TECHNICAL INFORMATION

How to Use UVTRON®

HAMAMATSU

The UVTRON is a sensor sensitive only to ultraviolet light with wavelengths shorter than 260 nm. Featuring high sensitivity high output, and high-speed response, the UVTRON is the ideal sensor for detecting flame and electrical discharge phenomena.

FEATURES

- Capable of detecting very weak ultraviolet light (down to 1 pW)
- Insensitive to visible and infrared light (solar blind characteristics)
- High reliability and long life (over 10,000 hours of continual discharge operation)
- High-speed response (less than a few milliseconds)
- Low current operation
- Miniature size and lightweight

APPLICATIONS

- Combustion monitors for gas/oil burner
- Fire alarms
- Arson surveillance sensors
- Flame detectors for gas/oil lighters and matches
- Detection of ultraviolet light leakage
- Detection of discharge phenomenon

Figure 1 shows typical spectral radiant intensity of a gas burner flame (city gas), tungsten lamp, and the sunlight on the earth's surface, along with UVTRON spectral response characteristics. As this figure shows, the UVTRON has no sensitivity in the visible range and is only sensitive to ultraviolet light in a very narrow region of spectrum.

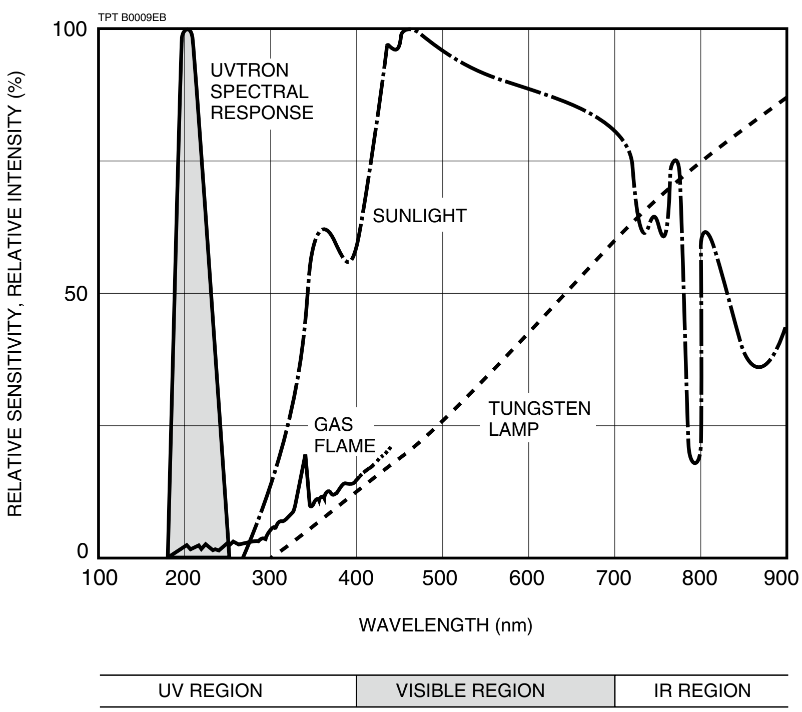

Figure 1: Typical Spectral Radiant Intensity

STRUCTURE AND BASIC OPERATING PRINCIPLES

The UVTRON is a bipolar tube with a structure similar to that of a phototube. Just as with phototubes, the UVTRON utilizes the photoelectric emission effect, but the inside of the UVTRON tube is filled with special a gas rather than being a vacuum, so it operates as a discharge tube. Figure 2 shows its structure and a schematic diagram of operation. A voltage is applied across the anode and photocathode (cathode) which is only sensitive to ultraviolet light. When UV light passing through the UV glass (UVTRON bulb) strikes the cathode, photoelectrons (electrons) are emitted from the cathode surface due to the photoelectric emission effect. These photoelectrons are then drawn to the anode by the electrical field created by the supply voltage. If the supply voltage is low, the operation is the same as for a phototube and the current, i, is extremely weak. When the voltage is increased to strengthen the electrical field, the photoelectrons are accelerated so they collide with the gas molecules within the tube and ionize them. The electrons produced by ionization continue to collide with other gas molecules while causing ionization until they finally reach the anode. Meanwhile, the positive ions are accelerated towards the cathode and the resulting collisions with the cathode generate a great number of secondary electrons. As this cycle is repeated, a large current suddenly flows between the anode and cathode, creating an electrical discharge. This phenomenon is called gas multiplication and the voltage at which this discharge starts is called the discharge starting voltage V_L of the UVTRON.

Once the electrical discharge has begun, the tube is filled with electrons and ions and the voltage that maintains the discharge drops to a low value. This value is called the discharge sustaining voltage Vs. Figure 3 shows this state. The UVTRON primarily operates in the glow discharge region, but in this region, since the discharge sustaining voltage Vs is lower than the discharge starting voltage V_L, the discharge will continue unless some means is employed to control the supply voltage.

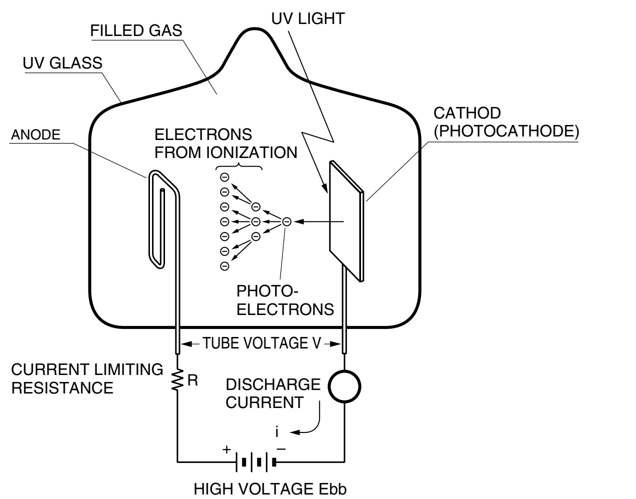

Figure 2: Schematic of UVTRON Operation

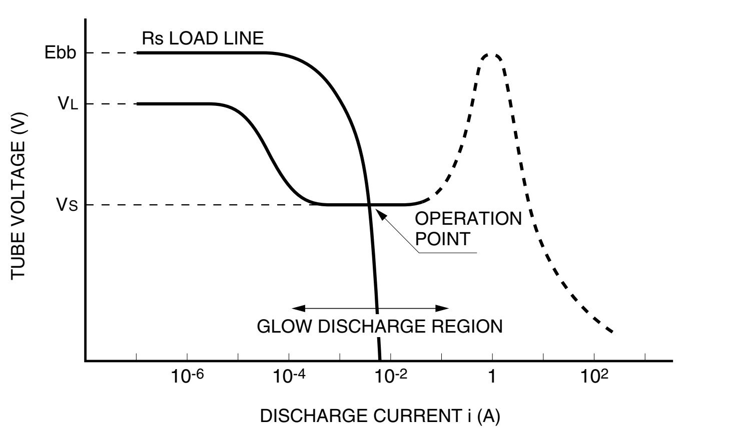

Figure 3: UVTRON Voltage-Current Characteristics

UVtron DRIVE CIRCUIT

Operating a UVTRON requires a high voltage of about 350 V. Figure 4 shows the basic circuit for the DC-DC converter high-voltage power supply and the operating waveforms for each part. In this case, it is important to lower the converter oscillation frequency, f, to reduce the capacitance of capacitor C_1 for smoothing the rectified high voltage, and to raise the power supply output impedance. Here is an explanation of the operation of this circuit. (See Figures 4-1 and 4-2.)

Point (a): This is the converter oscillation waveform. Pulses with a width of a few microseconds are generated at intervals of a few milliseconds to a few tens of milliseconds.

Point (b): The height of pulses is raised in proportion to the winding ratio for the step-up transformer.

Point (c): High DC voltage Ebb is supplied to the UVTRON's anode by rectifier diode D and smoothing capacitor C_1.

Point (d): Discharge starts when ultraviolet light enters the UVTRON. The charge on C_1 begins to flow as discharge current, i, to generate narrow voltage pulses across R and C_2.

Point (e): The charge on C_1 is exhausted, the anode voltage falls below the discharge sustaining voltage Vs, and the discharge stops. The anode voltage does not recover until the next charge. During that period, the ions in the UVTRON are quenched.

Point (f): If no ultraviolet light enters the UVTRON, the anode voltage recovers to Ebb, and there is no discharge until ultraviolet light is received.

The UVTRON repeats this cycle to indicate the presence or absence of ultraviolet light with pulse signal output. Here, it is important that the converter oscillation interval (l /the oscillation frequency f) be greater than the time required for the ions generated in the UVTRON tube by the discharge to be quenched, so this interval must be from 5 to l0 milliseconds. This period is called the quenching time. Also, since the capacitance of smoothing capacitor C_1 influences the discharge current, it is best to reduce the capacitance of C_1 in order to retard the wear on the electrodes and to reduce the number of ions generated. The optimum capacitance is a few tens of picofarads.

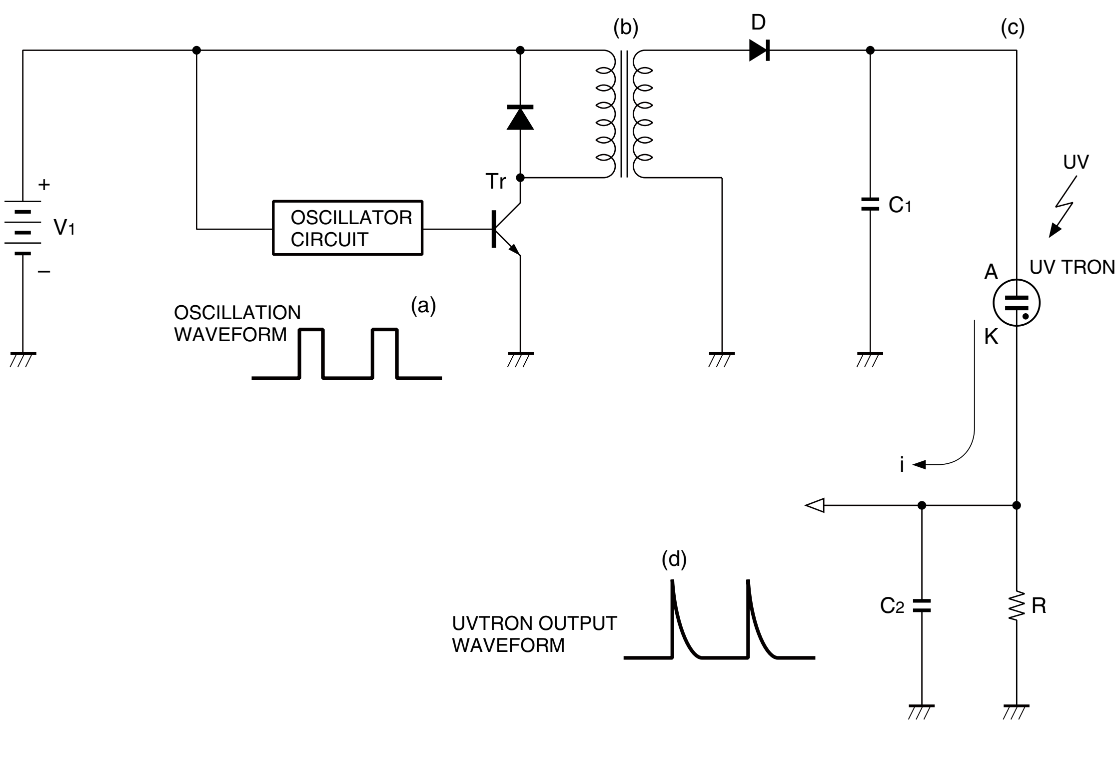

Figure 4-1: UVTRON Drive Circuit

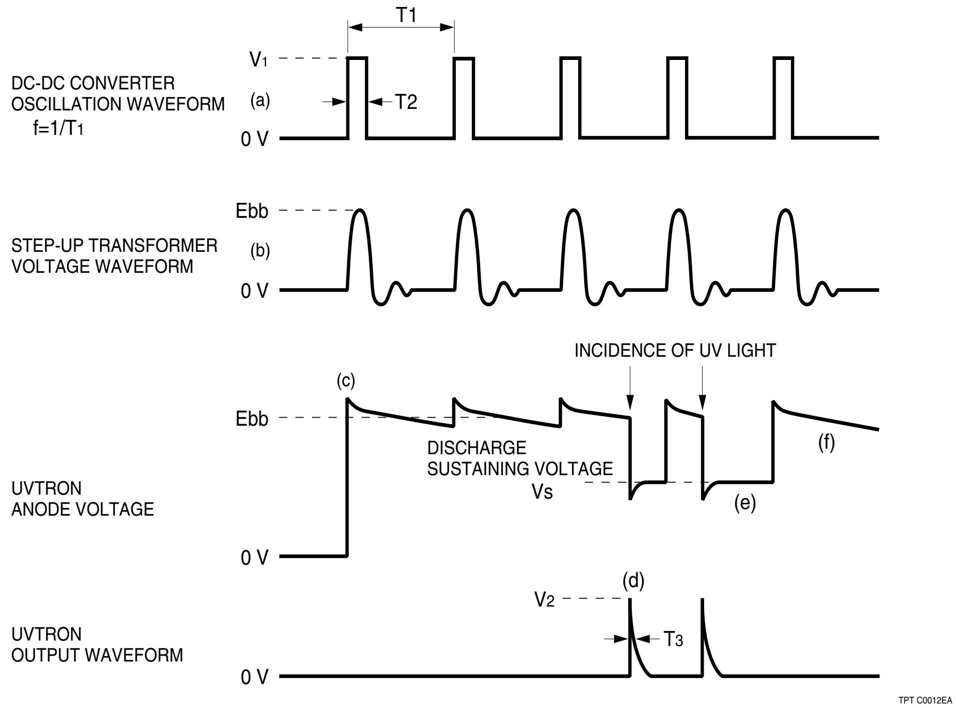

Figure 4-2: UVTRON Operation Waveforms

SIGNAL PULSES AND BACKGROUND

When the UVTRON is operated with the circuit shown in Figure 4-1, the number of output pulses is increased in proportion to the incident light intensity at low light levels. However, it will be saturated at the converter oscillation frequency f, as shown in Figures 5 and 6. Because of these characteristics, the UVTRON is better suited for on-off operation that determines whether or not ultraviolet light is present, rather than for precise measurement of light level.

The next point that must be considered is the background (BG). The BG is caused by sporadic discharges that occur due to radiation such as cosmic rays and static electricity, even if no ultraviolet light enters the UVTRON. Figure 6 also shows this phenomenon. When detecting ultraviolet light with the UVTRON, the BG causes false operation if the output pulses are directly used as the detection signals. Therefore, the signal must be processed to cancel out this background.

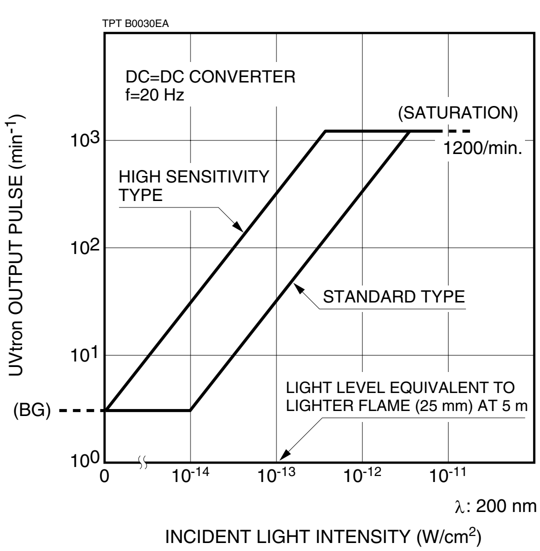

Figure 5: UVTRON Sensitivity and Background

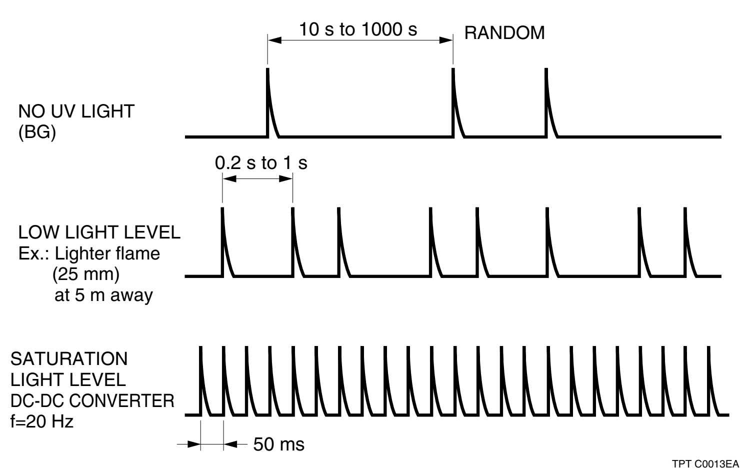

Figure 6: UVTRON Output Pulses

SIGNAL PROCESSING CIRCUIT

Since the UVTRON output pulse waveforms are the same for incident ultraviolet light and for background noise, the waveforms cannot be distinguished. Therefore, the pulse generation frequency (interval between pulses) is used to cancel out the BG. Figure 7 is a block diagram for the signal processing circuit and Figure 8 is a timing chart for its operation. The operation of this circuit is explained below.

Point (a): The output pulses from the UVTRON are input to the gate timer and the counter at the same time. The counter counts the pulses sequentially.

Point (b): The gate timer maintains the open state as long as the pulses enter in succession at time intervals shorter than the setting time T_1. When the pulse interval is greater than T_1, the gate timer closes the gate and resets the counter.

Point (c): When a series of pulses are input, the counter adds them up. When the number of pulses reaches the setting value, a pulse is generated to the output circuit and the counter is reset.

Point (d): At the output circuit, the output pulses from the counter are lengthened to the necessary time interval (T_2) and are output.

*1 (Figure 8): The setting time T_1 must be shorter than the interval at which background noise pulses are generated. It is usually safe to set T_1 to 5 seconds or less. If set too short, weak ultraviolet light cannot be detected.

*2 (Figure 8): The sensitivity of the device can be adjusted by the counter setting. To trigger the device with weak ultraviolet light, set the counter to 10 or less. To have the device only detect higher intensity of ultraviolet light, or to have the device operate for weak ultraviolet light if it is received for a long period of time, set the counter value to more than 10. If the counter value is set to 3 or less, the BG may not be cancelled out, so use caution.

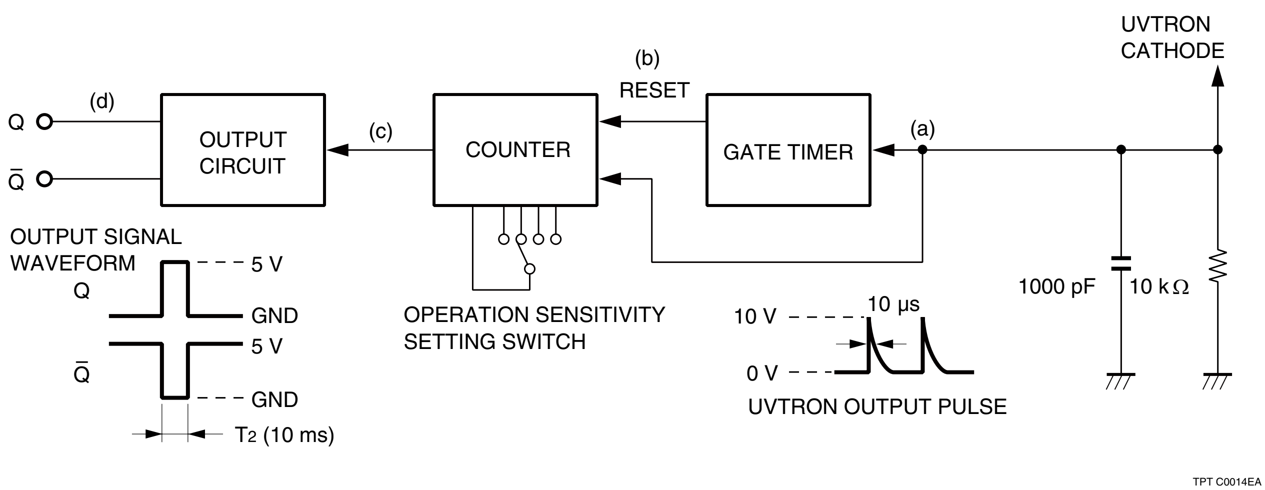

Figure 7: Signal Processing Circuit

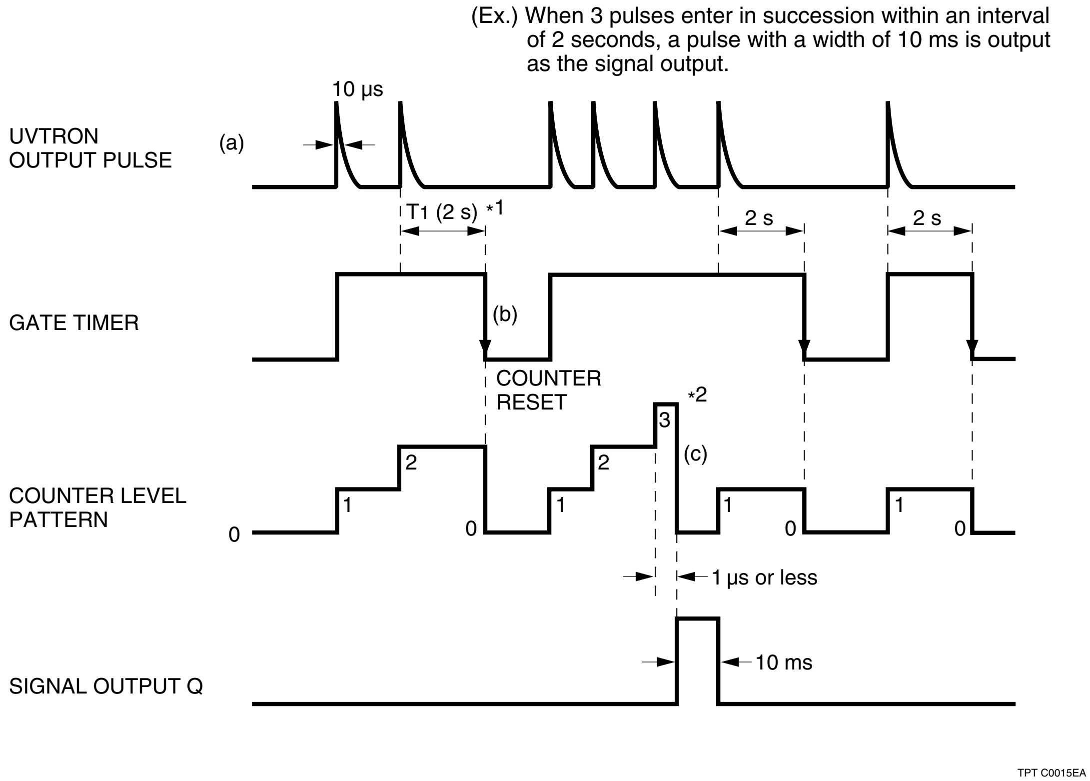

Figure 8: Operation Time Chart for Signal Processing Circuit

SUPPLY VOLTAGE AND SENSITIVITY

Figure 9 shows a typical relation between the supply voltage and the UVTRON sensitivity. The UVTRON is more sensitive as the supply voltage is increased, but this also increases the background noise. Keep the supply voltage within the recommended range.

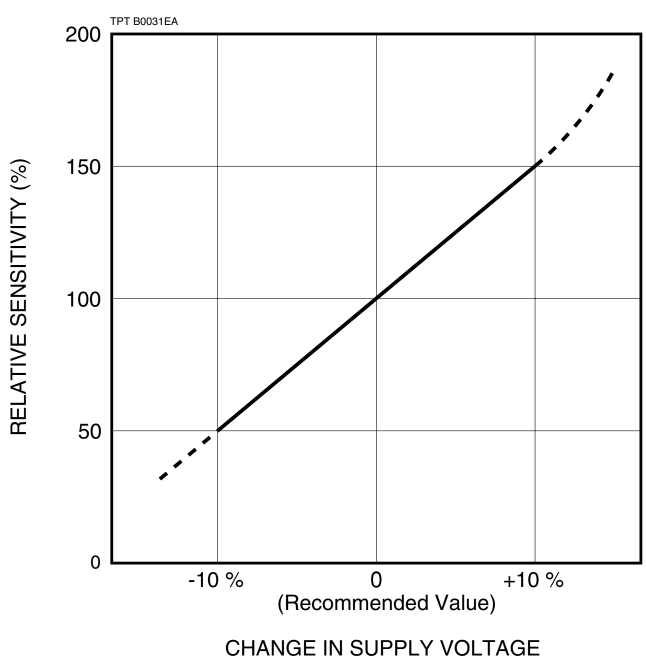

Figure 9: Supply Voltage and Sensitivity

PRECAUTIONS WHEN USING THE UVTRON

(1) Installation

When the UVTRON discharges, it emits ultraviolet radiation. If two or more UVTRONs are used in close proximity, they must be arranged so that they will not interfere with each other optically.

(2) Humidity

Humidity around the UVTRON leads may cause leak current, dropping the anode voltage and stopping the UVTRON from operating. In particular, if dirt or dust gets on the leads, it easily absorbs moisture, so keep the area around the leads clean.

(3) Dirt on the window

Since the UVTRON operates at high voltage, static electricity causes dust to build up on the surface of the glass bulb. This will lower the ultraviolet transmittance and UVTRON sensitivity, so periodic inspection and maintenance is necessary, such as wiping off with gauze moistened with alcohol.

(4) Soldering

When mounting the UVTRON on a printed circuit board, solder the leads quickly (soldering iron tip temperature: 350°C for less than 5 seconds). If the leads are heated excessively, the glass may crack or the UVTRON characteristics deteriorate. After soldering, wipe away the solder flux with alcohol, etc. The flux residue absorbs moisture which may cause current leak, dropping the UVTRON supply voltage and stopping the operation. When using a UVTRON with hard pins, use the mating sockets available from Hamamatsu Photonics.

(5) Vibration and shock

The UVTRON is designed to pass vibration and shock tests in compliance with IEC 60068-2-6 (sinusoidal vibration test – R9454, R9533: 3.0 mm peak to peak, 200 m/s^2,10 Hz to 2000 Hz; other types: 1.5 mm peak to peak, 100 m/s^2, 10 to 500 Hz) and IEC 60068-2-27 (shock test - R9454, R9533: 10000 m/s^2, 1 ms; other types: 1000 m/s^2, 11 ms). However, if the UVTRON is subjected to excessive shock such as dropping, the glass bulb may crack or the internal electrode may be deformed, resulting in poor electrical characteristics. So use extreme caution when handling the UVTRON.

(6) Polarity

The UVTRON has a cathode and an anode, so connect them with correct polarity. Reverse polarity connection causes malfunction or breakdown.

HAMAMATSU WEB SITE www.hamamatsu.com

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., 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10, E-mail: infos@hamamatsu.fr
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: Smidesvagän 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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