## FEATURES AND APPLICATIONS

### FEATURES

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

### SPECTRAL RESPONSE RANGE AND APPLICATIONS

<table>
<thead>
<tr>
<th>Spectral Range</th>
<th>Photocathode</th>
<th>Window Material</th>
<th>Spectral Response</th>
<th>Typical Applications</th>
<th>Applicable Phototube Type No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral response in vacuum UV region only</td>
<td>Cs-I</td>
<td>MgF₂</td>
<td>115 nm to 200 nm</td>
<td>Vacuum UV spectrophotometer</td>
<td>R1187</td>
</tr>
<tr>
<td></td>
<td>Quartz</td>
<td>160 nm to 200 nm</td>
<td></td>
<td></td>
<td>R5764</td>
</tr>
<tr>
<td>Vacuum UV region only</td>
<td>Diamond</td>
<td>MgF₂</td>
<td>115 nm to 220 nm</td>
<td>172 nm monitor for excimer lamp</td>
<td>R6800U-26</td>
</tr>
<tr>
<td></td>
<td>Quartz</td>
<td>160 nm to 220 nm</td>
<td></td>
<td>185 nm monitor for sterilizing mercury lamp</td>
<td>R6800U-16</td>
</tr>
<tr>
<td>Solar blind spectral response</td>
<td>Au (single metal)</td>
<td>Quartz</td>
<td>160 nm to 240 nm</td>
<td>185 nm monitor for sterilizing mercury lamp</td>
<td>R4044</td>
</tr>
<tr>
<td></td>
<td>Cs-Te</td>
<td>Quartz</td>
<td>160 nm to 350 nm</td>
<td>Monitor for 185 nm, 254 nm mercury line spectrum</td>
<td>R765, R6800U-11</td>
</tr>
<tr>
<td></td>
<td>UV glass</td>
<td>Quartz</td>
<td>185 nm to 350 nm</td>
<td>Ozone monitor</td>
<td>R1107, R1228, R6800U-01</td>
</tr>
<tr>
<td>Wide spectral response from UV to infrared</td>
<td>Sb-Cs</td>
<td>UV glass</td>
<td>185 nm to 650 nm</td>
<td>Spectrophotometer</td>
<td>R840, R727</td>
</tr>
<tr>
<td></td>
<td>Borosilicate</td>
<td>300 nm to 650 nm</td>
<td></td>
<td>Blood analyzer</td>
<td>R414</td>
</tr>
</tbody>
</table>

### 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 in 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 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 undesirable 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

CATHODE RADIANT SENSITIVITY (mA/W)

WAVELENGTH (nm)

1. Cs-I_MgF₂
2. Cs-I_Quartz
3. Diamond_MgF₂
4. Diamond_Quartz
5. Au_Quartz
6. Cs-Te_Quartz
7. Cs-Te_UV glass
8. Sb-Cs_UV glass
9. Sb-Cs_Borosilicate

TPT 3001ED
## CHARACTERISTICS

<table>
<thead>
<tr>
<th>Type No.</th>
<th>Spectral Response (nm)</th>
<th>Peak Wave-length (nm)</th>
<th>Outline Diagram No.</th>
<th>Tube Diameter (mm)</th>
<th>Photocathode Area Min. (mm)</th>
<th>Input Window Material</th>
<th>Absolute Maximum Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Anode Supply Voltage (V)</td>
</tr>
<tr>
<td>R1187</td>
<td>115 to 200</td>
<td>130</td>
<td>①</td>
<td>15</td>
<td>8</td>
<td>MgF₂</td>
<td>100</td>
</tr>
<tr>
<td>R5764</td>
<td>160 to 200</td>
<td>161</td>
<td>①</td>
<td>15</td>
<td>8</td>
<td>Quartz</td>
<td>100</td>
</tr>
<tr>
<td>R1228</td>
<td>185 to 350</td>
<td>240</td>
<td>②</td>
<td>15</td>
<td>8</td>
<td>UV glass</td>
<td>100</td>
</tr>
<tr>
<td>R727</td>
<td>185 to 650</td>
<td>340</td>
<td>②</td>
<td>20</td>
<td>15</td>
<td>UV glass</td>
<td>100</td>
</tr>
</tbody>
</table>

### GLASS BULB TYPE

**For Vacuum UV (Cs-I Photocathode)**

- R1187
- R5764

**For UV / High Power (Au Single Metal Photocathode)**

- R4044

**For UV / General Purpose (Cs-Te Photocathode)**

- R1107
- R765
- R1228

**For UV to Visible (Sb-Cs Photocathode)**

- R414
- R840
- R727

### METAL PACKAGE TYPE

**For Vacuum UV (Diamond Photocathode)**

- R6800U-26
- R6800U-16

**For UV / General Purpose (Cs-Te Photocathode)**

- R6800U-11
- R6800U-01

**NOTE:**
- ①See spectral response characteristics on page 2.
- ②Output current averaged over 1 second time interval. The whole photocathode is uniformly illuminated.
- ③When a tube is operated below -35 °C see page 6, "Caution."

## DIMENSIONAL OUTLINES (Unit: mm)

<table>
<thead>
<tr>
<th>R414, R1107</th>
<th>R765, R1228, R840</th>
<th>R5764, R4044, R1187</th>
<th>R727</th>
</tr>
</thead>
</table>

### Diagrams

- Diagrams of different types of phototubes with specifications for each type.

---

PHOTOTUBES

---
## Characteristics at 25 °C

<table>
<thead>
<tr>
<th>Luminous Sensitivity</th>
<th>Radiant Sensitivity</th>
<th>Dark Current</th>
<th>Recommended Operating Voltage</th>
<th>Interelectrode Capacitance</th>
<th>Type No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typ. (µA/µm)</td>
<td>Typ. (mA/W)</td>
<td>Max. (pA)</td>
<td>(V)</td>
<td>(pF)</td>
<td></td>
</tr>
<tr>
<td>Min. (µA/µm)</td>
<td>Min. (mW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>122 nm</td>
<td>254 nm</td>
<td>2</td>
<td>15</td>
<td>2.4</td>
<td>R1187</td>
</tr>
<tr>
<td>Pt Peak</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>15</td>
<td>2.4</td>
<td>R5764</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R4044</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>15</td>
<td>2.4</td>
<td>R1107</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R765</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>15</td>
<td>2.4</td>
<td>R1228</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R414</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>15</td>
<td>2.4</td>
<td>R840</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R727</td>
</tr>
</tbody>
</table>

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.

### R6800U-16, -26

- **Effective Area**: 12 - 0.45
- **PHOTOCATHODE**: 5.4 ± 0.3
- **INSULATION COVER (Polyoxymethylene)**: 12.8 ± 0.5
- **GUIDE MARK ANODE**: 5.0 ± 1
- **WINDOW**: 11.0 ± 0.4

### R6800U-11

- **Effective Area**: 12 - 0.45
- **PHOTOCATHODE**: 5.4 ± 0.3
- **INSULATION COVER (Polyoxymethylene)**: 12.8 ± 0.5
- **GUIDE MARK ANODE**: 5.0 ± 1
- **WINDOW**: 11.0 ± 0.4

### R6800U-01

- **Effective Area**: 12 - 0.45
- **PHOTOCATHODE**: 5.4 ± 0.3
- **INSULATION COVER (Polyoxymethylene)**: 12.8 ± 0.5
- **GUIDE MARK ANODE**: 5.0 ± 1
- **WINDOW**: 11.0 ± 0.4

**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 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.

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 transmission 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.