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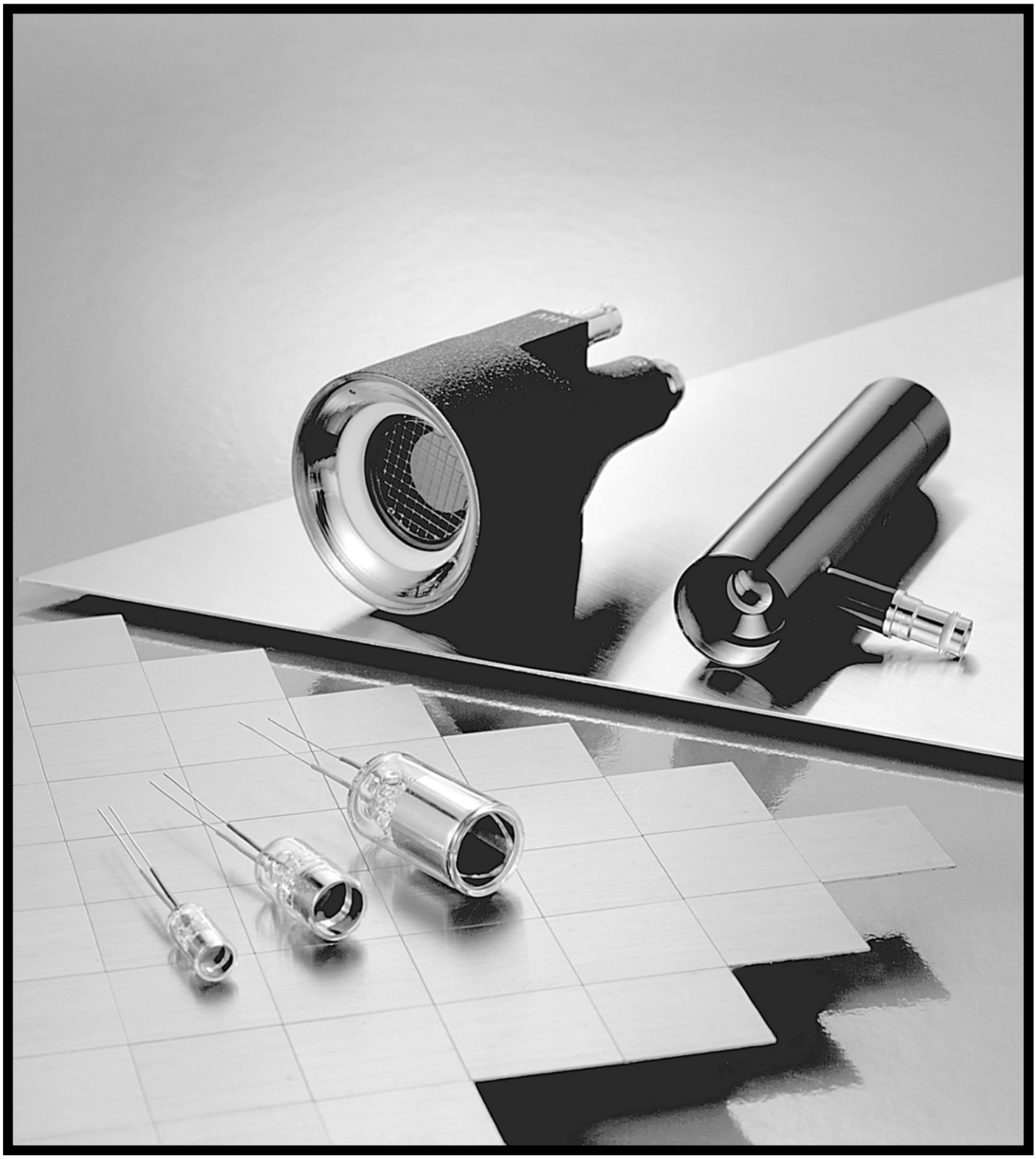
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Phototubes

Phototubes, Solar Blind Phototubes and Biplanar Phototubes



HAMAMATSU

FEATURES AND APPLICATIONS

■FEATURES AND APPLICATIONS OF PHOTOTUBES

FEATURES

High-speed response	In particular, biplanar phototubes achieve rise times as fast as 60 ps.
Choice of spectral response	As figure on right shows, phototubes offer a variety of spectral response characteristics, ranging from the vacuum UV (115 nm) to infrared (1100 nm) regions. Even a wide spectral response (from near UV to near infrared) can be covered by a single tube. The users can choose optimum tubes with photocathodes suitable for their application.
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.

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 crystal	115 nm to 200 nm	①	Vacuum UV spectrophotometer	R1187
		Quartz glass	160 nm to 200 nm	②		R5764
Solar blind spectral response	Au (single metal)	Quartz glass	160 nm to 240 nm	③	185 nm monitor for sterilizing mercury lamp	R4044
	Cs-Te	MgF_2 crystal	115 nm to 320 nm	④	Vacuum UV laser detection (biplanar phototube)	R1193U-54, R1328U-54
		Quartz glass	160 nm to 320 nm	⑤	Monitor for 254 nm mercury line spectrum	R765
		UV glass	185 nm to 320 nm	⑥	Ozone monitor	R1107, R1228, R1384
Near UV spectral response	Ag (single metal)	UV glass	180 nm to 350 nm	⑦	Excimer laser detection (193 nm, 248 nm, 308 nm)	R1193U-55
Wide spectral response from UV to infrared	Sb-Cs	UV glass	185 nm to 650 nm	⑧	Spectrophotometer	R840, R491, R727, 935,
		Borosilicate	300 nm to 650 nm	⑨	Blood analyzer	R1193U-52, R1328U-52
					Liquid chromatography	R414, PV16
	Multialkali (Na-K-Sb-Cs)	UV glass	185 nm to 850 nm	⑩	Pollution monitor	R518, R645,
		Borosilicate	300 nm to 850 nm	⑪	Colorimeter	R1193U-53, R1328U-53
	Ag-O-Cs	Borosilicate	300 nm to 1100 nm	⑫	Laser detection (biplanar phototube)	PV11, R1193U-51, R1328U-51

■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).

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

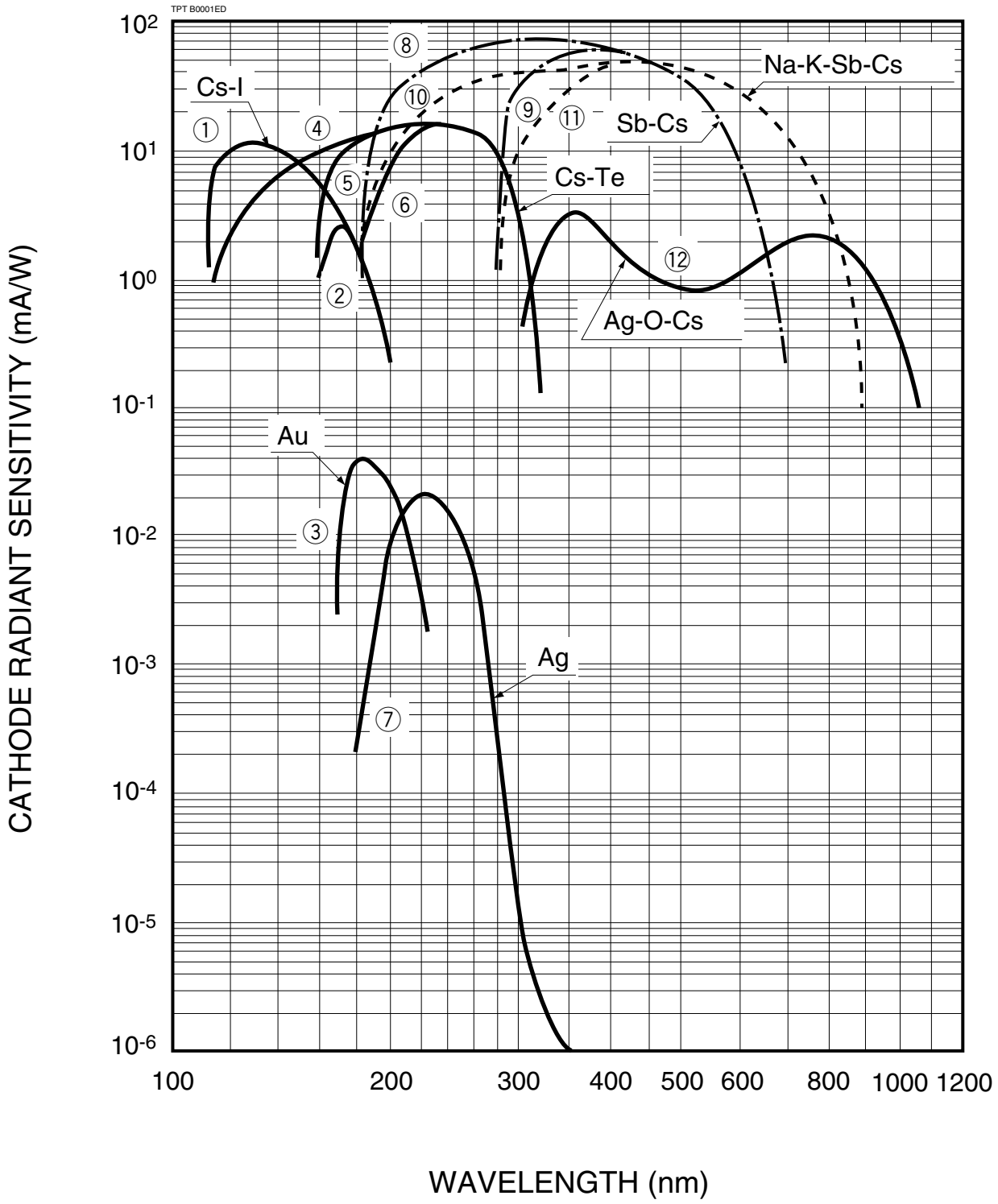
●Dark Current:
The current flowing between the anode and the cathode when light is removed.

●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 and Basing 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)
HEAD-ON TYPE											
For Vacuum UV (Cs-I Photocathode)											
R1187	115 to 200	130	❸	φ15	φ8	MgF_2 crystal	100	1	0.5	0.1	-80 to +50
R5764	160 to 200	165	❸	φ15	φ8	Quartz glass	100	2	0.5	0.1	-80 to +50
For UV / High Power (Au Single Metal Photocathode)											
R4044	160 to 240	185	❸	φ15	φ8	Quartz glass	100	1	0.05	0.1	-80 to +50
For UV / General Purpose (Cs-Te Photocathode)											
R1107	185 to 320	240	❶	φ10	φ6	UV glass	100	0.5	5	0.15	-80 to +50
R765	160 to 320	240	❷	φ15	φ8	Quartz glass	100	1.2	5	0.4	-80 to +50
R1228	185 to 320	240	❷	φ15	φ8	UV glass	100	1.2	5	0.4	-80 to +50
R1384	185 to 320	240	❹	φ20	φ13	UV glass	100	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	❺	φ20	φ15	UV glass	100	6	5	2	-80 to +50
For UV to Near IR (Na-K-Sb-Cs Multialkali Photocathode)											
R645	185 to 850	420	❻	φ20	φ15	UV glass	100	1	0.5	0.25	-80 to +50
SIDE-ON TYPE											
For UV to Visible (Sb-Cs Photocathode)											
PV16 (01)	300 to 650	400	❽	φ18	10 × 15	Borosilicate glass	250	6	5	2	-80 to +50
R491	185 to 650	340	❼	φ18	10 × 15	UV glass	250	6	5	2	-80 to +50
935	185 to 650	340	❾	φ30	15 × 33	UV glass	250	30	5	10	-80 to +50
For UV to Near IR (Na-K-Sb-Cs Multialkali Photocathode)											
R518	185 to 850	400	❼	φ18	10 × 15	UV glass	250	2	1	0.5	-80 to +50
For Visible to Near IR (Ag-O-Cs Photocathode)											
PV11	300 to 1100	730	❼	φ18	10 × 15	Borosilicate glass	250	6	5	2	-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 10, "Caution".

Ⓓ 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.

Ⓔ At recommended operating voltage.

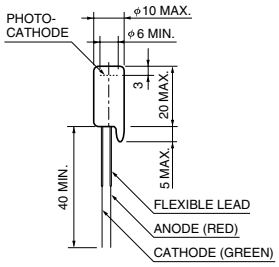
☐...Recommended Type

Characteristics at 25 °C							Type No.
Ⓓ Luminous Sensitivity Typ. (μA/lm)	Radiant Sensitivity Typ. 122 nm (mA/W)	254 nm (mA/W)	Pt Peak (mA/W)	Ⓔ Dark Current Max. (pA)	Recommended Operating Voltage (V)	Interelectrode Capacitance (pF)	
—	10	—	12	2	15	2.4	R1187
—	—	—	3	2	15	2.4	R5764
—	—	—	0.04	1	15	2.4	R4044
—	—	15	18	2	15	2.0	R1107
—	—	20	23	1	15	2.4	R765
—	—	20	23	1	15	2.4	R1228
—	—	15	18	1	15	2.0	R1384
50	—	—	47	10	15	2.0	R414
80	—	—	51	2	15	2.4	R840
110	—	—	70	2	15	2.0	R727
150	—	—	50	1	15	3.0	R645
80	—	—	51	10	40	1.6	PV16 (01)
80	—	—	59	50	40	1.0	R491
80	—	—	59	10	50	2.1	935
80	—	—	40	50	40	1.0	R518
25	—	—	2	100	40	1.1	PV11

■PHOTOTUBE DIMENSIONAL OUTLINES

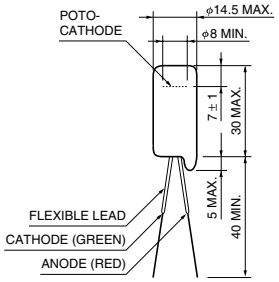
(Unit: mm)

❶ R414, R1107



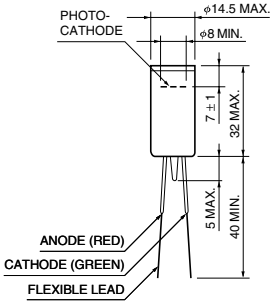
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❷ R765, R1228, R840



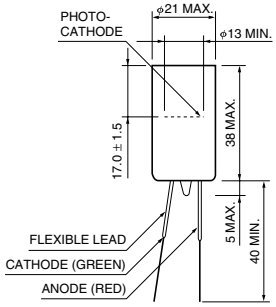
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❸ R5764, R4044, R1187



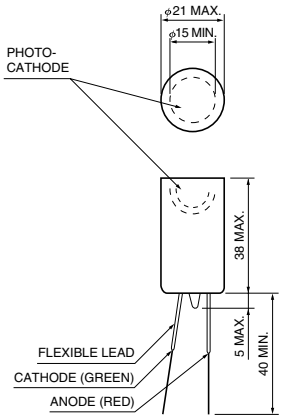
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❹ R1384



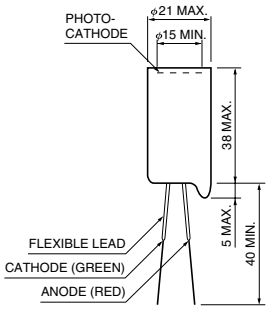
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❺ R727



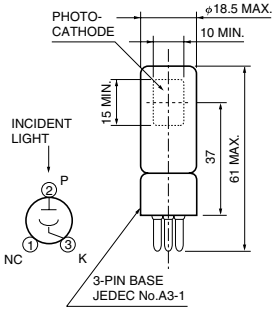
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❻ R645



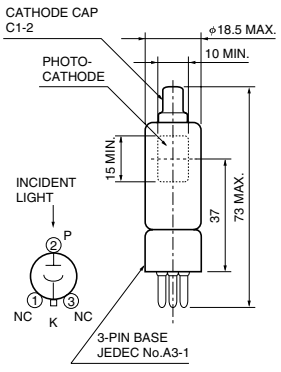
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❼ PV11, R491,R518



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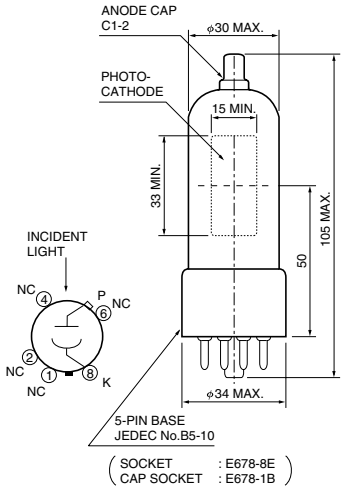
❽ PV16 (01)



(CAP SOCKET: E678-1B)

TPT A0005EB

❾ 935



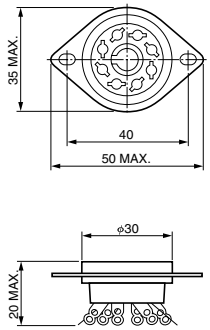
(SOCKET : E678-8E
CAP SOCKET : E678-1B)

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■SOCKET DIMENSIONAL OUTLINES

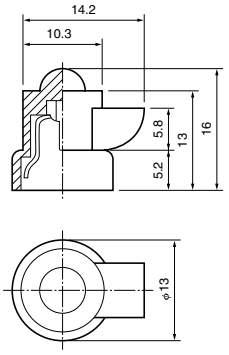
(Unit: mm)

Ⓐ Socket: E678-8E (For B5-10 Base)



TPT A0031EA

Ⓑ Socket: E678-1B (For Cathode Cap C1-2)



TACCA0065EA

BIPLANAR PHOTOTUBES

■ULTRA-FAST PHOTODETECTORS / BIPLANAR PHOTOTUBES

Recently, the use of high-power light sources producing ultra-short light pulses such as lasers has spread in a variety of fields. With this trend, the demand is increasing for ultra-fast photodetectors that can precisely reproduce ultra-fast pulses. The Hamamatsu biplanar phototubes are ultra-fast photodetectors that can satisfy such requirements. Various types of photocathodes are available so that they can be chosen for applications in wide spectral ranges from vacuum UV to infrared.

FEATURES

●Ultra-fast time response
●Excellent linearity with respect to high-power light
●High current operation
●Easily interfaceable with external circuits
●Virtually no ringing

APPLICATIONS

●Laser pulse observation
●Trigger for laser, streak camera, etc.
●Optical heterodyne detection

Type No.	Spectral Response	Peak Wave-length	Photocathode Material	Absolute Maximum Ratings					Characteristics at 25 °C				
				Anode Supply Voltage	Peak Cathode Current Density	Input Light Energy Density	Average Cathode Current	Ambient Tem-perature	Anode Supply Voltage	Luminous Sensitivity	Dark Current	Rise Time	Fall Time
										Typ.	Max.	Typ.	Typ.
	(nm)	(nm)		(V)	(A)	(W/mm^2)	(μA)	(°C)	(V)	(μA/lm)	(nA)	(ps)	(ps)
R1193U Series (Rise Time: 270 ps)													
R1193U-51	300 to 1100	750	Ag-O-Cs	2500	1	0.125	50	+75	2500	20	50	270	100
R1193U-52	185 to 650	340	Sb-Cs	2500	1	0.125	50	+75	2500	50	50	270	100
R1193U-53	300 to 850	400	Na-K-Sb-Cs	2500	1	0.125	50	+75	2500	80	50	270	100
R1193U-54	115 to 320	200	Cs-Te	2500	1	0.125	50	+75	2500	15 mA/W (254 nm)	50	270	100
R1193U-55	180 to 350	220	Ag	2500	2	1×10^2 (248 nm)	10	+75	2500	15 μA/W (248 nm)	50	270	130
R1328U Series (Rise Time: 60 ps)													
R1328U-51	300 to 1100	750	Ag-O-Cs	2000	0.3	0.125	5	+75	2000	20	100	60	55
R1328U-52	185 to 650	340	Sb-Cs	2000	0.3	0.125	5	+75	2000	50	100	60	55
R1328U-53	300 to 850	400	Na-K-Sb-Cs	2000	0.3	0.125	5	+75	2000	80	100	60	55
R1328U-54	115 to 320	200	Cs-Te	2000	0.3	0.125	5	+75	2000	15 mA/W (254 nm)	100	60	55

* For the R1328U-54 used in the vacuum UV region, a vacuum flange type is available. Consult our sales office.

●R1193U Series

The R1193U series biplanar phototubes have a large effective area and a fast time response of 270 ps rise time and 100 ps fall time. The R1193U-55 is specifically developed for direct measurement of high energy light such as excimer lasers. Its large sensitive area can detect all of the incident laser pulse, making relative comparison of light output more reliable.

●R1328U Series

The R1328U series biplanar phototubes offer a very fast time response of 60 ps rise time and 55 ps fall time. They also feature excellent impedance matching, thus reproducing precise waveform with no ringing.

●C3463-50 Power Supply for Biplanar Phototubes

A high-voltage power supply is required to operate a biplanar phototube. Hamamatsu provides the C3463-50 high-voltage power supply exclusively designed for biplanar phototubes. (A high voltage cable is supplied with the C3463-50.)

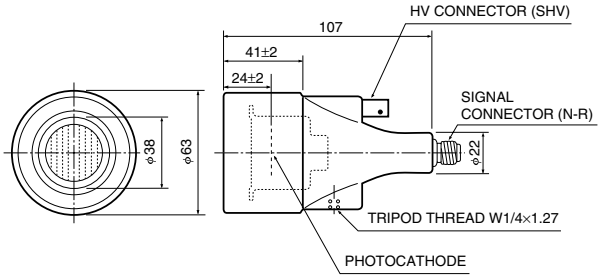
●E3331 Neutral Density Filter for R1193U-55

For measurement of ArF and KrF excimer lasers, Hamamatsu provides a dedicated neutral density filter. This filter can be easily fitted to the R1193U-55, allowing direct input of high-power light pulse.

■DIMENSIONAL OUTLINES (Unit: mm)

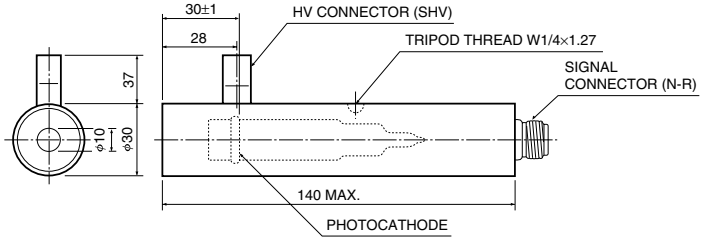
●Biplanar Phototubes

R1193U series



TPT A0017EB

R1328U series

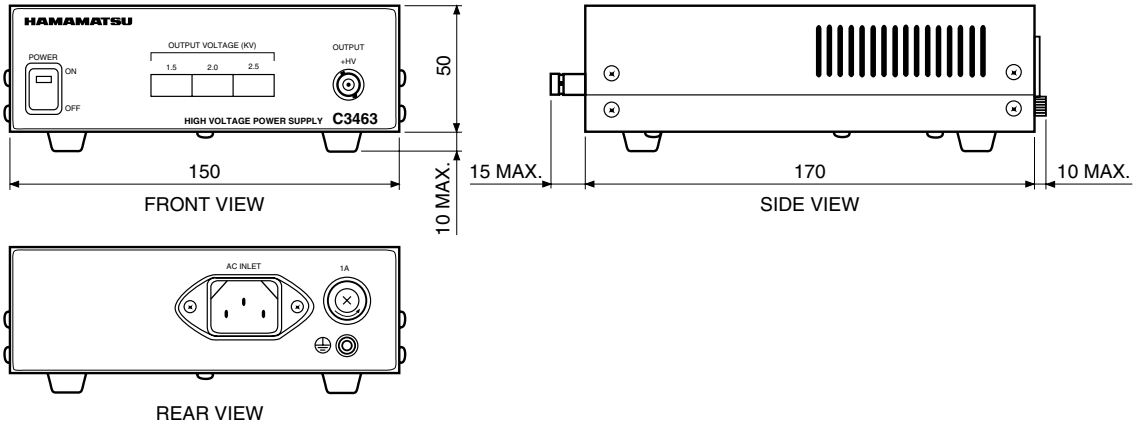


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Photocathode Diameter and Area

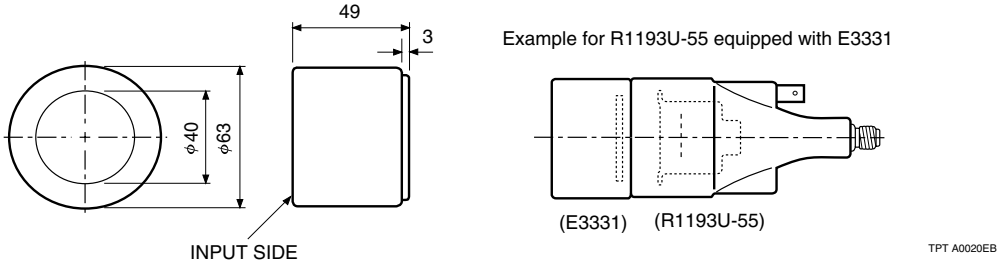
Type No.	Photocathode Diameter (mm)	Photocathode Area (mm^2)
R1193U-51 to -54	φ20	314
R1193U-55	φ29	660
R1328U series	φ10	78.5

●C3463-50 High-Voltage Power Supply for Biplanar Phototubes



TPT A0019EB

●E3331 Neutral Density Filter for R1193U-55



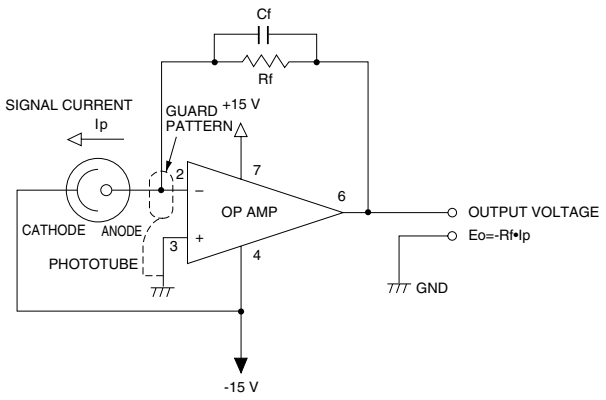
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EXAMPLE OF OPERATING CIRCUITS

■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

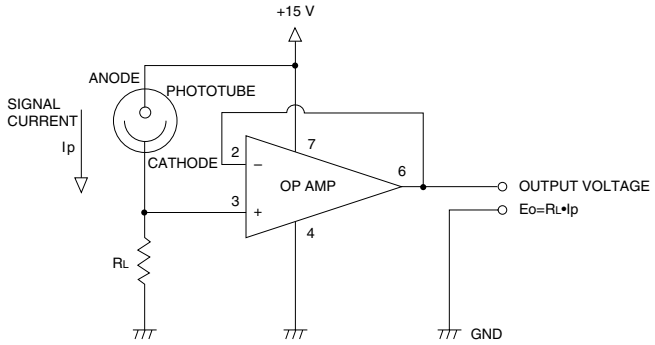


(Inverting current-voltage conversion circuit)
OP amp: AD549 (Analog Devices)
OPA128 (Burr-Brown)

TPT C0001EB

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)
OP amp: ICL7611 (IN TERSIL)
TLC271 (Texas Instruments)
TLC1078 (Texas Instruments) etc.

TPT C0002EB

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 AND WARRANTY

⚠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 less rugged than a plastic base, 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.

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

U.S.A.: Hamamatsu Corporation: 360 Foothill Road, P. O. Box 6910, Bridgewater. N.J. 08807-0910, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218 E-mail: usa@hamamatsu.com
Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-2658 E-mail: info@hamamatsu.de
France: Hamamatsu Photonics France S.A.R.L.: 8, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10 E-mail: infos@hamamatsu.fr
United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road Welwyn Garden City Hertfordshire AL7 1BW, United Kingdom, Telephone: 44-(0)1707-294888, Fax: 44(0)1707-325777 E-mail: info@hamamatsu.co.uk
North Europe: Hamamatsu Photonics Norden AB: Smidesvägen 12, SE-171-41 SOLNA, Sweden, Telephone: (46)8-509-031-00, Fax: (46)8-509-031-01 E-mail: info@hamamatsu.se
Italy: Hamamatsu Photonics Italia: S.R.L.: Strada della Moia, 1/E, 20020 Arese, (Milano), Italy, Telephone: (39)02-935 81 733, Fax: (39)02-935 81 741 E-mail: info@hamamatsu.it

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