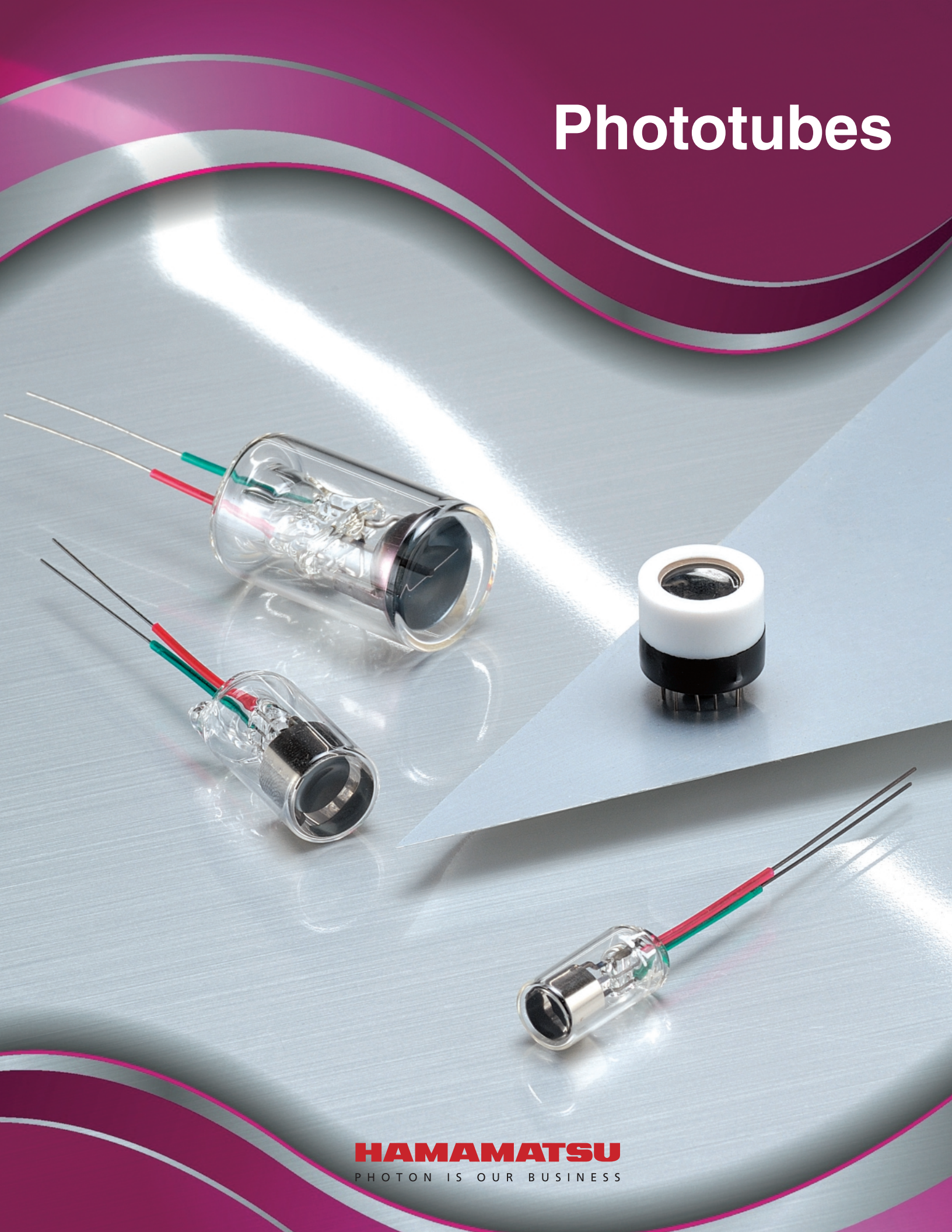
Phototubes



HAMAMATSU

PHOTON IS OUR BUSINESS

■FEATURES AND APPLICATIONS

FEATURES

High sensitivity and high stability	High sensitivity and high stability make phototubes very useful in chemical and medical analytical instruments which require high reliability.
Wide dynamic range	Phototubes feature a wide dynamic range from several picoamperes to several microamperes, providing signal output with excellent linearity.
Superior temperature stability	Phototubes show virtually no fluctuation with changes in the ambient temperature.
Large photosensitive area	Compared to semiconductor sensors, phototubes offer larger photosensitive area.
Low voltage operation	Phototubes are designed to operate at a low voltage.

SPECTRAL RESPONSE RANGE AND APPLICATIONS

Spectral Range	Photocathode	Window Material	Spectral Response		Typical Applications	Applicable Phototube Type No.
Spectral response in vacuum UV region only	Cs-I	MgF_2	115 nm to 200 nm	①	Vacuum UV spectrophotometer	R1187
		Quartz	160 nm to 200 nm	②		R5764
Vacuum UV region only	Diamond	MgF_2	115 nm to 220 nm	③	172 nm monitor for excimer lamp	R6800U-26
		Quartz	160 nm to 220 nm	④	185 nm monitor for sterilizing mercury lamp	R6800U-16
Solar blind spectral response	Au (single metal)	Quartz	160 nm to 240 nm	⑤	185 nm monitor for sterilizing mercury lamp	R4044
	Cs-Te	Quartz	160 nm to 350 nm	⑥	Monitor for 185 nm, 254 nm mercury line spectrum	R765, R6800U-11
		UV glass	185 nm to 350 nm	⑦	Ozone monitor	R1107, R1228, R6800U-01
Wide spectral response from UV to infrared	Sb-Cs	UV glass	185 nm to 650 nm	⑧	Spectrophotometer	R840, R727
		Borosilicate	300 nm to 650 nm	⑨	Blood analyzer	R414

■GLOSSARY OF TERMS

●Spectral response characteristic:
When light (photons) enters the photocathode, it is converted into electrons emitting from the photocathode at a certain ratio. This ratio depends on the wavelength of incident light. The relationship between the ratio and the wavelength is called spectral response characteristic.

●Peak wavelength:
The wavelength gives the maximum sensitivity to the photocathode. In this catalog, the peak wavelength for radiant sensitivity (A/W) is listed.

●Absolute maximum ratings:
The limiting values of the operating and environmental conditions applied to a phototube. Any conditions shall not exceed these ratings even instantaneously.

●Anode supply voltage:
The voltage applied across the anode and the cathode. Normally, the cathode is used at ground potential, so the anode supply voltage equals the potential difference between the anode and ground.

●Peak cathode current:
The peak current that can be allowed from the cathode when it is of pulse waveform.

●Average cathode current:
The average current that can be allowed from the cathode. Normally, it is the average for 30 seconds.

●Average cathode current density:
The average cathode current per unit surface area on the photocathode.

●Luminous sensitivity:
The ratio of photocurrent in amperes (A) flowing in the photocathode to the incident luminous flux in lumens (lm).

$$\text{Luminous sensitivity (A/lm)} = \frac{\text{Current (A)}}{\text{Luminous flux (lm)}}$$

●Radiant sensitivity:
The ratio of photocurrent in amperes (A) flowing in the photocathode to the intensity of the incident light in watts (W).

$$\text{Radiant sensitivity (A/W)} = \frac{\text{Current (A)}}{\text{Light intensity (W)}}$$

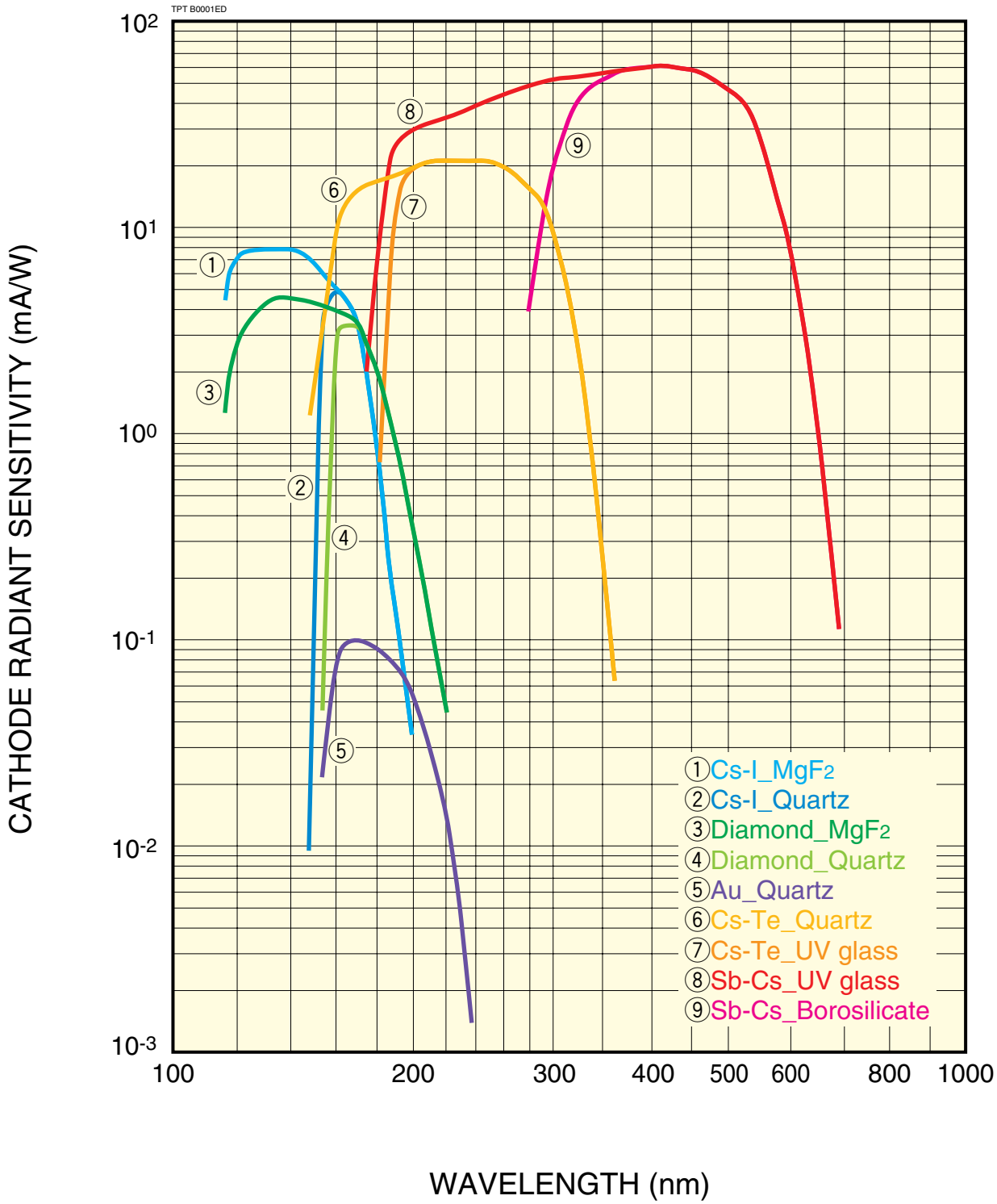
●Dark Current:
The current flowing between the anode and the cathode when light is removed.

●Interelectrode capacitance:
The electrostatic capacitance between the anode and the cathode.

●Recommended operating voltage:
The lifetime of a phototube tends to become shortened as the supply voltage increases. The supply voltage should be made as low as possible as compared to the maximum ratings, in order to lengthen useful life. However, if the supply voltage is too low, the voltagecurrent characteristics fall outside the saturation region, and undersirable phenomena such as hysteresis (Note 1) may occur. Considering these effects, the recommended operating voltage for each type of phototube is listed in this catalog.

(Note 1) Hysteresis: The temporary instability in output signal when light is applied to a phototube, showing "overshoot" or "undershoot" without being proportional to light input.

■SPECTRAL RESPONSE CHARACTERISTICS



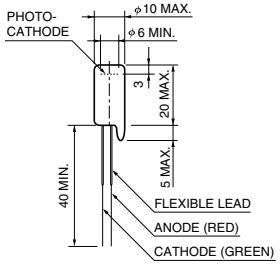
■CHARACTERISTICS

Type No.	Spectral Response Ⓐ (nm)	Peak Wave-length (nm)	Outline Diagram No.	Tube Diameter (nm)	Photocathode Area Min. (mm)	Input Window Material	Absolute Maximum Ratings: Anode Supply Voltage (V)	Peak Cathode Current (μA)	Average Cathode Current Density (μA/cm²)	Average Cathode Current Ⓑ (μA)	Ambient Temperature Ⓒ (°C)
●GLASS BULB TYPE											
For Vacuum UV (Cs-I Photocathode)											
R1187	115 to 200	130	❸	φ15	φ8	MgF_2	100	1	0.5	0.1	-80 to +50
R5764	160 to 200	161	❸	φ15	φ8	Quartz	100	1	0.5	0.1	-80 to +50
For UV / High Power (Au Single Metal Photocathode)											
R4044	160 to 240	185	❸	φ15	φ8	Quartz	100	1.2	5	0.4	-80 to +50
For UV / General Purpose (Cs-Te Photocathode)											
R1107	185 to 350	240	❶	φ10	φ6	UV glass	100	0.5	5	0.15	-80 to +50
R765	160 to 350	240	❷	φ15	φ8	Quartz	100	1.2	5	0.4	-80 to +50
R1228	185 to 350	240	❷	φ15	φ8	UV glass	100	1.2	5	0.4	-80 to +50
For UV to Visible (Sb-Cs Photocathode)											
R414	300 to 650	400	❶	φ10	φ6	Borosilicate glass	100	1	5	0.3	-80 to +50
R840	185 to 650	340	❷	φ15	φ8	UV glass	100	2	5	0.5	-80 to +50
R727	185 to 650	340	❹	φ20	φ15	UV glass	100	6	5	2	-80 to +50
●METAL PACKAGE TYPE											
For Vacuum UV (Diamond Photocathode)											
R6800U-26	115 to 220	135	❺	φ16	φ6	MgF_2	30	1.2	5	0.4	-80 to +50
R6800U-16	160 to 220	161	❺	φ16	φ6	Quartz	30	10	50	4	-80 to +50
For UV / General Purpose (Cs-Te Photocathode)											
R6800U-11	160 to 350	240	❻	φ16	φ8	Quartz	30	1.2	5	0.4	-80 to +50
R6800U-01	185 to 350	240	❼	φ16	φ8	UV glass	30	1.2	5	0.4	-80 to +50

NOTE: ⒶSee spectral response characteristics on page 2. ⒷOutput current averaged over 1 second time interval. The whole photocathode is uniformly illuminated. ⒸWhen a tube is operated below -35 °C see page 6, "Caution".

■DIMENSIONAL OUTLINES (Unit: mm)

❶ R414, R1107



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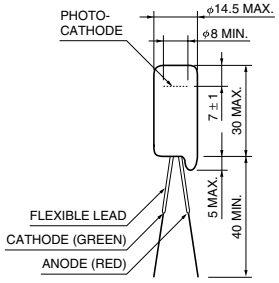
❷ R765, R1228, R840



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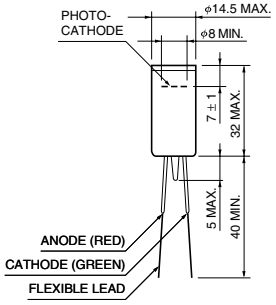
❸ R5764, R4044, R1187



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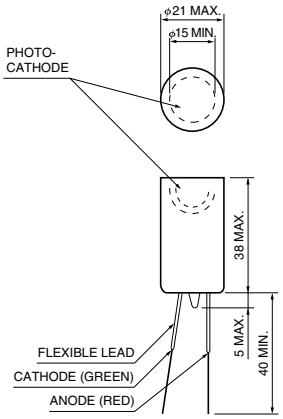
❹ R727



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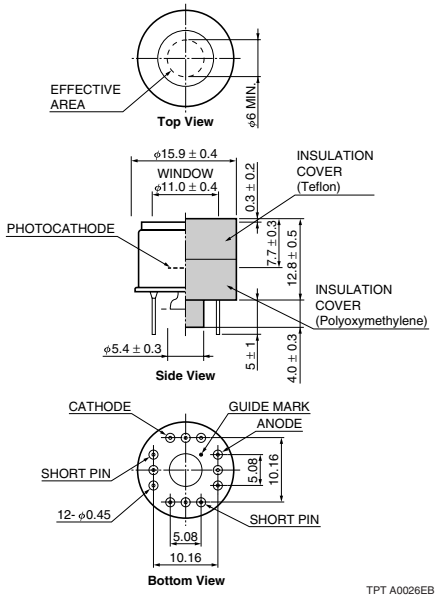
Characteristics at 25 °C										Type No.
Luminous Sensitivity Ⓓ		Radiant Sensitivity						Dark Current	Recommended Operating Voltage	Interelectrode Capacitance	
		122 nm		254 nm		Pt Peak Ⓔ					
Typ. (μA/lm)	Min. (μA/lm)	Typ. (mA/W)	Min. (mA/W)	Typ. (mA/W)	Min. (mA/W)	Typ. (mA/W)	Min. (mA/W)	Max. (pA)	(V)	(pF)	
—		8	2	—		—		2	15	2.4	R1187
—		—		—		5	1	2	15	2.4	R5764
—		—		—		0.1	0.02	1	15	2.4	R4044
—		—		15	10	—		2	15	2.0	R1107
—		—		20	10	—		1	15	2.4	R765
—		—		20	10	—		1	15	2.4	R1228
80	40	—		—		—		5	15	2.0	R414
80	40	—		—		—		2	15	2.4	R840
110	40	—		—		—		2	15	2.0	R727
—		3	1	—		—		1	15	3	R6800U-26
—		—		—		3	1	1	15	3	R6800U-16
—		—		20	10	—		1	15	3	R6800U-11
—		—		20	10	—		1	15	3	R6800U-01

ⒹThe photocurrent 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. ⒺSee peak wavelength.

❺ R6800U-16, -26



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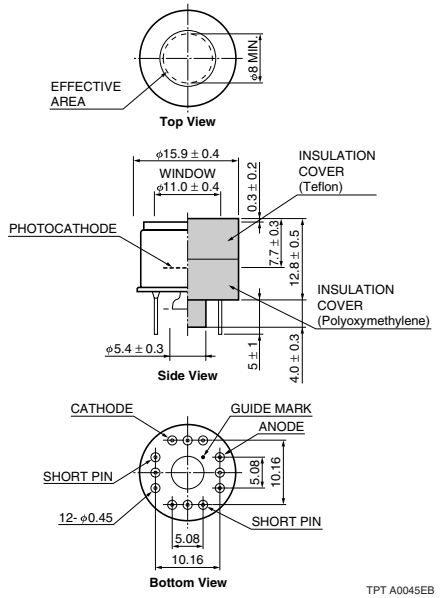
❻ R6800U-11



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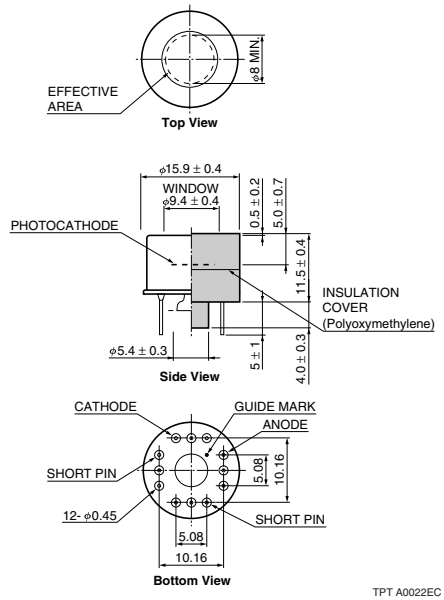
❼ R6800U-01



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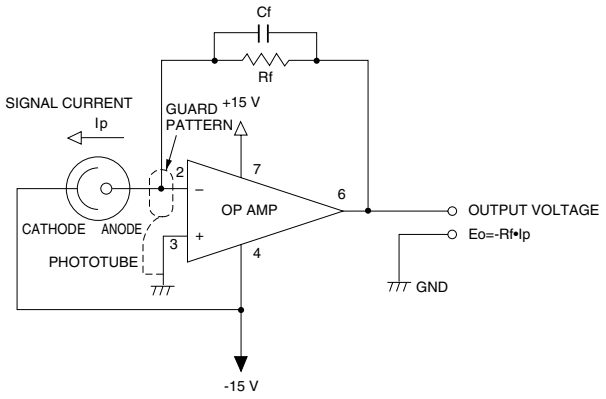
NOTE: Don't use pins excepting ANODE and CATHODE pins.

■EXAMPLE OF OPERATING CIRCUITS

OPERATING CIRCUITS FOR PHOTOTUBES

Figure 1 shows an operating circuit example using the phototube bias voltage also for the power to an operational amplifier. The feedback resistance Rf should be chosen so that the output voltage becomes 0.1 V to 1 V. Cf must be placed for stable operation and should be between 10 pF and 100 pF. It is recommended to use a low-bias, low-offset-current FET input operational amplifier. For the input terminal (pin 2), a guard pattern should be provided on the printed circuit board or a stand-off terminal made of Teflon should be used.

Figure 1: When Pulse / Minus Powers Are Available



(Inverting current-voltage conversion circuit)

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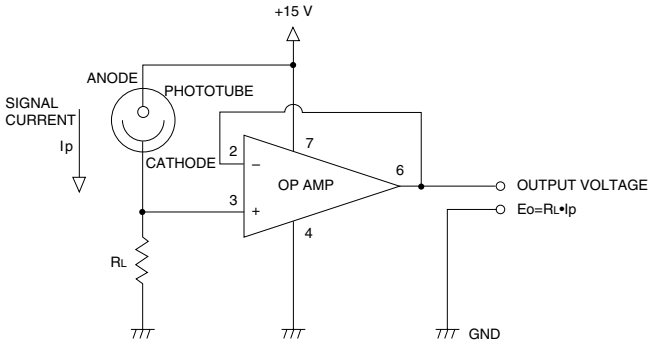
Figure 2 shows an operating circuit in which a low-impedance voltage is output from an operation amplifier after the signal current has been converted into a voltage through the road resistance RL. The operational amplifier should be a low-bias, low-offset-current type which can be operated on a single power.

Figure 2: Operating Circuit Operating on Signal Power



(Impedance conversion circuit)

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NOTE: The operational amplifiers that can be used in these circuits differ in such factors as operating temperature range, bias current, phase compensation, and offset adjustment method, depending on the type used. Please refer to the catalog or data sheet available from the manufacturer.
Sample circuits listed in this catalog introduce typical applications and do not cover any guarantee of the circuit design. No patent rights are granted to any of the circuits described herein.

■⚠CAUTIONS

● **Maximum ratings**
Always operate the phototube within the maximum rating listed in this catalog.

● **The light input surface area should be as large as possible**
The output current available from a phototube is determined by the maximum average cathode current and maximum average cathode current density. If the light input surface area is small, even if the output current is below the maximum average cathode current, the maximum average cathode current density may be exceeded. Therefore, the light input surface area should be as large as possible to decrease the cathode current per unit surface area. This is important also, from the standpoint of photocathode uniformity (i.e., variation in sensitivity with respect to incident light position).

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

● **Avoid mechanical vibration**
Mechanical vibration can cause microphonic noise (sensitivity fluctuation caused by vibration of the electrode.) and variation in sensitivity caused by displacement of the incident light position.

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

● **Avoid direct sunlight and other high-intensity light**
Avoid subjecting the phototube to direct sunlight or other high-intensity light, as this can adversely affect the photocathode, causing not only loss of sensitivity but instability as well.

● **Handling of tubes with a glass base**
A glass base (also called button stem) is weak, so care should be taken in handling this type of tube.

● **Cooling of tubes**
When cooling a phototube, the photocathode section is usually cooled. However, if you suppose that the base is also cooled down to -35 °C or below, please consult our sales office in advance.

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

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

■WARRANTY

In general, Hamamatsu products listed in this catalog are warranted for a period of one year from time of delivery. This warranty is limited to replacement for the defective product. Note, however, that this warranty will not apply to failures caused by natural calamity or misuse.

■CE MARKING

This catalog contains products which are subject to CE Marking of European Union Directives. For further details, please consult Hamamatsu sales offices.

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