High voltage power supply socket assemblies (DP type)

DP type socket assemblies include a high voltage power supply and so allow easily operating a photomultiplier tube just by supplying a low voltage (+15 V or +5 V). These socket assemblies ensure highly stable photomultiplier tube operation with excellent output linearity.

### Features

- Superior DC output linearity
- Active voltage divider (C12597-01)
- Fast high voltage programming response (C12597-01)
- Cockcroft-Walton circuit (C8991, C8991-01, C8991-05)
- Low power consumption (C8991-05)

### Specifications

Type No.	Applicable PMTs	Input voltage (V)	Maximum input voltage (V)	Maximum input current (mA) <sup>(A)</sup>	PMT	
					Linear DC output current Min. (μA)	Anode <sup>(D)</sup> ripple noise Typ. (mVp-p)
C12597-01	φ28 mm side-on type	+15 ± 1	+18	60	100 <sup>(B)</sup>	0.5
C8991		+11.5 to +15.5		8	100 <sup>(C)</sup>	1
C8991-01		+13.5 to +15.5	10	1.5		
C8991-05		+5.0 ± 0.5	+6	7	1	

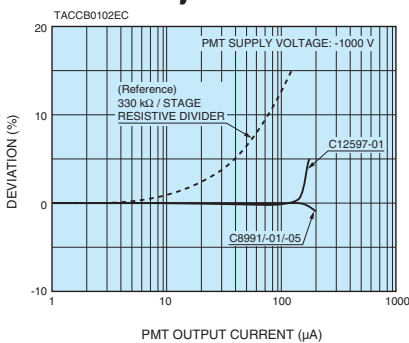
NOTE: (A) When photomultiplier tube is not attached

(B) PMT supply voltage: -1000 V, Within: ±2 % linearity

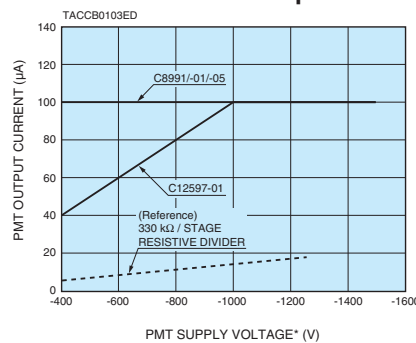
(C) PMT supply voltage: -1000 V, Within: ±0.5 % linearity

(D) Load resistance=1 MΩ, Load capacitance=20 pF to 25 pF

### DC linearity characteristics

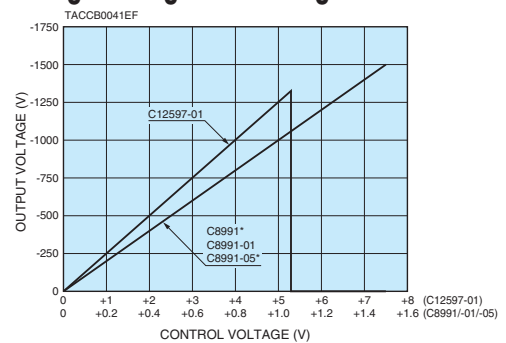


### Practical PMT DC output limits



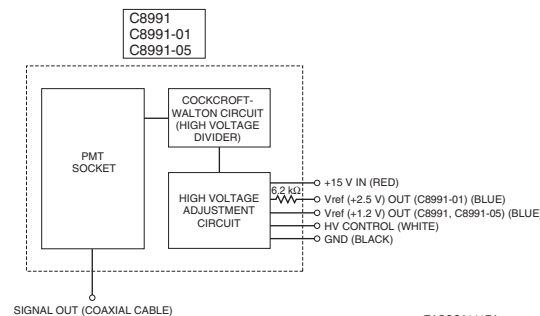
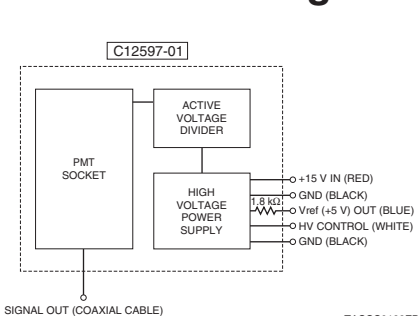
\* Photomultiplier tube must be used with a supply voltage within the rated range.

### High voltage controlling characteristics



\* C8991-05 can be controlled up to +1.2 V (output voltage -1200 V).

### Schematic diagrams







Output voltage range (V)	Linear regulation <sup>(F)</sup> Typ. (%)	High voltage power supply				Operating ambient temperature (°C)	Storage temperature (°C)	Weight (g)	Type No.
		Output voltage control	Output voltage programming response <sup>(G)</sup> Typ. (ms)	Settling time <sup>(H)</sup> (s)	Temperature coefficient Typ. (%/°C)				
-200 to -1250 <sup>(E)</sup>	±0.01	0 V to +5 V or external 50 kΩ potentiometer	80	—	±0.01	0 to +50	-15 to +60	45	C12597-01
-200 to -1200 <sup>(E)</sup>		0 V to +1.2 V or external 10 kΩ potentiometer	—	10	±0.005	0 to +50		57	C8991
-200 to -1500 <sup>(E)</sup>		0 V to +1.5 V or external 10 kΩ potentiometer						59	C8991-01
-200 to -1200 <sup>(E)</sup>		0 V to +1.2 V or external 10 kΩ potentiometer						45	C8991-05

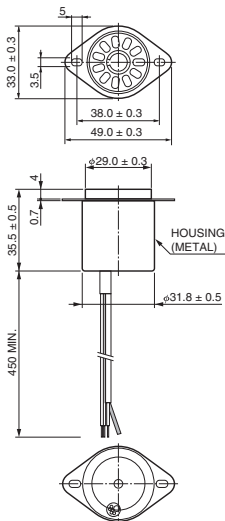
<sup>(E)</sup> Output voltage that guarantees the characteristics. <sup>(G)</sup> for 0 % → 99 % HV change

<sup>(F)</sup> Against ±1 V input change

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

## Dimensional outlines (Unit: mm)

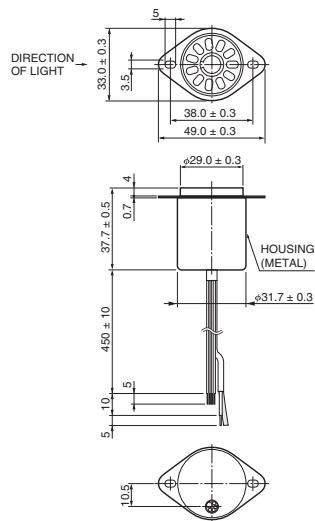
### C12597-01



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

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### C8991, C8991-01 C8991-05



SIGNAL OUTPUT	COAXIAL CABLE RG-174U
+15 V INPUT	AWG 24, RED
(C8991, C8991-01)	
+5 V INPUT (C8991-05)	AWG 24, RED
ref OUTPUT	AWG 24, BLUE
HV CONTROL INPUT	AWG 24, WHITE
GND	AWG 24, BLACK

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\* See page 121 for details on flanges and housing contains a magnetic shield case.

# DP-type socket assemblies

## High voltage power supply socket assemblies (DP type)

DP type socket assemblies include a high voltage power supply and so allow easily operating a photomultiplier tube just by supplying a low voltage (+15 V or +5 V). These socket assemblies ensure highly stable photomultiplier tube operation with excellent output linearity.

### Features

- Superior DC output linearity
- Active voltage divider
- Fast high voltage programming response (C13002-01, C13002-02, C13003-01, C13004-01)
- Cockcroft-Walton circuit (C10344-03, C12842-01, C12842-02)
- Low power consumption (C10344-03, C12842-01, C12842-02)

### Specifications

Type No.	Applicable PMTs	Input voltage (V)	Maximum input voltage (V)	Maximum input current (mA)	PMT		
					Linear DC output current Min. (μA)	Anode <sup>Ⓔ</sup> ripple noise Typ. (mVp-p)	
C13003-01	φ25 mm head-on type R1924A, R1925A, R3550A, R5070A, etc.	+15 ± 1	+18	60	100 <sup>Ⓒ</sup>	0.5	
C13004-01							φ28 mm head-on type R374, R2228, R5929, R6094, R6095, etc.
C10344-03							
C13002-01	8 stage dynode, head-on type R6231, R6232, R6233, R6234, R6235, R6236, R6237, etc.	+15 ± 1	+18	60	100 <sup>Ⓓ</sup>	1	
C13002-02							R1306, R1307, etc.
C12842-01 <sup>Ⓐ</sup>	8 stage dynode, head-on type R6231, R6232, R6233, R6234, R6235, R6236, R6237, etc.	+5 ± 0.5	+6	3	100 <sup>Ⓓ</sup>	0.6 (Max.)	
C12842-02 <sup>Ⓐ</sup>							10 stage dynode, head-on type R878, R550, R594, R877, R1512, R1513, etc.

**NOTE:** (A) C12842-01S/-02S which is with shutter(10 ms to DC) function are also available. Please refer the individual datasheet for details.

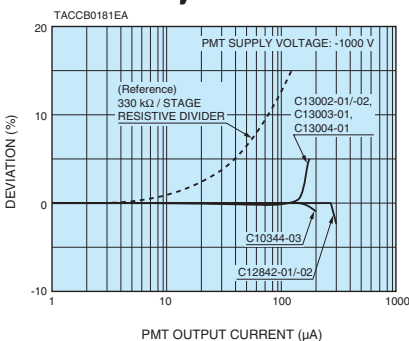
(B) When photomultiplier tube is not attached.

(C) PMT supply voltage: -1000 V, Within: ±2 % linearity

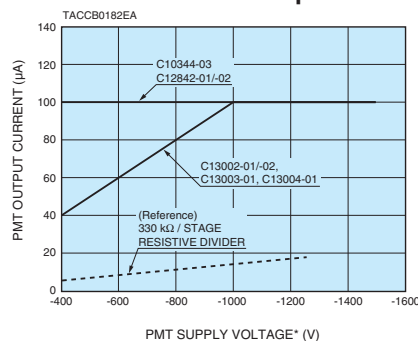
(D) PMT supply voltage: -1000 V, Within: ±0.5 % linearity

(E) Load resistance=1 MΩ, Load capacitance=20 pF to 25 pF

### DC linearity characteristics

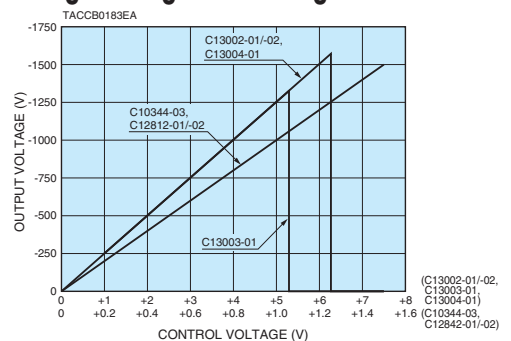


### Practical PMT DC output limits



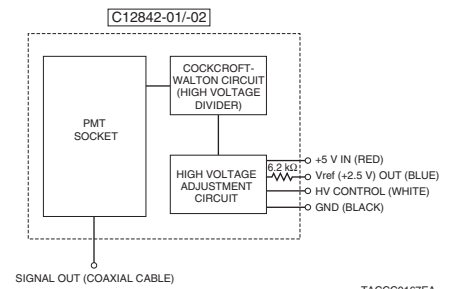
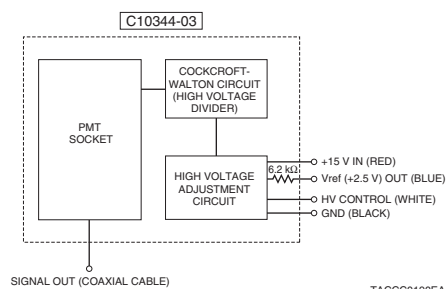
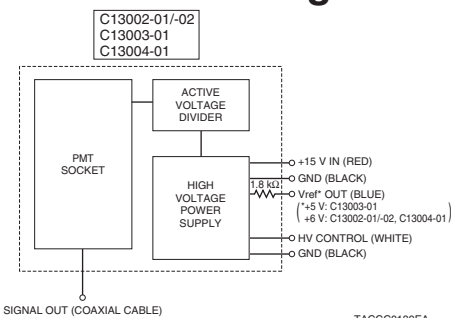
\* Photomultiplier tube must be used with a supply voltage within the rated range.

### High voltage controlling characteristics



\* C8991/-05 can be controlled up to +1.2 V (output voltage -1200 V).

### Schematic diagrams





High voltage power supply						Operating ambient temperature (°C)	Storage temperature (°C)	Weight (g)	Type No.
Output voltage range (V)	Linear regulation Typ. (%)	Output voltage control	Output voltage programming response Typ. (ms)	Settling time (s)	Temperature coefficient Typ. (%/°C)				
-200 to -1250 <sup>Ⓕ</sup>	±0.01	0 V to +5 V or external 50 kΩ potentiometer	80	—	±0.01	0 to +40	-15 to +60	40	C13003-01
-200 to -1500 <sup>Ⓕ</sup>		0 V to +6 V or external 50 kΩ potentiometer	—	—	±0.01	0 to +40		40	C13004-01
-200 to -1500 <sup>Ⓕ</sup>		0 V to +1.5 V or external 10 kΩ potentiometer	—	10	±0.005	0 to +50		57	C10344-03
0 to -1500 <sup>Ⓕ</sup>		0 V to +6 V or external 50 kΩ potentiometer	80	—	±0.01	0 to +45		122	C13002-01
0 to -1500		0 V to +1.5 V or external 10 kΩ potentiometer	—	10	±0.01	0 to +50		176	C12842-01 <sup>Ⓐ</sup>
									C12842-02 <sup>Ⓐ</sup>

<sup>Ⓕ</sup> Output voltage that guarantees the characteristics.

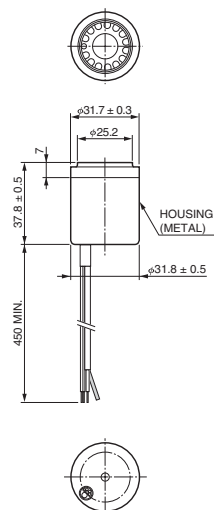
<sup>Ⓖ</sup> Against ±1 V input change

<sup>Ⓗ</sup> for 0%→99% HV change

<sup>Ⓛ</sup> The time required for the output to reach a stable level following a change in the control voltage from +1.0 V to +0.5 V.

## Dimensional outlines (Unit: mm)

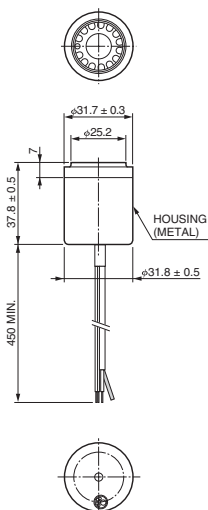
C13003-01



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

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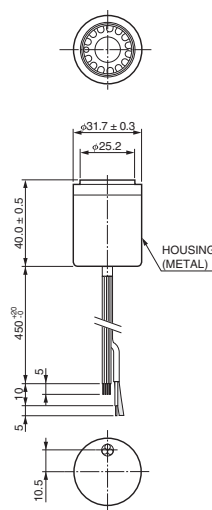
C13004-01



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

TACCA0330JA

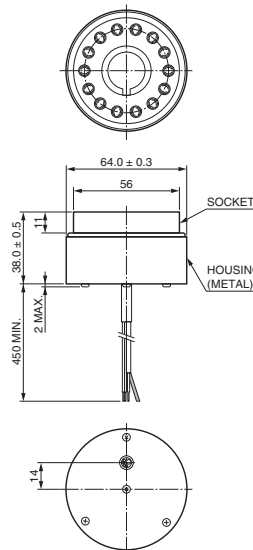
C10344-03



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

TACCA0294EA

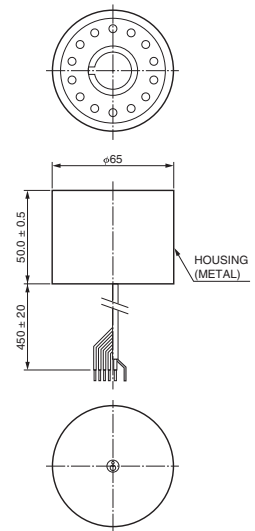
C13002-01  
C13002-02



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

TACCA0068EA

C12842-01/-02



SIGNAL OUTPUT	COAXIAL CABLE RG-174U
+5 V INPUT	AWG 26, RED
Vref OUTPUT	AWG 26, BLUE
HV CONTROL INPUT	AWG 26, WHITE
GND	AWG 26, BLACK

TACCA0323EA

\* See page 121 for details on flanges and housing contains a magnetic shield case.

# DAP-type socket assemblies

## High voltage power supply socket assemblies with transimpedance amplifier (DAP type)

DAP type socket assemblies contain an high voltage power supply and an amplifier that converts high impedance current signals from the photomultiplier tube into low impedance voltage signals. These socket assemblies ensure stable photomultiplier operation with excellent output linearity.

### Features

- Superior DC output linearity
- Active voltage divider (C13654-01, C14019-01, C14019-02)
- Fast high voltage programming response (C13654-01, C14019-01, C14019-02)
- Cockcroft-Walton circuit (C12843-01, C12843-02)
- Low power consumption (C12843-01, C12843-02)
- Wide frequency bandwidth (C14019-01, C14019-02)
- Single power supply operation (C13654-01)

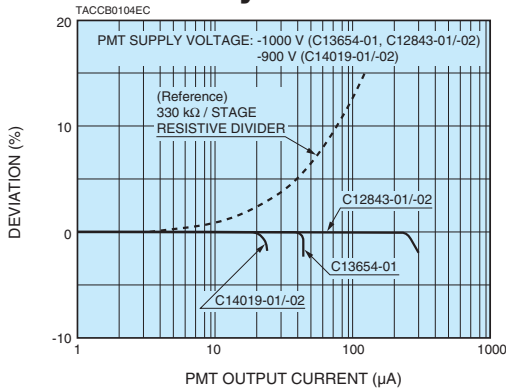
### Specifications

Type No.	Applicable PMTs	Input voltage (V)	Maximum input voltage (V)	Maximum input current (mA) <sup>Ⓑ</sup>	PMT		Amplifier	
					Linear DC output current Min. (μA)	Frequency bandwidth (-3 dB)	Current to voltage conversion factor (V/μA)	Maximum output signal voltage (V)
C13654-01	φ28 mm side-on type	+15 ± 1	+18	+60/—	43 (load resistance 10 kΩ) <sup>Ⓒ</sup>	DC to 10 kHz	0.3 (load resistance 10 kΩ)	+13 (load resistance 10 kΩ)
C14019-01		±15 ± 1	±18	+70/-20	20 (load resistance 50 Ω) <sup>Ⓓ</sup>	DC to 5 MHz	0.15 (load resistance 50 Ω)	+3 (load resistance 50 Ω)
C14019-02	φ28 mm head-on type R374, R2228, R5929, R6094, R6095, etc.	±15 ± 1	±18	+82/-20				
C12843-01 <sup>Ⓐ</sup>	8 stage dynode, head-on type R6231, R6232, R6233, R6234, R6235, R6236, etc.	±5 ± 0.5	±6	+6.5/-3.5	40 (load resistance 10 kΩ) <sup>Ⓔ</sup>	DC to 200 kHz	0.1 (load resistance 10 kΩ)	+4 (load resistance 10 kΩ)
C12843-02 <sup>Ⓐ</sup>	10 stage dynode, head-on type R878, R550, R594, R877, R1512, R1513, etc.							

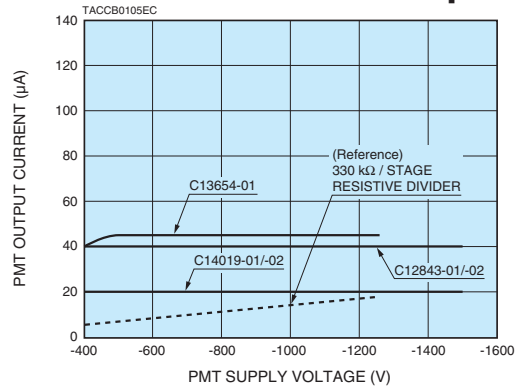
NOTE: (A) C12843-01S/-02S which is with shutter(10ms to DC) function are also available. Please refer the individual datasheet for details.  
(B) When photomultiplier tube is not attached.

(C) PMT supply voltage: -1000 V, Within: ±2 % linearity  
(D) PMT supply voltage: -1000 V, Within: ±2 % linearity  
(E) PMT supply voltage: -1000 V, Within: ±0.5 % linearity

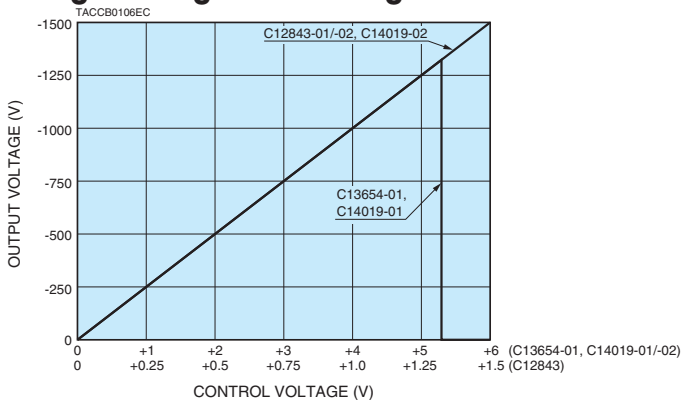
### DC linearity characteristics



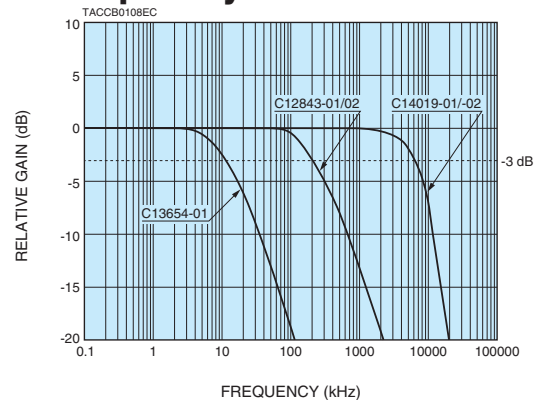
### Practical PMT DC output limits



### High voltage controlling characteristics



### Frequency bandwidth



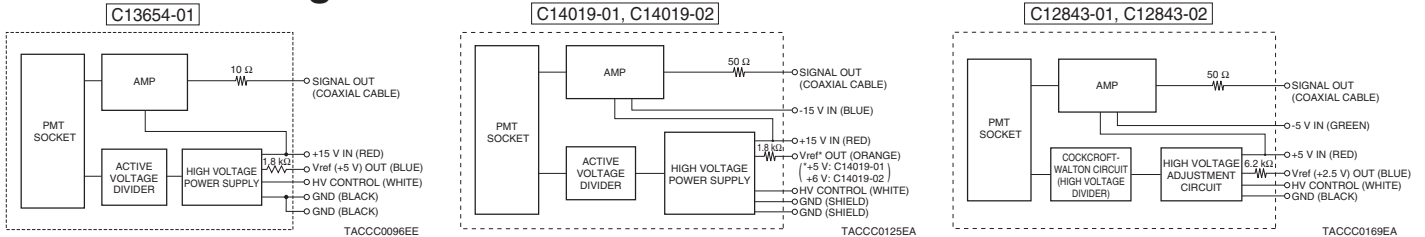


Amplifier		High voltage power supply						Operating ambient temperature (°C)	Storage temperature (°C)	Weight (g)	Type No.
Signal output offset voltage Typ. (mV)	Induced ripple on signal output	Output voltage range (V)	Line regulation Typ. (%)	Output voltage control	Output voltage programming response Typ. (ms)	Settling time (s)	Temperature coefficient Typ. (%/°C)				
±0.3	2 mVp-p <sup>Ⓕ</sup> (Typ.)	0 to -1250	±0.01	0 V to +5 V or external 50 kΩ potentiometer	80	—	±0.01	0 to +40	-15 to +60	55	C13654-01
±10	10 mVrms <sup>Ⓖ</sup> (Typ.)	0 to -1250	±0.01	0 V to +5 V or external 50 kΩ potentiometer	80	—	±0.01	0 to +40		60	C14019-01
		0 to -1500		0 V to +6 V or external 50 kΩ potentiometer						60	C14019-02
±1	1 mVp-p <sup>Ⓕ</sup> (Max.)	0 to -1500	±0.01	0 V to +1.5 V or external 10 kΩ potentiometer	—	10	±0.01	0 to +50		180	C12843-01 <sup>Ⓐ</sup>
										180	C12843-02 <sup>Ⓐ</sup>

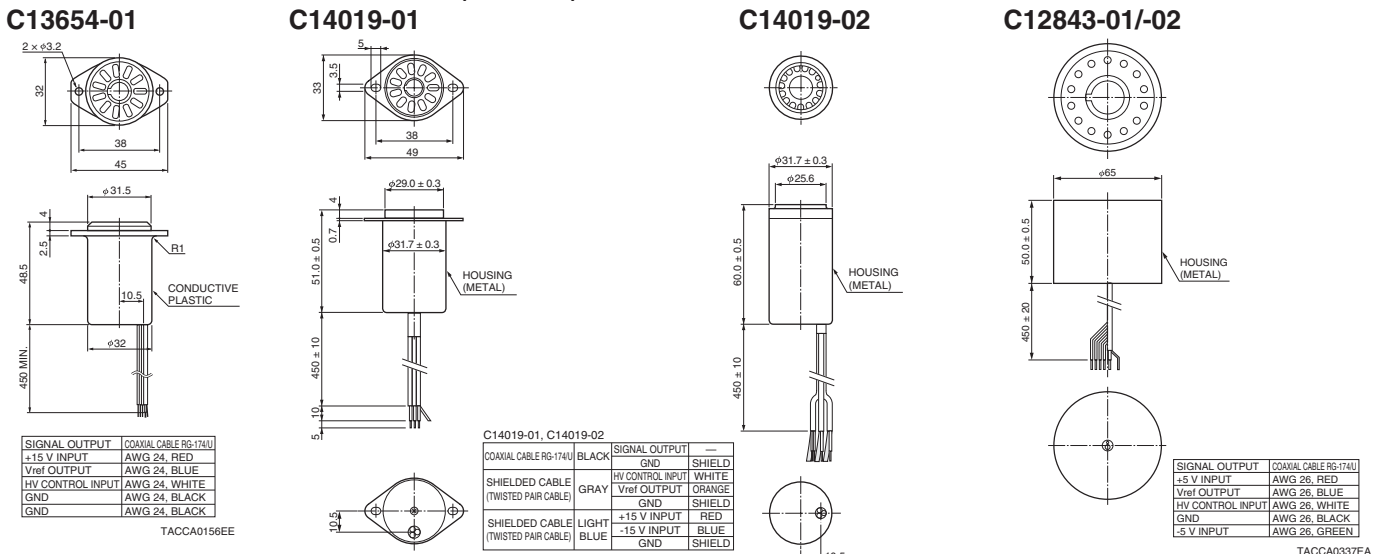
Ⓕ Load resistance=1 MΩ, Load capacitance=20 pF to 25 pF  
 Ⓖ Load resistance=50 Ω, Load capacitance=25 pF  
 Ⓗ Against ±1 V input change

Ⓘ for 0%→99% HV change  
 Ⓣ The time required for the output to reach a stable level following a change in the control voltage from +1.0 V to +0.5 V.

## Schematic diagrams



## Dimensional outlines (Unit: mm)



\* See page 121 for details on flanges and housing contains a magnetic shield case.

# Amplifier units / Amplifier modules

## Amplifier series

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



▲From left: C7319, C11184, C9663, C5594, C6438



▲From left: M7279, M8879

## Specifications

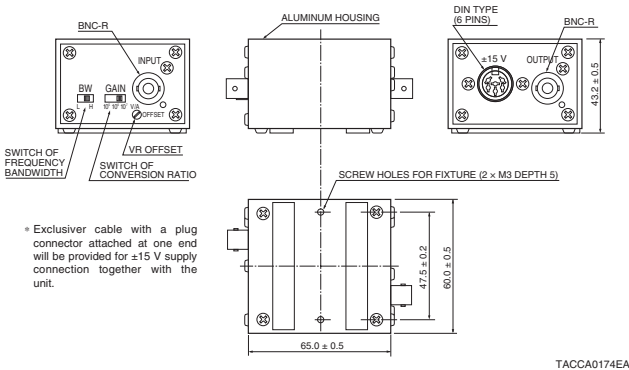
Type No.	Frequency bandwidth (-3 dB)	Current-to-voltage conversion factor (At Recommended Load Resistance)	Rise time Typ.
<b>C7319</b>	DC to 20 kHz DC to 200 kHz (Switchable) <sup>(A)</sup>	0.1 V/μA or 1 V/μA or 10 V/μA (Switchable) <sup>(A)</sup>	1.75 μs to 17.5 μs <sup>(A)</sup>
<b>C12419</b>	DC to 1 MHz	1 V/μA	350 ns
<b>C9999</b>	DC to 10 MHz	50 mV/μA	35 ns
<b>C9999-01</b>		10 mV/μA	
<b>C6438</b>	DC to 50 MHz	0.5 mV/μA	7 ns
<b>C6438-01</b>		25 mV/μA	
<b>C6438-02</b>		5 mV/μA	
<b>C9663</b>	DC to 150 MHz	4 mV/μA	2.3 ns
<b>C11184</b>	DC to 300 MHz	1.25 mV/μA	1.2 ns
<b>C5594-12</b>	50 kHz to 1.5 GHz	3.15 mV/μA	0.23 ns
<b>C5594-22</b>			
<b>C5594-44</b>			
<b>M7279</b>	DC to 10 MHz	10 mV/μA	35 ns
<b>M8879</b>	DC to 150 MHz	4 mV/μA	2.3 ns

<sup>(A)</sup>Specifications of C7319

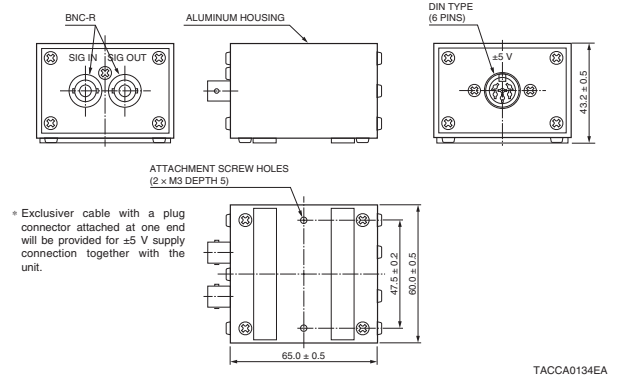
Rise time (μs)	Current-to-voltage conversion factor		
	0.1 V/μA	1 V/μA	10 V/μA
DC to 20 kHz	17.5		
	DC to 200 kHz <sup>(B)</sup>	1.75	3.5 <sup>(B)</sup>
Output noise voltage (mVrms)	DC to 20 kHz	0.15	0.2
	DC to 200 kHz <sup>(B)</sup>	0.3	0.6

## Dimensional outlines (Unit: mm)

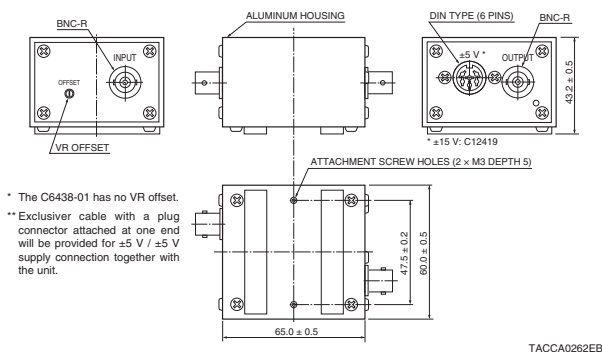
### C7319



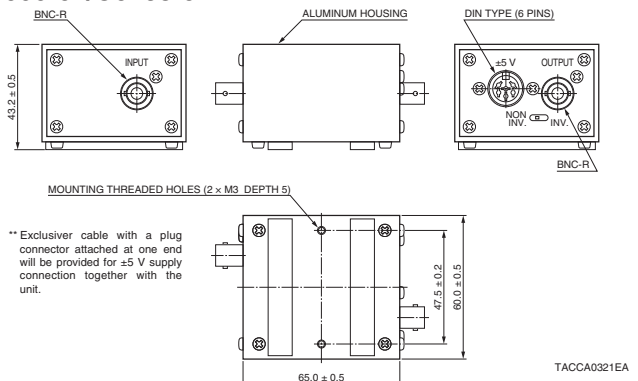
### C6438



### C12419/C9999/C6438-01/C9663



### C9999-01/C6438-02



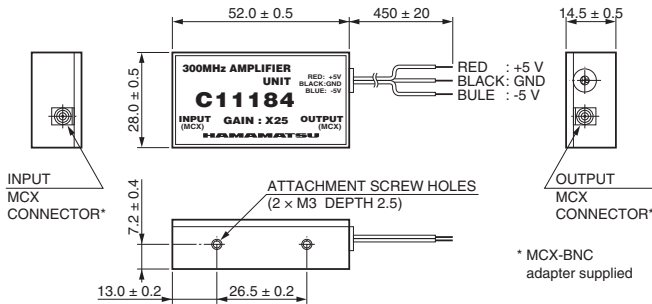
Input polarity (Output)	Input/Output impedance (Ω)	Max. output signal voltage Min. (V)	Output noise voltage Typ. (mVrms)	Signal connector		Supply voltage (V)	Supply current Max. (mA)	Weight (g)	Type No.
				Input	Output				
Positive/Negative (inverted)	Low/50	±13 (R <sub>L</sub> : 10 kΩ) ±2 (R <sub>L</sub> : 50 Ω)	0.15 to 2 <sup>(A)</sup>	BNC-R		±5 to ±15	±50	170 <sup>(D)</sup>	<b>C7319</b>
Positive/Negative (inverted)	Low/50	±11 (R <sub>L</sub> : 1 kΩ) ±3 (R <sub>L</sub> : 50 Ω)	1	BNC-R		±15	±100	165 <sup>(D)</sup>	<b>C12419</b>
Positive/Negative (non-inverted)	360/50	±3.2 (R <sub>L</sub> : 1 MΩ) ±1.3 (R <sub>L</sub> : 50 Ω)	2.2	BNC-R		±5	±70	180 <sup>(D)</sup>	<b>C9999</b>
Positive/Negative (inverted / non-inverted switchable)	50	±3 (R <sub>L</sub> : 1 MΩ) ±1.3 (R <sub>L</sub> : 50 Ω)	1.2				±140	165 <sup>(D)</sup>	<b>C9999-01</b>
Positive/Negative (non-inverted)	50	±2 (R <sub>L</sub> : 1 MΩ) ±1 (R <sub>L</sub> : 50 Ω)	0.5 (Max.)	BNC-R		±5	±55	160 <sup>(D)</sup>	<b>C6438</b>
			8 (Max.)				±80	<b>C6438-01</b>	
			2 (Max.)				±140	165 <sup>(D)</sup>	<b>C6438-02</b>
Positive/Negative (inverted / non-inverted switchable)	50	±3 (R <sub>L</sub> : 1 MΩ) ±1.3 (R <sub>L</sub> : 50 Ω)	2 (Max.)						
Positive/Negative (non-inverted)	50	±3 (R <sub>L</sub> : 1 MΩ) ±1.4 (R <sub>L</sub> : 50 Ω)	2.8	BNC-R		±5	±80	180 <sup>(D)</sup>	<b>C9663</b>
Positive/Negative (non-inverted)	50	±2 (R <sub>L</sub> : 1 MΩ) ±1 (R <sub>L</sub> : 50 Ω)	1	MCX-R (with BNC adapter)		±5	±70	40	<b>C11184</b>
Positive/Negative (non-inverted)	50	+0.8 / -2.5 (R <sub>L</sub> : 50 Ω)	5 dB <sup>(C)</sup>	SMA-P	SMA-R	+12 to +16	+95	70	<b>C5594-12</b>
				SMA-R	SMA-R			70	<b>C5594-22</b>
				BNC-R	BNC-R			85	<b>C5594-44</b>
Positive/Negative (non-inverted)	100 / 50	±3.5 (R <sub>L</sub> : 1 MΩ) ±1.5 (R <sub>L</sub> : 50 Ω)	1	On-board mounting		±5 to ±6.5	±45	1.1	<b>M7279</b>
Positive/Negative (non-inverted)	50	±3 (R <sub>L</sub> : 1 MΩ) ±1.4 (R <sub>L</sub> : 50 Ω)	2.8	On-board mounting		±5 to ±6	±61	2.5	<b>M8879</b>

<sup>(B)</sup>Limited to DC to 100 kHz at 10 V/μA

<sup>(C)</sup>Noise figure

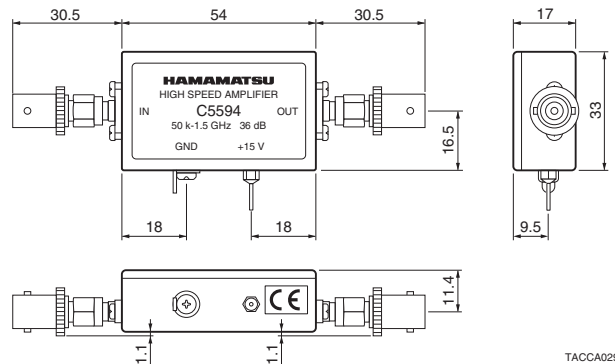
<sup>(D)</sup>Not including the supplied cable

### C11184



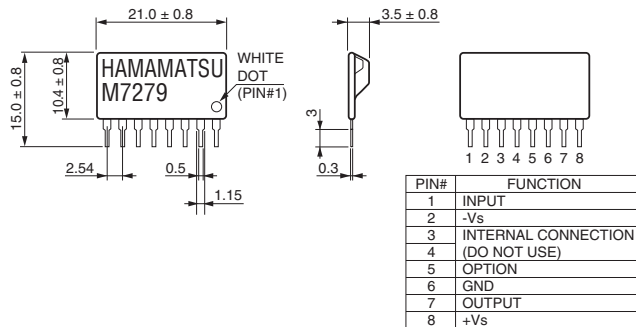
TACCA0303EA

### C5594-44



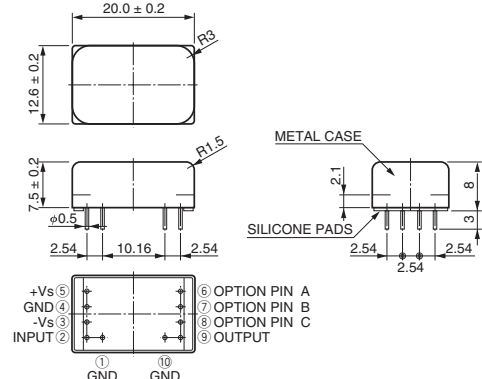
TACCA0295EB

### M7279



TACCA0183ED

### M8879



TACCA0249EA

# High voltage power supplies

## Voltage dependence of photomultiplier tube gain

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

The relationship of the secondary electron emission  $\delta$  for each dynode to the supplied voltage is expressed as follows:

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

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

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

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

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

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

## How to select a high voltage power supply

The high voltage power supply you will need differs depending on the photomultiplier tube to be used. Select an optimal high voltage power supply according to the following basic criteria for selecting the output voltage and current.

**Output voltage: Power supply output voltage should be higher than the maximum supply voltage for the photomultiplier tube.**

Check the maximum supply voltage between the anode and cathode of the photomultiplier tube to be used, and choose an appropriate high voltage power supply that covers the entire voltage range basically. Please operate the PMT not to exceed the maximum supply voltage.

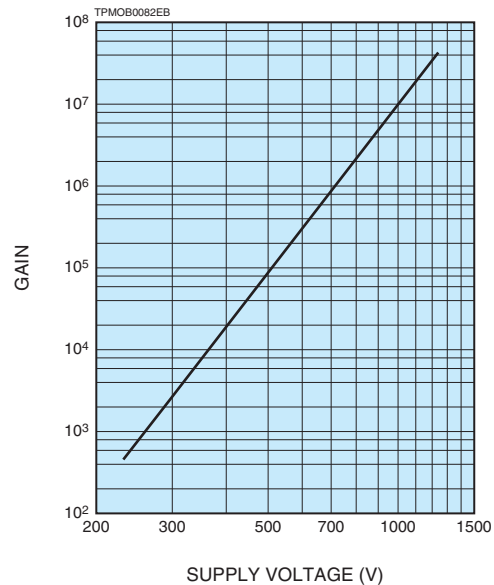
**Output current: Power supply output current should be 1.5 times higher than the divider current.**

Find the divider current that will flow in the voltage divider circuit and choose a high voltage power supply whose output current is at least 1.5 times higher than the divider current.

The divider current can be calculated from the supply voltage actually used for the photomultiplier tube. For example, if the maximum supply voltage for the photomultiplier tube is 1250 V and the actual operating voltage is 1000 V, find the divider

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

## Gain vs. Supply voltage



current that will flow in the voltage-divider circuit operating at 1000 V and select a high voltage power supply that provides an output current at least 1.5 times higher than the divider current. Giving an extra safety margin to the output current also allows increasing the operating voltage. There will be no problems with measurement if the output current capacity is greater than the divider current when operated at the maximum supply voltage.













If operating two or more photomultiplier tubes from a single high voltage power supply, select a power supply capable of providing output current larger than the total divider current according to the number of voltage-divider circuits.

All models of Hamamatsu high voltage power supplies are designed for high stability optimized for photomultiplier tube operation.

Besides output voltage and current, other factors to consider include the input voltage, size, and availability of external control. Hamamatsu provides a full line of high voltage power supplies as listed on the following pages. Select a high voltage power supply that best meets your applications and usage.



## High voltage power supply modules

	Type No.		Output voltage (Max.)(V)	Output current (Max.)(mA)	Ripple/Noise (p-p) Typ. (mV)	Regulation		Input voltage (V)	Size W × H × D <sup>Ⓒ</sup> (mm)	Note
						Line Typ. (%)	Load Typ. (%)			
	C14210 *	-14	-1100	0.4	100 (>5 kHz) 150 (≤5 kHz)	±0.01	±0.01	+3 to +5	15 × 7.3 × 15	Compact and lightweight SMT type
		C10940	-03	-1200	0.6	50	±0.02	±0.01	+5	15 × 18 × 15
	-03-R2									
	-53		+1200							
	-53-R2									
	C13890	-15	-1250	0.6	38	±0.01	±0.01	+11 to +16	46 × 24 × 12	UL60601-1 
		-55	+1250							
	C11152	—	-1500	1	5 (>5 kHz) 8 (≤5 kHz)	±0.01	±0.01	+15	41 × 10 × 41	Low ripple / noise 
		-01						+12		
		-50	+1500					+15		
		-51						+12		
	C9619 *	—	-2000	2	60	±0.01	±0.01	+15	62 × 15 × 45	
		-01						+12		
		-50	+2000					+15		
		-51						+12		
	C12446 *	-12	-1000	10	50	±0.01	±0.01	+24	62 × 15 × 45	For multiple PMT operation High current output 
		-52	+1000							
	C13887 *	-12	-2500	15	125	±0.01	±0.01	+24	128 × 25.5 × 72	For multiple PMT operation High current output
		-52	+2500							
	C12766 *	-12	-1500	30	75	±0.01	±0.01	+24	107 × 25.5 × 72	For multiple PMT operation High current output -12: UL60601-1 
		-52	+1500							





<sup>Ⓐ</sup>At maximum output voltage

<sup>Ⓑ</sup>At maximum output current

<sup>Ⓒ</sup>Excluding the projection and the cable

\* Please check individual catalogue for more detailed information.

## Bench-top type high voltage power supplies

	Type No.		Output voltage (Max.)(V)	Output current (Max.)(mA)	Ripple/Noise (p-p) Typ. (mV)	Regulation		Input <sup>Ⓒ</sup> voltage (V)	Size W × H × D <sup>Ⓓ</sup> (mm)	Note
						Line Typ. (%)	Load Typ. (%)			
	C9525	-02	-2000	1.8	60	±0.005	±0.03	AC100 to AC240	246 × 85 × 312	USB control Multiple outputs of ±5 V, ±15 V 
		-03								
		-52	+2000							
		-53								
	C9727	—	-3500	2	105	±0.005	±0.03	AC100 to AC240	246 × 85 × 312	USB control Multiple outputs of ±5 V, ±15 V 
		-01								
		-50	+3500							
		-51								

<sup>Ⓐ</sup>At maximum output voltage

<sup>Ⓑ</sup>At maximum output current

<sup>Ⓒ</sup>C9525-02/C9525-52/C9727-50: AC cable with a rating 125 V is supplied with the product

C9525-03/C9525-53/C9727-01/C9727-51: AC cable with a rating 250 V is supplied with the product

<sup>Ⓓ</sup>Excluding projecting parts

# High voltage power supplies

## High voltage power supply modules C10940 series



The C10940 series is an on-board type high voltage power supply module with a compact size of 15 mm × 18 mm × 15 mm.

The C10940 series requires minimal mounting space or footprint on a circuit board and so helps reduce equipment size. Type "-R2" for RS-485 control is also provided.

### Features

- Compact and lightweight
- High stability
- High conversion efficiency
- Digital control RS-485 Daisy-chain (Max. 32 ch, -R2 type only)
- Various protective functions

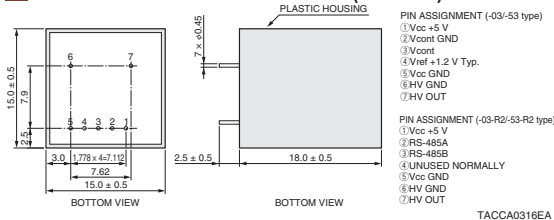
### Specifications

Parameter		C10940-03	C10940-03-R2	C10940-53	C10940-53-R2	Unit
Input voltage		+5 ± 0.5				V
Input current <sup>(A)</sup>	with no load	Typ. 60				mA
	with full load	Typ. 230				mA
Variable output voltage range *		-10 to -1200		+10 to +1200		V
Specification guaranteed output voltage range		-200 to -1200		+200 to +1200		V
Output current		Max. 0.6				mA
Line regulation against ±0.5 V input change <sup>(A)(B)</sup>		Typ. ±0.02				%
Load regulation against 0 % to 100 % load change <sup>(A)</sup>		Typ. ±0.01				%
Ripple / Noise (p-p) <sup>(A)(B)</sup>		Typ. 50				mV
Output voltage control		C10940-03/-53		By external controlling voltage (0 V to +1.2 V) or external potentiometer (50 kΩ)		—
		C10940-03-R2/-53-R2		Controlled by command via RS-485		—
Controlling voltage input impedance		200	—	200	—	kΩ
Reference voltage output		Typ. +1.2		—		V
Output voltage setting (Absolute value)		Typ. Controlling voltage × 1000		—		V
Output voltage rise time (0 % → 99 %) <sup>(A)(B)</sup>		Typ. 120	300	120	300	ms
Temperature coefficient <sup>(A)(B)</sup>		Typ. ±0.01				%/°C
Operating ambient temperature <sup>(A)(B)</sup>		0 to +50				°C
Operating ambient humidity <sup>(C)</sup>		Below 80				%
Storage temperature		-20 to +60				°C
Storage humidity <sup>(C)</sup>		Below 80				%
Weight		Typ. 7.7				g
Protective functions		Units protected against reversed power input, reversed/excessive controlling voltage input, continuous overloading/short circuit output				—

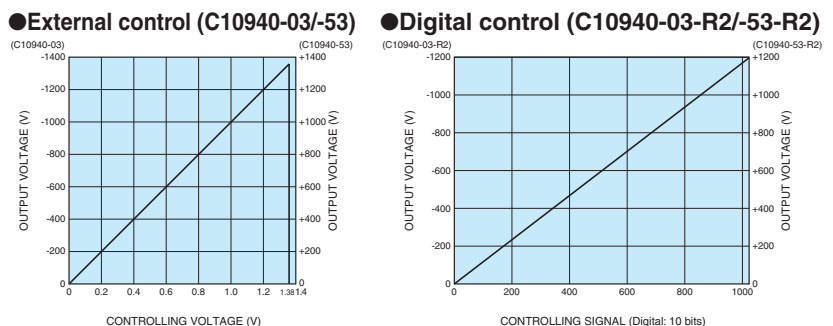
NOTE: (A) At maximum output voltage (B) At maximum output current (C) No condensation

\* All specifications cannot be guaranteed at output voltage below 200 V.

### Dimensional outlines (Unit: mm)

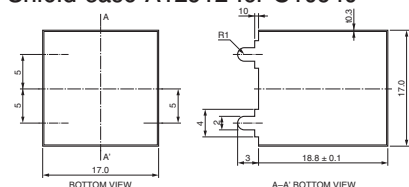


### Output voltage controlling characteristics



### Sold separately (Unit: mm)

Shield case A12912 for C10940



# Compact high voltage power supply modules C13890 series



The C13890-15/-55 are compact PC-board mountable high voltage power supplies, especially designed for photomultiplier tubes. The design offers better performance compared to previous model.

## Features

- Compact and lightweight
- Low power consumption
- High stability
- UL60601-01 (Only C13890-15)
- Quick response
- Various protective functions



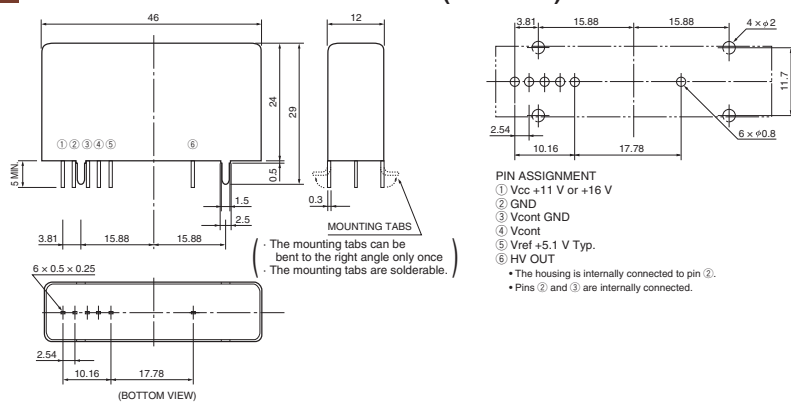
## Specifications

Parameter		C13890-15	C13890-55	Unit
Input voltage		+11 to +16		V
Input current <sup>(A)</sup>	with no load Typ.	35		mA
	with full load <sup>(B)</sup> Typ.	125		mA
Variable output voltage range *		0 to -1250	0 to +1250	V
Specification guaranteed output voltage range		-200 to -1250	+200 to +1250	V
Output current		Max. 0.6		mA
Line regulation against +11 V or +16 V input change <sup>(A)(C)</sup>		Typ. ±0.01		%
Load regulation against 0 % to 100 % load change <sup>(A)</sup>		Typ. ±0.01		%
Ripple / Noise (p-p) <sup>(A)(C)</sup>		Typ. 38		mV
Output voltage control		By external controlling voltage (0 V to +5 V) or external potentiometer (50 kΩ ± 2.5 kΩ)		
Controlling voltage input impedance		Typ. 75		kΩ
Reference voltage output		Typ. +5.1 (50 kΩ external potentiometer)		V
Output voltage setting (Absolute value)		Typ. Controlling voltage × 250		V
Output voltage rise time (0 % → 99 %) <sup>(A)(C)</sup>		Typ. 100		ms
Temperature coefficient <sup>(A)(C)</sup>		Typ. ±0.01		%/°C
Operating ambient temperature <sup>(A)(C)</sup>		-10 to +60		°C
Operating ambient humidity <sup>(D)</sup>		Below 80		%
Storage temperature		-20 to +70		°C
Storage humidity <sup>(D)</sup>		Below 80		%
Weight		Typ. 29		g
Protective functions		Units protected against reversed power input, reversed / excessive controlling voltage input, continuous overloading / short circuit in output		

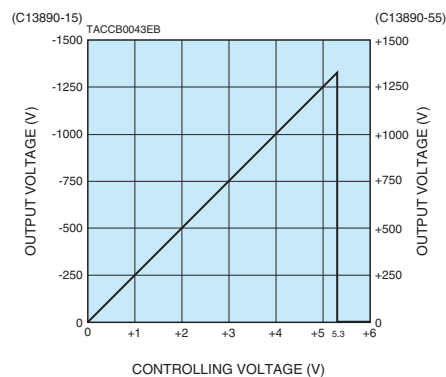
<sup>(A)</sup>At maximum output voltage    <sup>(B)</sup>At input voltage: At +11 V    <sup>(C)</sup>At maximum output current    <sup>(D)</sup>No condensation

\* All specifications cannot be guaranteed at output voltage below 200 V.

## Dimensional outlines (Unit: mm)



## Output voltage controlling characteristics



# High voltage power supplies

## High voltage power supply modules C11152 series



CE

The C11152 series is an on-board type low-profile high voltage power supply module developed to minimize ripple noise. The C11152 series includes a high voltage output monitor and can also be turned on and off from an external device.

### Features

- Low Ripple / Noise
- Compact and lightweight
- High stability
- High voltage output monitor
- Various protective functions

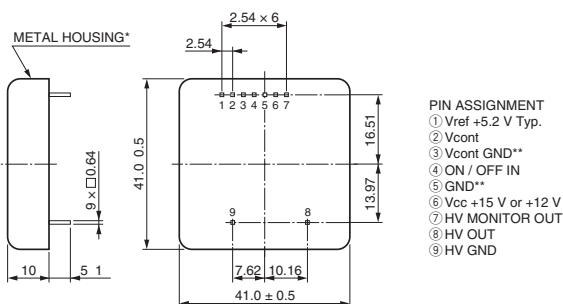
### Specifications

Parameter		C11152	C11152-01	C11152-50	C11152-51	Unit
Input voltage		+15 ± 1	+12 ± 0.5	+15 ± 1	+12 ± 0.5	V
Input current <sup>(A)</sup>	with no load	Typ. 45	50	45	50	mA
	with full load	Typ. 180	220	180	220	
Variable output voltage range *		0 to -1500		0 to +1500		V
Specification guaranteed output voltage range		-240 to -1500		+240 to +1500		V
Output current		Max. 1				mA
Line regulation against ±1 V or ±0.5 V input change <sup>(A)(B)</sup>		Typ. ±0.01				%
Load regulation against 0 % to 100 % load change <sup>(A)</sup>		Typ. ±0.01				%
Ripple / Noise (p-p) <sup>(A)(B)</sup>		Typ. 5 (>5 kHz), 8 (≤5 kHz)				mV
Output voltage control		By external controlling voltage (0 V to +5 V) or external potentiometer (50 kΩ)				—
Controlling voltage input impedance		Typ. 130		150		kΩ
Reference voltage output		Typ. +5.2				V
Output voltage setting (Absolute value)		Typ. Controlling voltage × 300				V
Output voltage rise time (0 % → 99 %) <sup>(A)(B)</sup>		Typ. 120				ms
Temperature coefficient <sup>(A)(B)</sup>		Typ. ±0.005				% / °C
High voltage monitor output		0 to +5 (Output impedance 10 kΩ)				V
ON / OFF input		TTL positive logic				—
ON / OFF input impedance		30				kΩ
Operating ambient temperature <sup>(A)(B)</sup>		0 to +50				°C
Operating ambient humidity <sup>(C)</sup>		Below 80				%
Storage temperature		-20 to +60				°C
Storage humidity <sup>(C)</sup>		Below 80				%
Weight		Typ. 38				g
Protective functions		Units protected against reversed power input, reversed / excessive controlling voltage input, continuous overloading / short circuit in output				—

NOTE: <sup>(A)</sup>At maximum output voltage <sup>(B)</sup>At maximum output current <sup>(C)</sup>No condensation

\* All specifications cannot be guaranteed at output voltage below 240 V.

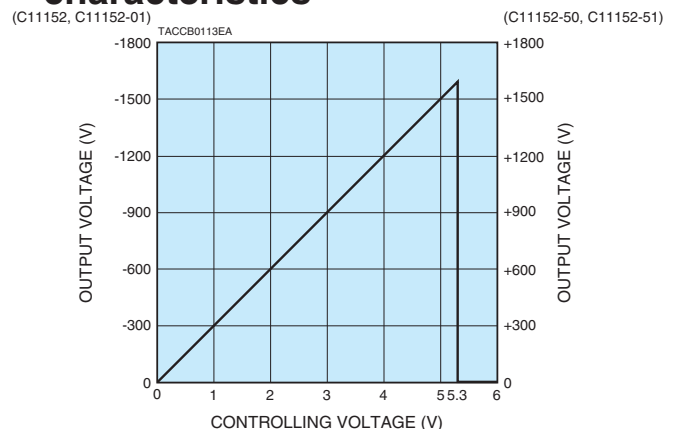
### Dimensional outline (Unit: mm)



\* The metal housing is internally connected to Pin ⑤.

\*\* Never connect the Pin ③ and ⑤ directly and externally.

### Output voltage controlling characteristics



# Bench-top type high voltage power supplies C9525 series, C9727 series



The C9525 series and C9727 series are multi-output high voltage power supplies that include a high-voltage power supply unit and a low-voltage power supply unit and can be remotely controlled.

## Features

- Compact bench-top type
- High output voltage  
C9525 series (2 kV/1.8 mA),  
C9727 series (3.5 kV/2 mA)
- Low output voltage  $\pm 5$  V,  $\pm 15$  V
- High stability
- USB control
- Output voltage monitor
- Output current monitor (only C9727)



## Specifications

Parameter		C9525-02 C9525-03	C9525-52 C9525-53	C9727 C9727-01	C9727-50 C9727-51	Unit
High voltage output	Output voltage *	0 to -2000	0 to +2000	0 to -3500	0 to +3500	V
	Specification guaranteed output voltage	-320 to -2000	+320 to +2000	-320 to -3500	+320 to +3500	V
	Output current	1.8		2		mA
	Line regulation (For 10 % change in line voltage) <sup>(A)(B)</sup>	Max.		$\pm 0.005$		%
	Load regulation (For 0 % to 100 % change in load) <sup>(A)</sup>	Max.		$\pm 0.03$		%
	Ripple / Noise (p-p) <sup>(A)(B)</sup>	Typ.		0.003		%
	Drift (After 30 minute warm-up) <sup>(A)(B)</sup>	Typ.		$\pm 0.05$		%/h
	Temperature coefficient <sup>(A)(B)</sup>	Typ.		$\pm 0.01$		%/°C
	High voltage output monitoring accuracy <sup>(A)</sup>	Typ.		$\pm (0.1 \% + 2 \text{ V})$		—
Output connector		SHV-R				—
Low voltage output	Output voltage	$+5 \pm 0.25, -5 \pm 0.25, +15 \pm 0.75, -15 \pm 0.75$				V
	Output current	+5 V, -5 V	500 (Total value of two connector outputs)		200 (Total value of two connector outputs)	mA
		+15 V, -15 V	200 (Total value of two connector outputs)			mA
Output connector		DIN-R (6 pin) $\times$ 2				—
AC input voltage		AC100 to AC240				V
Power consumption <sup>(A)(B)</sup>		Max. 60				V·A
Operating ambient temperature <sup>(A)(B)</sup>		0 to +40				°C
Operating ambient humidity <sup>(C)</sup>		Below 85				%
Storage temperature		-20 to +50				°C
Storage humidity <sup>(C)</sup>		Below 90				%
Weight		Approx. 3.0				kg

<sup>(A)</sup>At maximum output voltage    <sup>(B)</sup>At maximum output current    <sup>(C)</sup>No condensation

\* All specifications cannot be guaranteed at output voltage below 320 V.

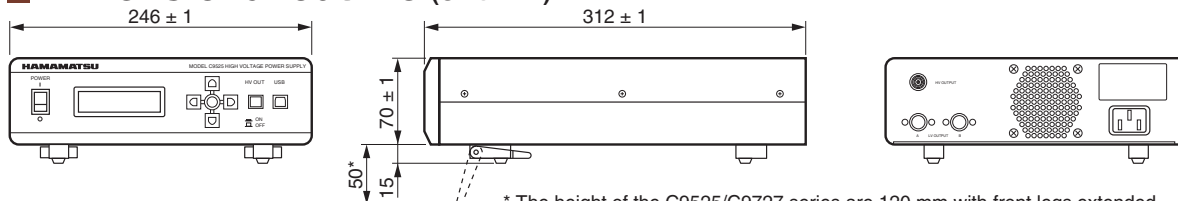
### Accessories

- ① AC line cable (2 m long)  
C9525-02/C9525-52/C9727/C9727-50: AC cable with a rating of 125 V ..... 1  
C9525-03/C9525-53/C9727-01/C9727-51: AC cable with a rating of 250 V ..... 1
- ② High voltage output cable (1.5 m long) terminated with SHV-P E1168-17 (C9525 series) .... 1  
High voltage output cable (1.5 m long) terminated with SHV-P E1168-19 (C9727 series) .... 1
- ③ 3P/2P connector AC plug (C9525-02/C9525-52/C9727/C9727-50 only) ..... 1
- ④ USB cable (1.5 m long) with filter ..... 1
- ⑤ Low voltage power supply section DIN connector plugs ..... 2
- ⑥ CD-ROM (Containing instruction manual, sample software) ..... 1
- ⑦ Clamp filter (C9525-02/-03/-52/-53 only) ..... 2

### Sold separately

Connecting cable for low voltage power supply section E1168-26 (for C9744, C7319, C12419, C9999/-01, C6438/-01/-02, C9663)

## Dimensional outline (Unit: mm)



\* The height of the C9525/C9727 series are 120 mm with front legs extended

# Thermoelectric coolers

## High performance thermoelectric coolers C10372, C10373 For 28 mm, 38 mm, 51 mm diameter head-on PMT and MCP-PMT



Left: Power Supply  
Right: Cooled PMT Housing

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

### Features

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

### Specifications

#### [Cooled PMT housing]

Parameter	C10372-01/-02 <sup>(A)</sup>	C10373-01/-02 <sup>(A)</sup>	Unit
Cooling method	Thermoelectric cooling using Peltier module		—
Heat exchange medium	Water (1 L/min to 3 L/min, water pressure: below 0.3 MPa)		—
Cooling temperature (with cooling water at +20 °C)	Approx. -30		°C
Time to stable cooling temperature	Approx. 120		min
Optical window material	Evacuated double-pane silica glass window with heater (185 nm to 2200 nm)		—
Applicable PMTs (sold separately)	28 mm (1-1/8" Dia.), 38 mm (1-1/2" Dia.) and 51 mm (2" Dia.) Head-on	MCP-PMT (R3809U-50 Series, R3809U-61/-63/-64)	—
Applicable socket assembly / Holder (sold separately)	E2762 Series <sup>(B)</sup>	E3059-500 (R3809U-50 Series, R3809U-61/-63/-64)	—
Operating ambient temperature / Humidity <sup>(C)</sup>	+5 °C to +40 °C / Below 75 %		—
Storage temperature / Humidity <sup>(C)</sup>	-15 °C to +50 °C / Below 80 %		—
Weight	Approx. 5.8	Approx. 5.5	kg

NOTE: <sup>(A)</sup>C10372 / C10373: For AC 100 V operation. C10372-01 / C10373-01: For AC 120 V operation. C10372-02 / C10373-02: For AC 230 V operation.  
<sup>(B)</sup>See P.117    <sup>(C)</sup>No condensation

#### [Power supply]

Parameter	Value / Description	Unit
AC input voltage	AC100 to AC240 (50 Hz/60 Hz)	V
Maximum power consumption	200	V·A
Temperature controllable range (with cooling water at +20 °C)	-30 to 0 (continuously adjustable)	°C
Output voltage	24 to 27	V
Output current	4.2	A
Protection circuit	Protective circuits to safeguard Peltier module in case of low water and to prevent output short-circuit, output overvoltage, and excessive temperature rise in power supply.	—
Operating ambient temperature / Humidity <sup>(C)</sup>	+5 °C to +40 °C / Below 75 %	
Storage temperature / Humidity <sup>(C)</sup>	-15 °C to +50 °C / Below 80 %	
Weight	Approx. 2.1	kg

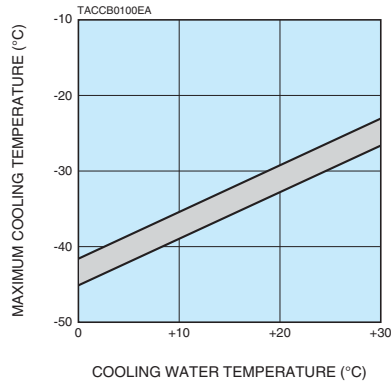
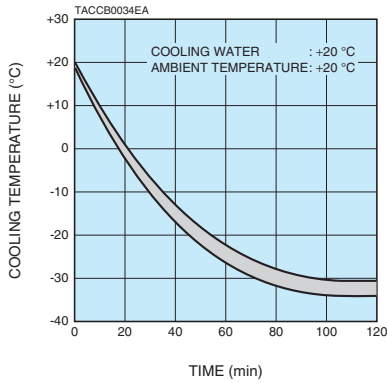
NOTE: <sup>(C)</sup>No condensation

#### [Components and accessories]

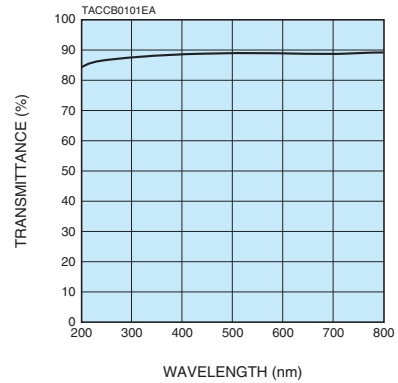
- Cooled PMT housing    ● Power supply    ● Light shield cap    ● Water hose clamps (2 pcs)    ● Connection cable (1.5 m)
- AC line cable    ● Socket assembly / PMT holder mounting screws (4 pcs)

\* To use these coolers, water hoses with an inner diameter of 15 mm and a water supply line with the matching round faucet are required. Prepare those hoses of the desired length. Hoses can also be connected by using PT 1/8 pipe taper screws.

## Cooling characteristics

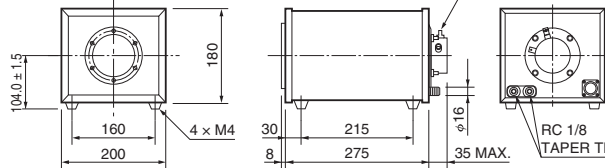


## Spectral transmission characteristics of optical window

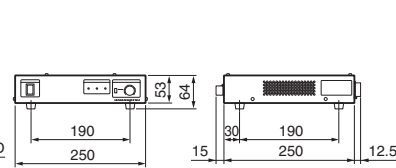


## Dimensional outlines (Unit: mm)

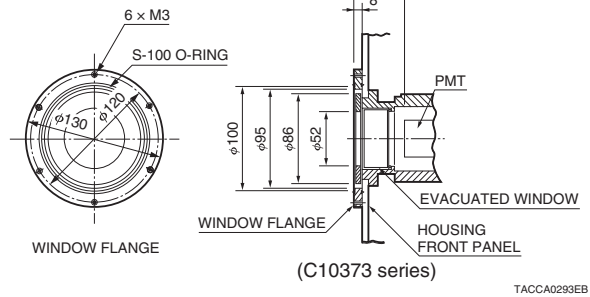
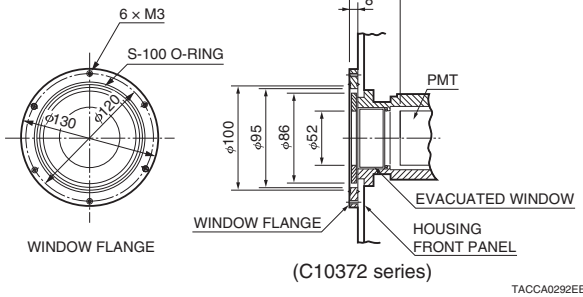
### HOUSING



### POWER SUPPLY

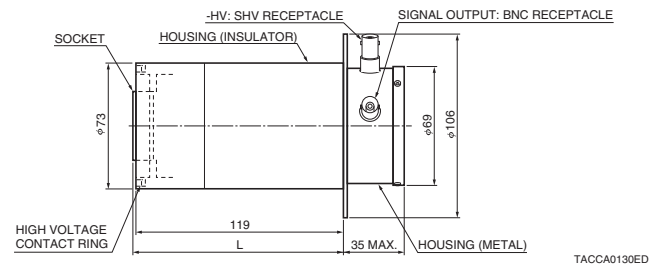


\* The 1 mm thickness of the folded aluminum plate is not included in.



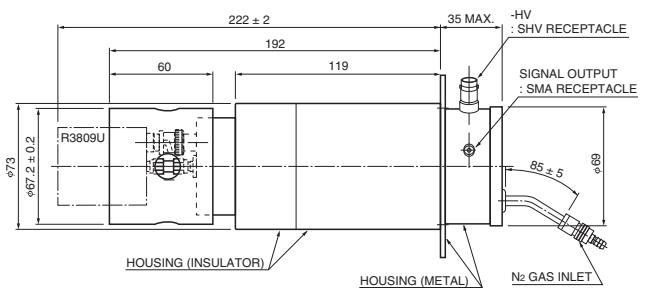
## Sold separately (Unit: mm)

### Socket assemblies for C10372 series E2762 series



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

### MCP-PMT holder for C10373 series E3059-500 (For R3809U series)



NOTE: (A)

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

# Thermoelectric coolers

## High performance thermoelectric coolers for 28 mm Dia. side-on PMTs C14760, C14761 series



▲Left: Controller for C14761 and C14760  
Right: C14761 and socket assembly C9145

The C14760 and the C14761 are thermoelectric coolers designed for 28mm diameter side-on photomultiplier tubes (PMTs). The C14760 and the C14761 improve S/N (signal to noise ratio) of PMT measurement because of reduction of thermal electrons, which are emitted from PMT photocathode, and minimization of external noise by a built-in electrostatic and magnetic shield. The C14760 and the C14761 can communicate with a PC via an RS-232C serial interface. It enables the PC to control the cooling temperature. The C14760 and the C14761 use water and forced air respectively to exchange heat of the thermoelectric cooler (Peltier module).

### Features

- Thermoelectric cooling using Peltier module
- Built-in electrostatic and magnetic shield
- Internal protective circuits safeguards Peltier module in case of low water flow or suspension of fan operation
- PMT temperature control by PC
- Water cooling makes it robust against temperature changes (C14760)
- Air cooling means easier handling (C14761)

### Specifications

#### [Cooled PMT housing]

Parameter	C14760-C2/-C3 <sup>Ⓐ</sup>	C14761-C2/-C3 <sup>Ⓐ</sup>	Unit
Cooling method	Thermoelectric cooling using Peltier module		—
Heat exchange medium	Water	Forced air	—
Cooling temperature	Approx. -30 <sup>Ⓑ</sup> (with cooling water of +20 °C)	Approx. -25 <sup>Ⓒ</sup> (with ambient temperature of +25 °C)	°C
Maximum cooling temperature	-30		°C
Time to stable cooling temperature	Approx. 70	Approx. 90	min
Optical window material	Evacuated double-pane silica glass (185 nm to 2200 nm)		—
Light Input aperture dimension	8 × 24		mm
Applicable PMTs (sold separately)	28 mm Dia. Side-on type		—
Applicable socket assembly (sold separately)	C9145 (DP-type), E9146 (D-type)		—
Operating ambient temperature / Humidity <sup>Ⓓ</sup>	+5 °C to +40 °C / Below 75 %	+5 °C to +35 °C / Below 75 %	—
Storage temperature / Humidity <sup>Ⓓ</sup>	-20 °C to +50 °C / Below 85 %		—
Weight	Approx. 1	Approx. 1.7	kg

NOTE: ⒶC14760-C2/C14761-C2: For AC 100 V to 120 V operation. C14760-C3/C14761-C3: For AC 230 V operation.

ⒷC14760 achieves cooling temperature of approx. -30 °C with water temperature of +20 °C. If the water temperature is higher, the possible lowest cooling temperature becomes higher (Note: Maximum cooling temperature is -30 °C).

ⒸC14761 achieves cooling temperature of approx. -25 °C with ambient temperature of +25 °C. If the ambient temperature is higher, the possible lowest cooling temperature becomes higher. If the ambient temperature is lower, the possible lowest cooling temperature becomes lower (Note: Maximum cooling temperature is -30 °C). ⒹNo condensation

#### [Controller]

Parameter	Value / Description	Unit
AC input voltage	AC100 to AC240 (50 Hz / 60Hz)	V
Maximum power consumption	150	V·A
Temperature controllable range	-30 to -5 (0.1 °C step) <sup>Ⓔ</sup>	°C
Protection circuit	Protective circuits to safeguard Peltier module in case of low water or suspension of fan operation and to prevent output short-circuit, output overvoltage, and excessive temperature rise in controller.	—
Serial interface	RS-232C, 9600 bps	—
Operating temperature / Humidity <sup>Ⓓ</sup>	+5 °C to +40 °C / Below 75 %	—
Storage temperature / Humidity <sup>Ⓓ</sup>	-20 °C to +50 °C / Below 85 %	—
Weight	Approx. 2	kg

NOTE: ⒹNo condensation

ⒺPMT temperature may not achieve set up cooling temperature controlled by the operator if ambient temperature and/or water temperature is high.

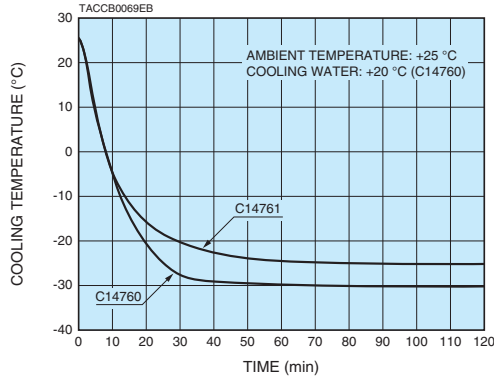
#### [Components and accessories]

- Cooled PMT housing
- Controller
- Light shield cap
- AC line cable
- Connection cable (1.5 m) between cooled PMT housing and controller
- Serial communication cable (RS-232C crossing cable 1.8 m)
- CD-ROM (Instruction manual, sample software for control of cooling temperature)
- Spare fuses (2 pcs)

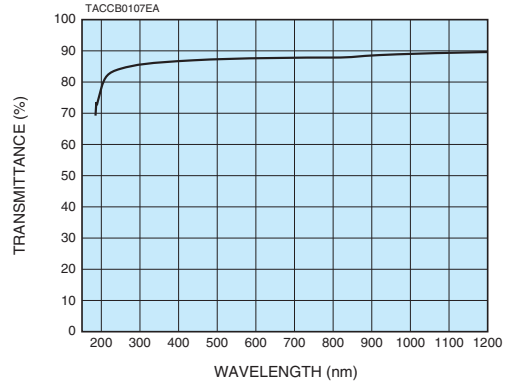
\* To use C14760 series, water hoses with an outer diameter of 6 mm and an inner diameter of 4 mm and a water supply line with the matching round faucet are required. Prepare those hoses of the desired length. In addition, prepare a filter for removing impurities such as chlorine ions.



## Cooling characteristics

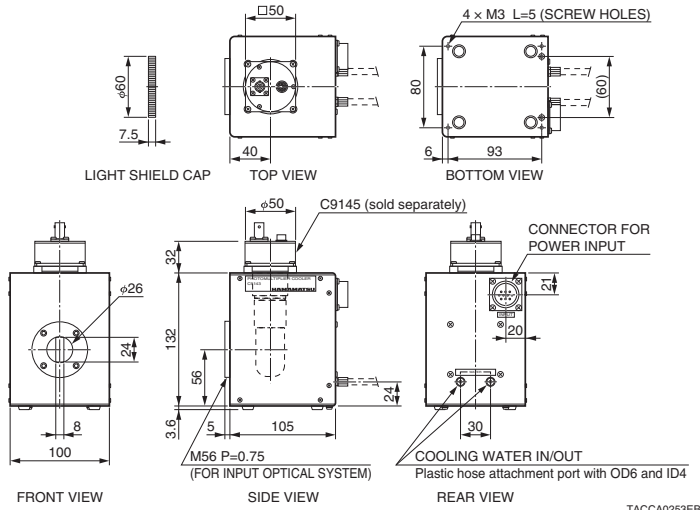


## Spectral transmission characteristics of optical window

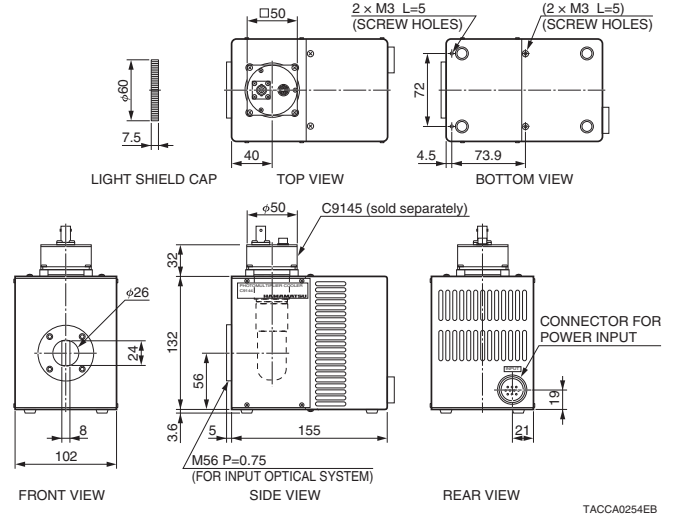


## Dimensional outlines (Unit: mm)

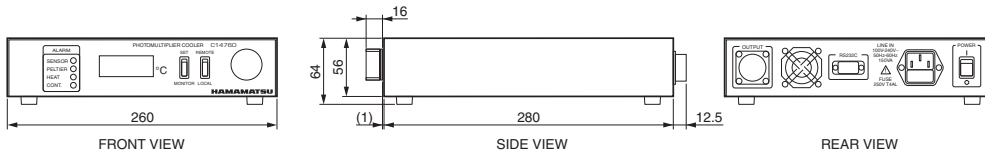
### ●C14760 HOUSING



### ●C14761 HOUSING

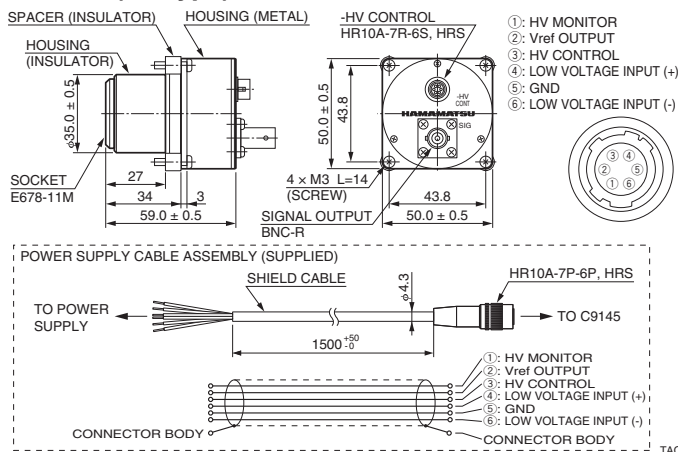


### ●CONTROLLER



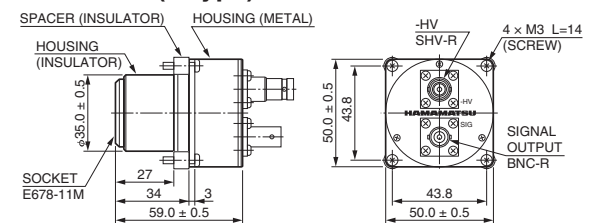
## Sold separately (Unit: mm)

### ●C9145 (DP type) \*MAXIMUM SUPPLY VOLTAGE: -1200 V



### ●E9146 (D type) \*MAXIMUM SUPPLY VOLTAGE: -1250 V

### ●E9146-01 (D type) \*MAXIMUM SUPPLY VOLTAGE: -1500 V



# Magnetic shield cases

## Magnetic shield cases E989 series



TACCF0093

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

### Features

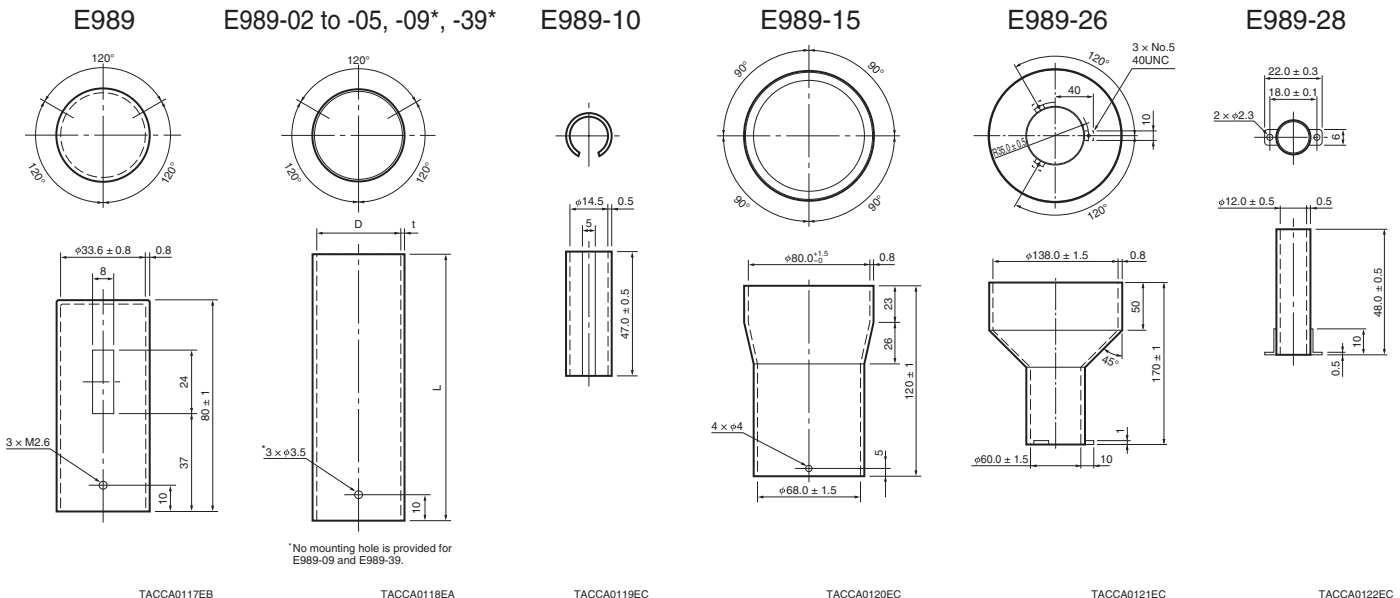
- Made of high-permeability permalloy (Ni: 78 %, Fe and others: 22 %)
- Various sizes available with inner diameters from 12 mm to 138 mm
- Lusterless black paint finish

### Specifications

	Photomultiplier tube diameter	Type No.	Internal Dia. D ( $\phi$ mm)	Thickness t (mm)	Length L (mm)	Weight (g)
Side-on	$\phi$ 13 mm (1/2")	E989-10	$14.5 \pm 0.5$	$0.5^{+0.2}_{-0.1}$	$47 \pm 0.5$	10
	$\phi$ 28 mm (1-1/8") *	E989	$33.6 \pm 0.8$	$0.8^{+0.2}_{-0.1}$	$80 \pm 1$	66
Head-on	$\phi$ 10 mm (3/8")	E989-28	$12 \pm 0.5$	$0.5^{+0.2}_{-0.1}$	$48 \pm 0.5$	9
	$\phi$ 13 mm (1/2")	E989-09	$16 \pm 0.5$	$0.8^{+0.2}_{-0.1}$	$75 \pm 0.5$	28
	$\phi$ 19 mm (3/4")	E989-02	$23 \pm 0.5$	$0.8^{+0.2}_{-0.1}$	$95 \pm 1$	50
	$\phi$ 25 mm (1")	E989-39	$29 \pm 0.5$	$0.8^{+0.2}_{-0.1}$	$48 \pm 0.5$	32
	$\phi$ 28 mm (1-1/8")	E989-03	$32 \pm 0.5$	$0.8^{+0.2}_{-0.1}$	$120 \pm 1$	90
	$\phi$ 38 mm (1-1/2")	E989-04	$44^{+1}_{-0}$	$0.8^{+0.2}_{-0.1}$	$100 \pm 1$	102
	$\phi$ 51 mm (2")	E989-05	$60^{+1}_{-0}$	$0.8^{+0.2}_{-0.1}$	$130 \pm 1$	180
	$\phi$ 76 mm (3")	E989-15	$80^{+1.5}_{-0}$	$0.8^{+0.2}_{-0.1}$	$120 \pm 1$	170
	$\phi$ 127 mm (5")	E989-26	$138 \pm 1.5$	$0.8^{+0.2}_{-0.1}$	$170 \pm 1$	400

\* Photomultiplier tubes with HA treatment (see page 11 to 12) extending to the base portion cannot be used. Please consult our sales offices for details.

### Dimensional outlines (Unit: mm)



# Housings, Flange

## Housings E1341-01/-02

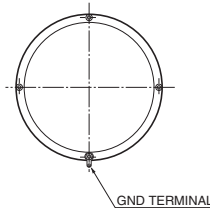
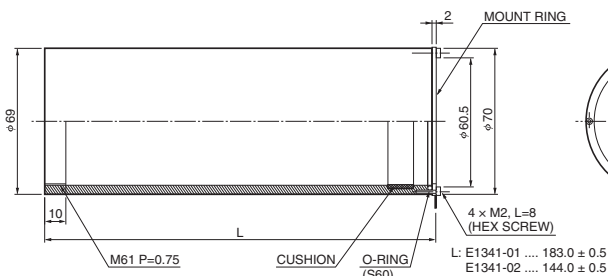


TACCF0177

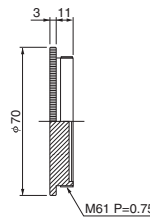
The E1341-01/-02 are metal housings designed for the D-type socket assembly E5859 series (for 51 mm diameter head-on photomultiplier tubes; see page 97 to 98) operated at room temperature. To install the E5859 series socket assembly into the E1341-01/-02 and to ensure complete light-shielding, a magnetic shield case E989-62/-68 (sold separately) is required. The E1341-01/-02 housings can be easily attached to a monochromator by preparing a simple adapter.

Type No.	Suitable photomultiplier tube	Magnetic shield case
E1341-01	R464, R649, R329-02, etc.	E989-62
E1341-02	R943-02	E989-68

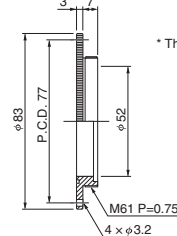
### Dimensional outlines (Unit: mm)



CAP (SUPPLIED)



MOUNT FLANGE\* (SUPPLIED)

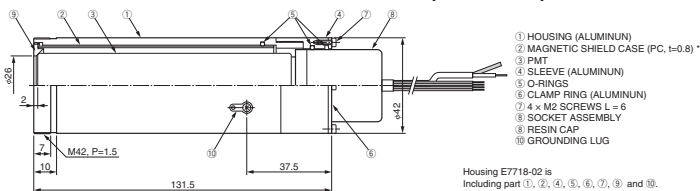


\* The O-ring (S56) is supplied.

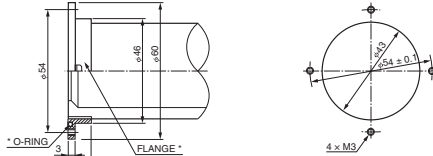
TACCA0228EB

## Housing E7718-02

### Dimensional outline (Unit: mm)



[HOW TO USE THE HOUSING WITH FLANGE] [SUGGESTED FIXTURE LAYOUT FOR THE FLANGE]



\* Flange and O-ring are sold separately. (Type No.: A7719)  
 \*\* Magnetic shield case is electrically floating.

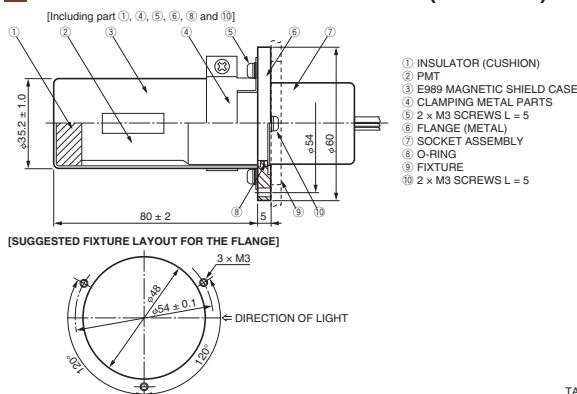
TACCA0327EA

The E7718-02 housing contains a magnetic shield case and is designed for use with 28 mm diameter head-on photomultiplier tubes. It can be easily attached to another device by connecting the A7719 flange (sold separately).

Suitable PMT	Suitable socket assembly	
R374, R2228, R5929	DA type	C7246/-22, C7247/-22
R6094, R6095, etc.	DP type	C13004-01, C10344-03
	DAP type	C14019-02

## Flange A7709

### Dimensional outline (Unit: mm)



[SUGGESTED FIXTURE LAYOUT FOR THE FLANGE]

TACCA0199EB

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

Suitable PMT	Suitable socket assembly	
φ28 mm Side-on type	D type	E717-63/-501
	DA type	C7246-01/-23, C7247-01/-23
	DP type	C8991, C8991-01, C12597-01
	DAP type	C14019-01

\* A7708 dedicated flange is provided for C13654-01.

# Power and signal cables, Connector adapters

## Power and signal cables E1168 series



TACCF0153

Hamamatsu offers the E1168 series cables for connection of photomultiplier tube assemblies and their accessories. A variety of cables are available, for handling high voltage, low voltage and signals. In addition, Hamamatsu also provides the A5059 series connector adapters designed for BNC/SMA connector conversion.

### Selection guide

#### ● For high voltage

Type No.	Cable type	Cable diameter	Maximum voltage	Connector types
E1168-10	RG-59B/U	φ6.15 mm	2.3 kV Max.	MHV plug—SHV plug
E1168-17				SHV plug—SHV plug
E1168-19	Custom high voltage cable	φ6.15 mm	5 kV Max.	SHV plug—SHV plug
E1168-20				MHV plug—SHV plug

#### ● For low voltage

Type No.	Cable type	Connector types
E1168-26	Multiconductor Cable with Shield	DIN6P plug—DIN6P plug

#### ● For signal

Type No.	Cable type	Impedance	Connector types
E1168-01	3D-2V	50 Ω	N plug—N plug
E1168-02			N plug—BNC plug
E1168-05	3D-2V	50 Ω	BNC plug—BNC plug
A5026	Custom coaxial cable	50 Ω	SMA plug—SMA plug
A5026-01			SMA plug—SMA jack

#### ● Connector adapters

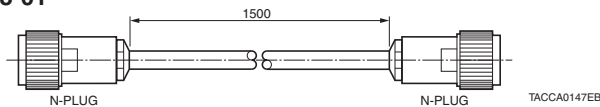
Type No.	Connector types
A5059-01	BNC jack—SMA jack
A5059-02	BNC jack—SMA plug
A5059-03	BNC plug—SMA jack

#### ● Relay adapters

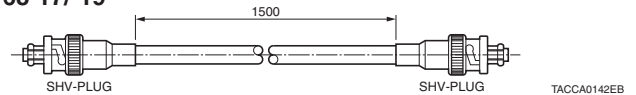
Type No.	Connector types
A5074	SHV jack—SHV jack
A7992	BNC jack—BNC jack

### Dimensional outlines (Unit: mm)

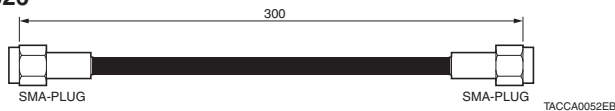
#### E1168-01



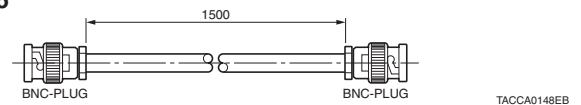
#### E1168-17/-19



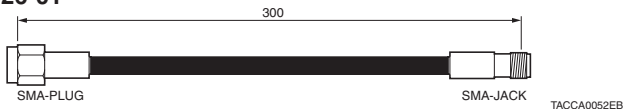
#### A5026



#### E1168-05



#### A5026-01



#### A5059-01



#### A5059-02



#### A5059-03



TACCC0104EA

# Related products for photon counting

## Photon counting unit C9744



TACCF0195

This photon counting unit contains an amplifier and a discriminator to convert the single photoelectric pulses from a photomultiplier tube into a 5 V digital signal.

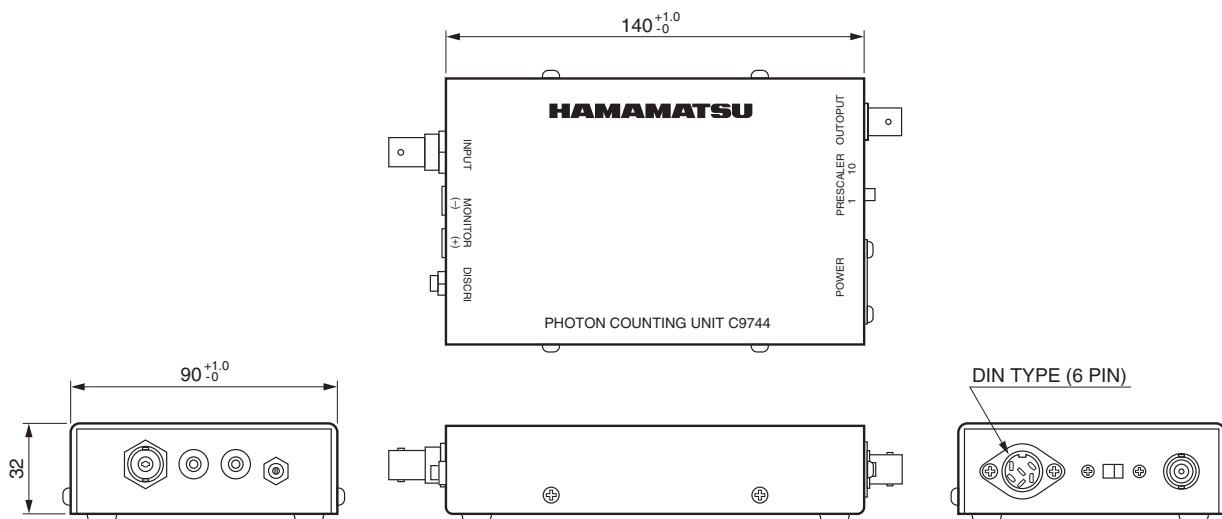
The C9744 has an output linearity up to  $1 \times 10^7 \text{ s}^{-1}$ , and a high-speed counter is not required when set to division by 10.

### Specifications

Parameter		Description / Value
Input impedance		50 $\Omega$
Discrimination level (input conversion)		-0.4 mV to -16 mV
PMT gain		$3 \times 10^6$
Prescaler		$\div 1 / \div 10$
Count linearity	$\div 1$	$4 \times 10^6 \text{ s}^{-1}$
	$\div 10$	$1 \times 10^7 \text{ s}^{-1}$
Pulse-pair resolution	$\div 1$	25 ns
	$\div 10$	10 ns
Output pulse		CMOS 5 V, POSITIVE LOGIC
Output pulse width	$\div 1$	10 ns
	$\div 10$	Depends on count rate
Supply voltage		+5.0 V $\pm$ 0.2 V, 130 mA / -5.0 V $\pm$ 0.2 V, 50 mA
Connector	Input	BNC-R
	Output	BNC-R
	Power	DIN (6 PIN) <sup>Ⓑ</sup>
Dimensions (W $\times$ H $\times$ D)		90 mm $\times$ 32 mm $\times$ 140 mm (excluding rubber feet and projecting parts)
Weight		Approx. 250 g
Operating ambient temperature / Humidity <sup>Ⓐ</sup>		0 $^{\circ}$ C to +50 $^{\circ}$ C / Below 80 %
Storage temperature / Humidity <sup>Ⓐ</sup>		-15 $^{\circ}$ C to +60 $^{\circ}$ C / Below 85 %

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

### Dimensional outline (Unit: mm)



# Related products for photon counting

## Counting unit C8855-01



The C8855-01 is a counting unit with a USB interface and can be used as a photon counter when combined with a photon counting head, etc. The counter of the C8855-01 has two counter circuits (double counter method) capable of counting input signals with no dead time. Since the C8855-01 is hot-swap compatible (plug and play compatible), it helps you set up measurement environment quickly. You can start measurement on the day the C8855-01 is delivered by the sample software.

- **Time-resolved measurement (minimum resolution: 50  $\mu$ s) for monitoring chemiluminescence and biological clocks**
- **Quick measurement setups (hot-swap compatible)**

When software such as a device driver is installed into your PC beforehand, you can start measurement by just connecting the USB cable, without restarting the PC.

- **Applicable to various measurement methods**

The C8855-01 is controlled only by DLL(dynamic link library) supplied. Hamamatsu Photonics publishes all DLL functions to enable users to construct suitable software for different measurement depending on various applications.

## Specifications

Parameter		Description / Value
Input	Number of input signals	1 ch
	Signal input level	CMOS positive logic (high level: 2 V min.)
	Signal pulse width	8 ns or longer
	Input impedance	50 $\Omega$
Counter	Counter method	Double counter method
	Maximum count rate	50 MHz
	Maximum counter capacity	2 <sup>32</sup> counts / counter gate
Counter gate	Counter gate mode	Internal counter gate only
	Internal counter gate time <sup>(A)</sup>	50 $\mu$ s to 10 s (1, 2, 5 step)
Trigger	Trigger method	Software / External trigger
	External trigger signal	TTL negative logic
ID switch <sup>(B)</sup>		0 to F(hexadecimal number)
General output section		Open collector / 2 bits
Voltage output		+5 V / 200 mA Max.
Compatible OS		Windows <sup>®</sup> 8.1 Pro / 10 Pro
Interface		USB
Supply voltage		+7 V / 500 mA Max. (supplied from AC adapter)
Dimensions (W × H × D)		120 mm × 30 mm × 96 mm (excluding rubber feet and projecting parts)
Weight		250 g
Operating ambient temperature / Humidity <sup>(C)</sup>		+5 °C to +45 °C / Below 80 %
Storage temperature / Humidity <sup>(C)</sup>		0 °C to +50 °C / Below 85 %
CE marking		Conforms to the IEC 61326-1 GROUP 1, CLASS B
AC adapter	AC input	AC100 V to AC240 V
	Output	+7 V / 1.6 A

**NOTE:** <sup>(A)</sup>The C8855-01 is not suitable for applications requiring time resolution higher than 50  $\mu$ s.

<sup>(B)</sup>The ID switch is used to set ID numbers when two or more C8855-01 units are connected to single PC.

<sup>(C)</sup>No condensation

Supplied: CD-ROM (containing instruction manual, device driver, DLL, sample software\*, etc.), USB cable, AC adapter, AC cable, power output connector

\* Sample software is configured from Lab VIEW<sup>™</sup> of National Instruments, Inc.



# Cautions and warranty

## SAFETY PRECAUTIONS

### WARNING



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

## HANDLING PRECAUTIONS

### ● Handle tubes with extreme care.

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

### ● Keep faceplate and base clean.

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

### ● Do not expose to strong light.

The photocathode of photomultiplier tubes may be damaged if exposed to direct sunlight or intense illumination. Never allow strong light to strike the photocathode.

### ● Carefully handle tubes with a glass base.

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

### ● Helium permeation through silica bulb

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

## WARRANTY

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

## ORDERING INFORMATION

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

## WHEN DISPOSE THE PRODUCT

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

\* Characteristics and specifications in this catalog are subject to change without prior notice due to product improvement or other factors.

Before you design equipment according to the characteristics and specifications of our products listed in this catalog, please contact us to check the product specifications.



# Typical photocathode spectral response

Curve codes	Photocathode materials	Window materials	Luminous (Typ.) ( $\mu\text{A/lm}$ )	Spectral response						PMT examples
				Range (nm)	Peak wavelength					
					Radiant sensitivity		QE			
					(mA/W)	(nm)	(%)	(nm)		

## Semitransparent photocathode

○	100M	Cs-I	MgF <sub>2</sub>	—	115 to 200	14	140	13	130	R972, R1081, R6835
○	200S	Cs-Te	Silica	—	160 to 320	29	240	16	210	R759, R821, R6834
○	200M	Cs-Te	MgF <sub>2</sub>	—	115 to 320	29	240	17	200	R1080, R6836
	201S	Cs-Te	Silica	—	160 to 320	31	240	17	210	R2078
○	400K	Bialkali	Borosilicate	95	300 to 650	88	420	27	390	R329-02, R1307, R1635 R1924A, R5611A-01, R11102, etc.
○	400U	Bialkali	UV	95	185 to 650	88	420	27	390	R750, R3479, R10560, R7056
○	400S	Bialkali	Silica	95	160 to 650	88	420	27	390	R2496
○	401K	High temp. Bialkali	Borosilicate	40	300 to 650	51	375	17	375	R1288A, R3991A, R4177-01, R4607A-01
○	402K	Low noise Bialkali	Borosilicate	40	300 to 650	54	375	18	375	R2557, R3550A, R5610A
○	500K(S-20)	Multialkali	Borosilicate	150	300 to 850	64	420	20	375	R550, R649, R1513, R1617, R1878 R1925A
○	500U	Multialkali	UV	150	185 to 850	64	420	25	280	R374, R1463
○	500S	Multialkali	Silica	150	160 to 850	64	420	25	280	R375
○	501K(S-25)	Extended red Multialkali	Borosilicate	200	300 to 900	40	600	8	580	R669, R2228, R2257
○	502K	Multialkali	Borosilicate (prism)	230	300 to 900	69	420	20	390	R5070A, R5929
○	600K	GaAsP	Borosilicate	700	280 to 720	180	550 to 650	40	480 to 530	R3809U-64
○	601K	Extended red GaAsP	Borosilicate	750	280 to 820	160	550 to 650	36	480 to 530	R3809U-63
○	602K	GaAs	Borosilicate	700	370 to 920	85	750 to 850	12	600 to 750	R3809U-61
○	700K(S-1)	Ag-O-Cs	Borosilicate	20	400 to 1200	2.2	800	0.36	740	R5108
○	900S	InP/InGaAsP(Cs)	Silica	—	950 to 1200	18	1100	2	1000 to 1100	H10330-25*
○	901S	InP/InGaAs(Cs)	Silica	—	950 to 1700	24	1500	2	1000 to 1550	H10330-75*

## Semitransparent photocathode (UBA [Ultra Bialkali], SBA [Super Bialkali], EGBA [Extended Green Bialkali])

○	440K	Super Bialkali	Borosilicate	105	300 to 650	110	400	35	350	R7600U-100, R7600U-100-M4, R5900U-100-L16, etc.
○	441K	Ultra Bialkali	Borosilicate	135	300 to 650	130	400	43	350	R7600U-200, R7600U-200-M4, R5900U-200-L16, etc.
	442K	Super Bialkali	Borosilicate	105	230 to 700	110	400	35	350	R9880U-110
	443K	Ultra Bialkali	Borosilicate	135	230 to 700	130	400	43	350	R9880U-210
○	444K	Extended Green Bialkali	Borosilicate	160	300 to 700	127	420	40	380	H7546B-300, H8711B-300

## Reflection mode photocathode

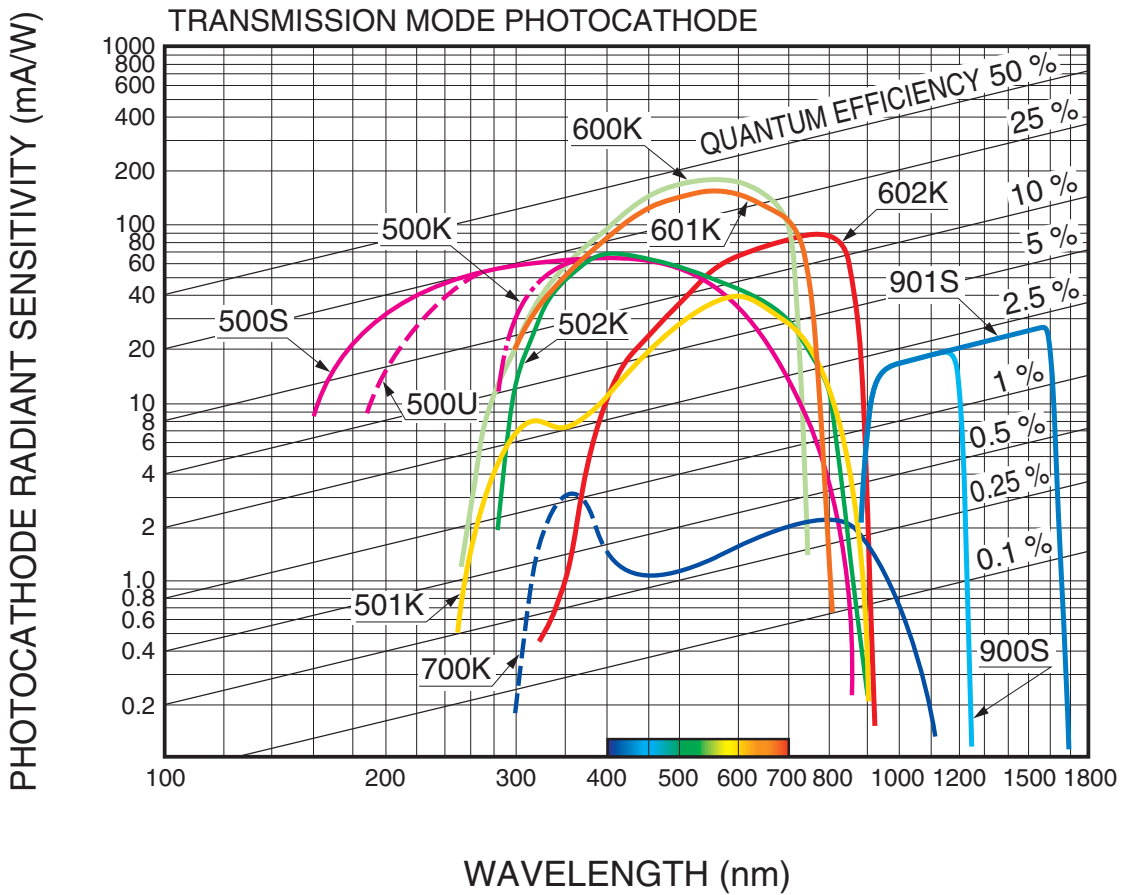
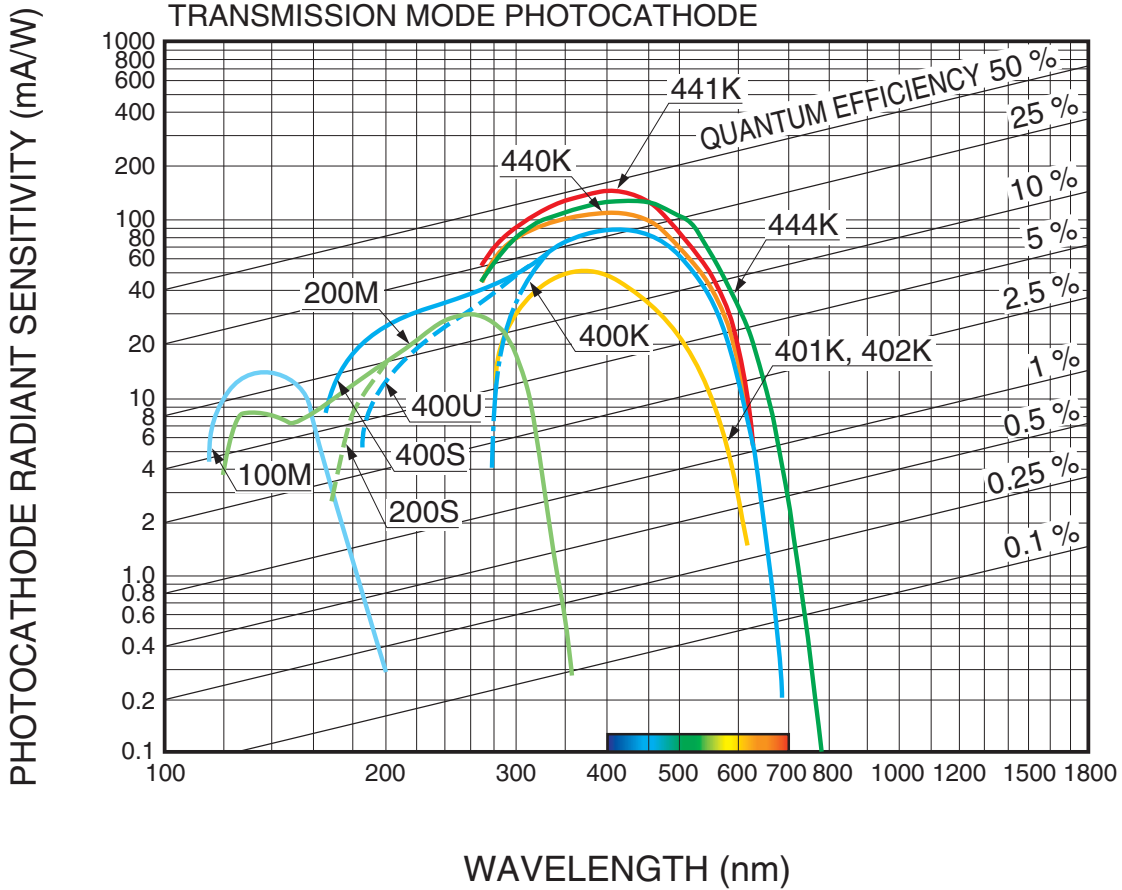
○	150M	Cs-I	MgF <sub>2</sub>	—	115 to 195	25.5	130	26	125	R8487, R10825
○	250S	Cs-Te	Silica	—	160 to 320	62	230	37	210	R6354, R7154
○	250M	Cs-Te	MgF <sub>2</sub>	—	115 to 320	63	200	35	220	R8486, R10824
○	350U(S-5)	Sb-Cs	UV	40	185 to 650	48	340	20	280	R6350
○	452U	Bialkali	UV	120	185 to 750	90	420	30	260	R3788, R6352
	453K	Bialkali	Borosilicate	60	300 to 650	60	400	20	370	R11558
	453U	Bialkali	UV	60	185 to 650	60	400	23	330	R11568
○	456U	Low noise Bialkali	UV	60	185 to 680	60	400	19	300	R1527, R4220, R5983, R6353, R7518
	550U	Multialkali	UV	150	185 to 850	45	530	15	250	R6355
	552U	Multialkali	UV	200	185 to 900	68	400	26	260	R2949
○	555U	Multialkali	UV	525	185 to 900	90	450	30	260	R3896, R9110, R9220
	556U	Multialkali	UV	200	185 to 850	80	430	27	280	R4632
	557U	Multialkali	UV	650	185 to 900	109	450	35	260	R10699
	561U	Multialkali	UV	200	185 to 830	70	530	24	250	R6358
○	562U	Multialkali	UV	300	185 to 900	76	400	26	260	R928, R5984
○	563U	Multialkali	UV	280	185 to 980	74	400	25	260	R13456
○	650U	GaAs	UV	550	185 to 930	62	300 to 800	23	300	R636-10
○	650S	GaAs	Silica	550	160 to 930	62	300 to 800	23	300	R943-02
○	850U	InGaAs	UV	100	185 to 1010	40	400	14	330	R2658
	851K	InGaAs	Borosilicate	150	300 to 1040	50	400	16	370	R3310-02*
○	950K	InP/InGaAsP(Cs)	Borosilicate	—	300 to 1400	21	1300	2	1000 to 1300	R5509-43*
○	951K	InP/InGaAs(Cs)	Borosilicate	—	300 to 1700	24	1500	2	1000 to 1500	R5509-73*

\* : Spectral response characteristics vary from tube to tube, so the above values may differ from actual data.

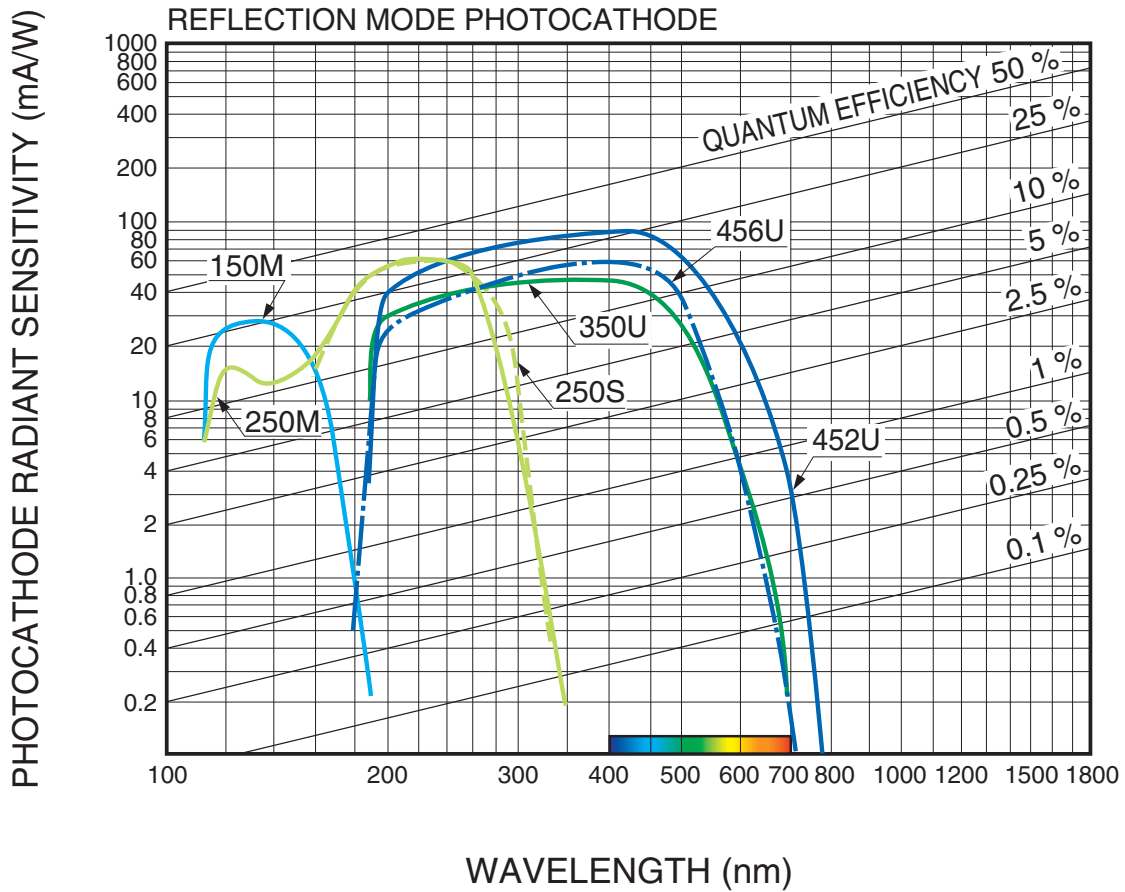
○ : Spectral response curves are shown on page 128, 129

\* : Products marked are not listed in this catalog.

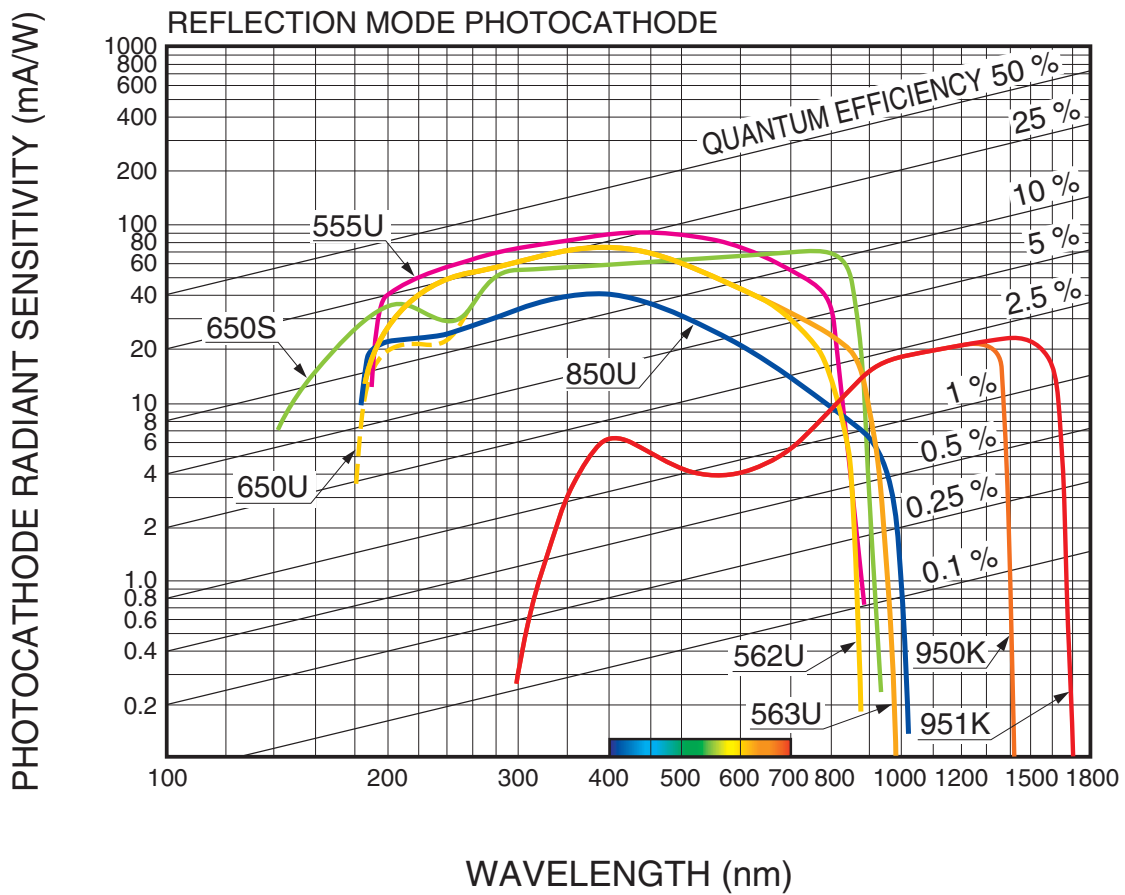
# SEMITRANSSPARENT PHOTOCATHODE SPECTRAL RESPONSE CHARACTERISTICS



# OPAQUE PHOTOCATHODE SPECTRAL RESPONSE CHARACTERISTICS



TPMOB0079EH



TPMOB0080EK

## Notes

**A** Types marked \* are newly listed in this catalog.

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

**C** Photocathode materials

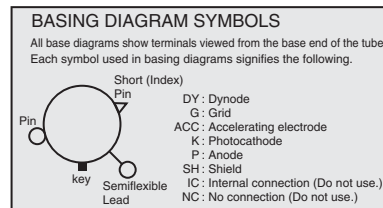
BA :	Bialkali
LBA :	Low noise bialkali
HBA :	High temperature bialkali
SBA :	Super bialkali
UBA :	Ultra bialkali
EGBA :	Extended green bialkali
MA :	Multialkali
ERMA :	Extended red multialkali
DIA :	Diamond

Other photocathodes are indicated by the element symbols.

**D** Window materials

MF :	MgF <sub>2</sub>
Q :	Quartz (silica)
K :	Borosilicate glass
U :	UV glass

**E** Base diagram



**F** Dynode structure

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

**G** See page 88, 89 for suitable socket assemblies.

See page 72, 73 for suitable sockets E678 series.

\*: A socket will be supplied with the tube.

No mark: Sockets may be obtained from electronics supply houses or our sales office.

**H** Operating ambient temperature range for the photomultiplier itself is -30 °C to +50 °C except for some types of tubes.

However, when photomultiplier tubes are operated below -30 °C at their base section, please consult us in advance.

**J** Averaged over any interval of 30 seconds maximum.

**K** Measured at the peak sensitivity wavelength.

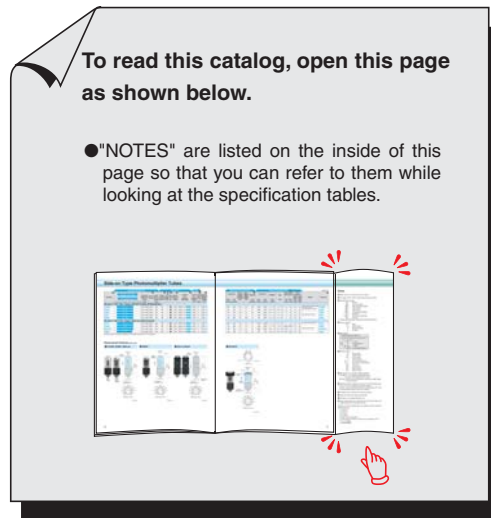
**L** See page 70 for voltage distribution ratio.

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

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

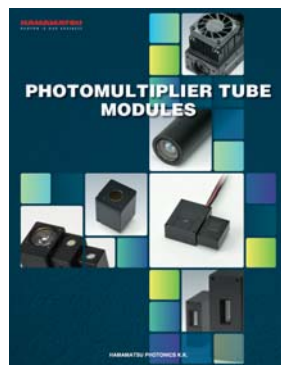
- a at 122 nm
- b at 254 nm
- c at 4 A/lm
- d at 10 A/lm
- e Dark count per second (s<sup>-1</sup>)
- f Dark count per second (s<sup>-1</sup>) after one hour storage at -20 °C
- g at 1 × 10<sup>6</sup> gain
- h Under peltier device operation

# How to use this folding page



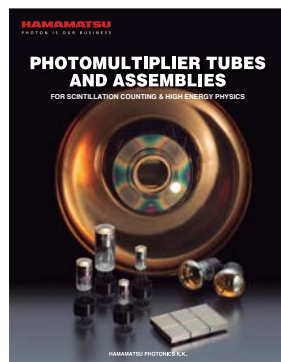
## Related product catalogs

### Photomultiplier tube modules



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

### Photomultiplier tubes and assemblies for Scintillation counting & High energy physics



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

## Main Products

### Opto-semiconductors

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

### 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

### 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

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Please thoroughly read the precautions and the prohibited uses included in the user manual before installation and use.

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