HAMAMATSU

Xenon Flash Lamps

PATENT PENDING

SQ (Super-Quiet) **Types**

HQ (High-Quality) **Types**

High-Power Types (Built-in reflector)

Xenon Flash Lamps

Xenon flash lamps feature a more compact construction and less heat build-up than continuous mode lamps. They also provide a high-intensity continuous spectrum from the UV through the visible to the infrared range. Hamamatsu Xenon Flash Lamps are especially applicable for precision photometry, because of such outstanding characteristics as arc stability 5 times higher and service life 10 times longer than those of conventional lamps, with the improved electrode construction and materials.

■ APPLICATIONS

- Stroboscope
- Specimen Scanner
- High-speed Camera
- Photomask Alignment
- Color Analyzer
- Blood Gas Analysis
- Clinical Chemistry Analysis
- Fluorescence Analysis
- Atmospherics Analysis
- Water Pollution Analysis
- HPLC
- Blood Cell Counter

■ FEATURES

- **High-stability: Fluctuation (at 100 Hz) .. 3% Typ.**
  Jitter (at 100 Hz) .... 200 ns Typ.
- **Long life .... 10^9 flashes Min.**
- **Flash pulse-width (FWHM) .... Below 1 µs to 10 µs**
- **Spectral distribution .... 160 to 2000 nm (Synthetic silica glass)**
- **Flash efficiency (at 0.1 to 1J) .... 10% Min.**
- **Flash repetition rate .... 100 Hz Max.**
- **Color temperature .... 15000K Max.**
- **Compact size**
- **Low heat radiation**

Construction and Operation

CONSTRUCTION

Figure 1 shows the external view and construction of a Xenon Flash Lamp. The lamp has a compact bulb which is filled with several thousand pascals (several hundred torrs) of high-purity xenon gas.

The electrode consists of a main electrode with outstanding electron emissivity, plus several trigger probes. The high-power type, in order to effectively utilize emitted light, is equipped with a built-in reflecting mirror. The window is located in the top of the bulb and is made of synthetic silica, UV glass or borosilicate glass. Figure 2 shows the transmittance of these window materials. The spectral distribution varies in the ultraviolet range depending on the type of material used for the window.

A discharge is created by applying a specified voltage across the cathode and anode and supplying trigger energy to the trigger probes.

Figure 1: External View and Construction

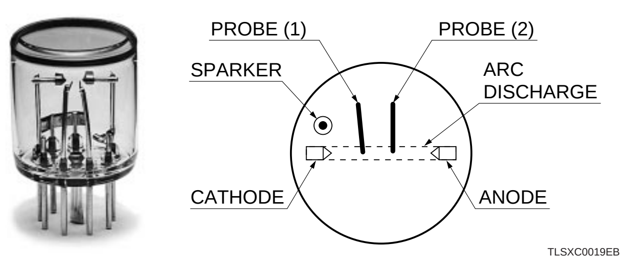
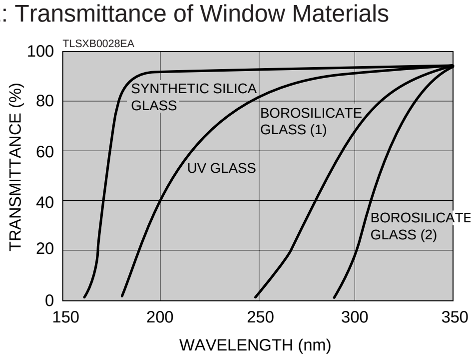


Figure 2: Transmittance of Window Materials



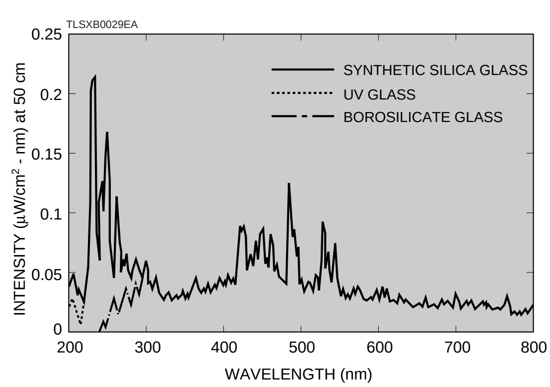
ARC STABILITY

Conventional Xenon Flash Lamps lacked arc stability because the characteristics of the cathode, anode and trigger probes vary each time the lamp is flashed. Hamamatsu Xenon Flash Lamps employ an improved electrode construction and specially developed high-performance electrode materials in order to provide a high level of arc stability.

SPECTRAL DISTRIBUTION

The spectral distribution of Xenon Flash Lamps ranges continuously from the ultraviolet, through the visible to the infrared range. The intensity of the ultraviolet range, in particular, is higher than that of continuous mode lamps. The spectral distribution varies depending on the window material. Lamps available for use include two models designed for the ultraviolet range, one with a synthetic silica window and one with a UV glass window, and a model for the visible range, with a window made of borosilicate glass. The user can select the appropriate model for the application at hand. Figure 3 shows the spectral distribution for each type of window.

Figure 3: Spectral Distribution

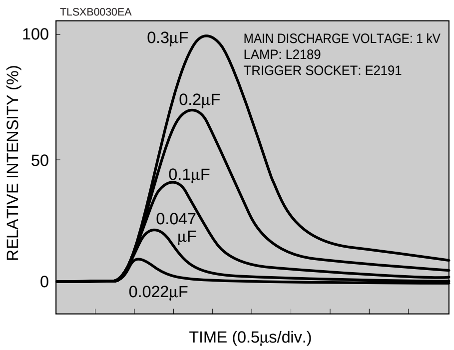


FLASH PULSE WAVEFORM

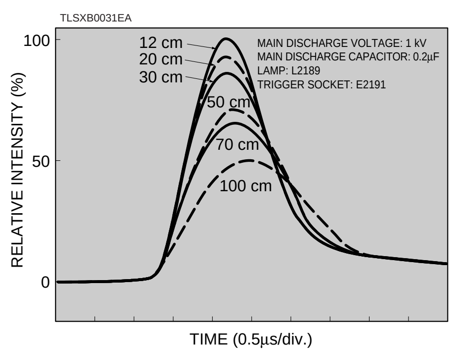
The flash duration and pulse height vary depending on the capacitance of the main supply capacitor, the inductance between the lamp and the main supply capacitor (i.e. length of trigger socket cable), and the operating voltage. The flash duration also varies depending on the distance between the anode and cathode. Figure 4 shows changes in the flash pulse waveform for main supply capacitors of different capacitances (a) and changes for trigger socket cables of different lengths (inductance) (b).

Figure 4: Flash Pulse Waveforms

(a) Capacitance

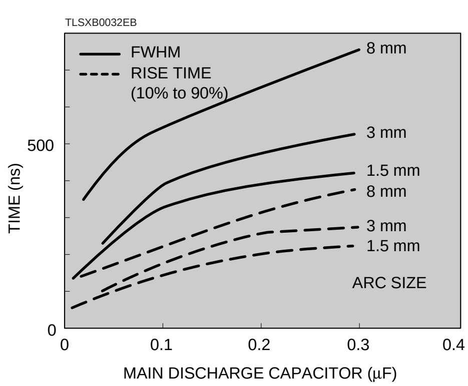


(b) Trigger Socket Cables



When an especially short flash is desirable, the main supply capacitor must be connected directly to the lamp. Figure 5 shows changes in flash duration (FWHM and rise time) when adaptors are used to connect the main discharge capacitance directly to the respective lamps having different arc lengths.

Figure 5: Changes in Flash Duration

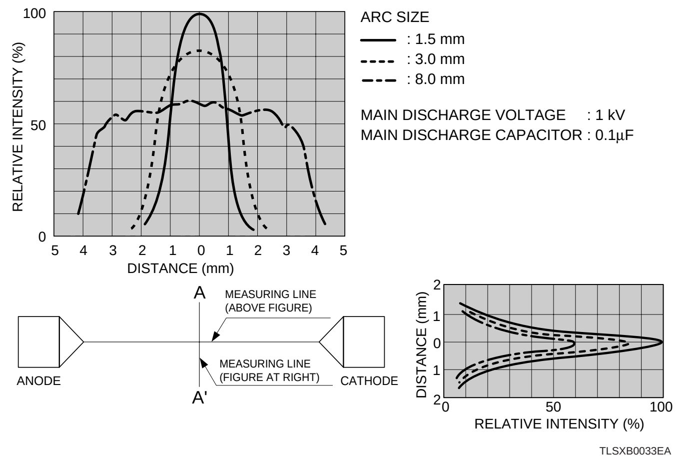


INTENSITY DISTRIBUTION AND LIGHT FLUX DISTRIBUTION

The intensity of a Xenon Flash Lamp varies depending on the interval between the electrodes. Figure 6 shows the intensity distribution for different intervals between electrodes.

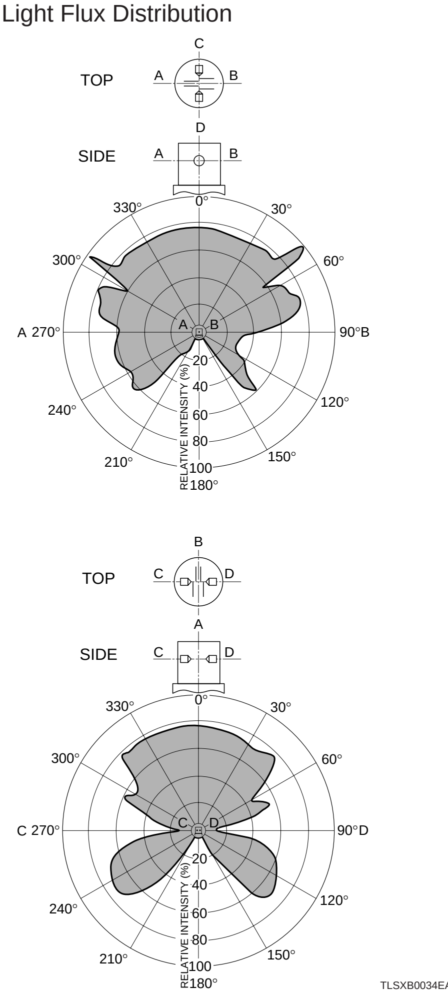
Lamps with a shorter interval between electrodes have a higher intensity. The wider the interval, the greater the volume of light emitted from the lamp.

Figure 6: Intensity Distribution for Different Electrode Intervals



Light is emitted from the top of a Xenon Flash Lamp. Light within ±45° from the emission point is effective.

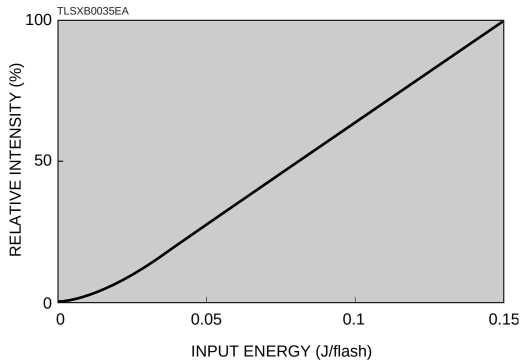
Figure 7: Light Flux Distribution



INPUT ENERGY AND FLASH INTENSITY

The flash intensity of Xenon Flash Lamps is almost proportional to the input energy. Figure 8 shows the variation of flash intensity in accordance with input energy.

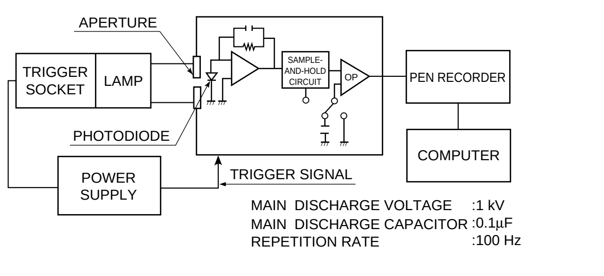
Figure 8: Input Energy and Flash Intensity



STABILITY OF FLASH INTENSITY

The stability of a Xenon Flash Lamp is expressed as the fluctuation of the intensity of each flash. Measurement is done by using the sample-and-hold method to evaluate the operating characteristics under conditions close to real time.
To measure the characteristics, the pulse light from a Xenon Flash Lamp is input to a detector, and an OP amp is used to integrate the photoelectric current. A sample-and-hold circuit is then used to indicate the integrated values continuously.

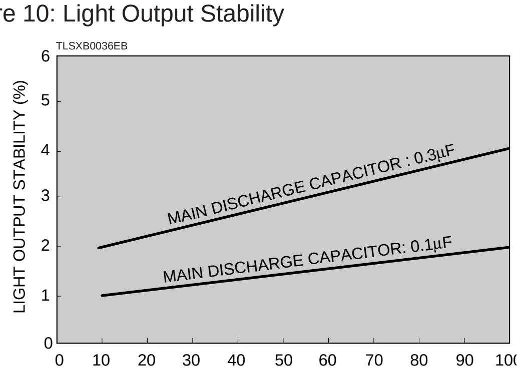
Figure 9: Block Diagram of Measurement Using the Sample-and-Hold Method



$$\text{Light output stability (\%)} = \frac{\text{(Max. light volume} - \text{Min. light volume)}}{\text{Average light output}} \times 100$$

With Xenon Flash Lamps, the lower the repetition rate in relation to the light output stability, the higher the stability of the emitted light will be.

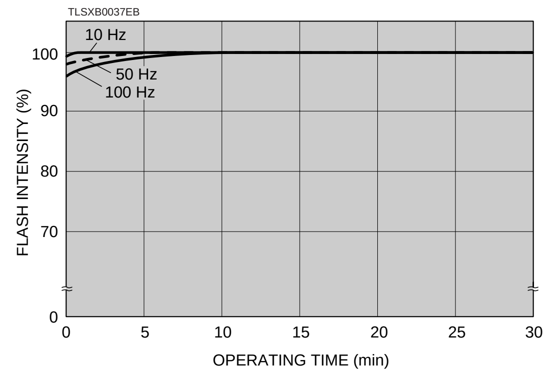
Figure 10: Light Output Stability



FLASH INTENSITY AT INITIAL OPERATION

The lamp flashes immediately after the power is turned on, but approximately 10 minutes (at 100 Hz) are required to reach peak flash intensity. This is because flash intensity increases together with the increase in the temperature of the gas pressure inside the bulb, and varies with flash repetition rate. Figure 11 shows the state and the time required to reach the peak flash intensity at different repetition rates. There is less heat build-up than with other discharge tubes, however, so less time is required to reach peak flash intensity.

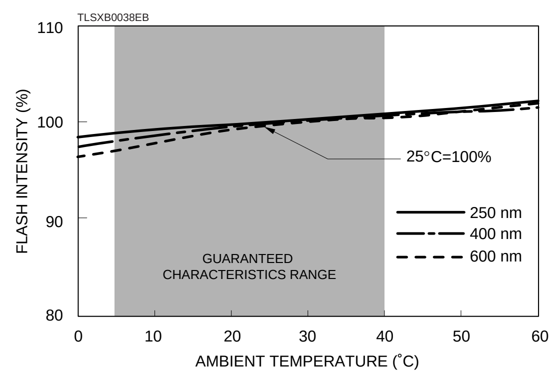
Figure 11: Flash Intensity at Initial Operating Time



FLASH INTENSITY AND AMBIENT TEMPERATURE

The intensity of Xenon Flash Lamps also varies with ambient temperature because flash efficiency varies with the pressure of the gas. This relationship is shown in Figure 12.
The ambient temperature range in which characteristics can be guaranteed is +5 to +40°C.

Figure 12: Flash Intensity and Ambient Temperature



Life

The life of Xenon Flash Lamps is represented by the total number of flashes the lamp will emit. This is greatly influenced by the input energy per flash. Since the input energy is given by the equation $E = 1/2 \times CV^2$, the life varies depending on the main discharge capacitor and the main discharge voltage.
Hamamatsu Xenon Flash Lamps have a life of more than 10^9 flashes under standard operating conditions (main discharge voltage: 1 kV; main discharge capacitor: 0.1 µF; repetition rate: 100 Hz). The life is determined by the point at which either the overall flash intensity drops to less than 50% of its original level or output fluctuation exceeds the rated value (please refer to the section on output fluctuation on pages 6 and 7).
Figure 13 shows the relationship between input energy per flash and the total number of flashes. Figure 14 shows the results of life tests under standard operating conditions.

Figure 13: Life
(Number of flashes vs. input energy per flash)

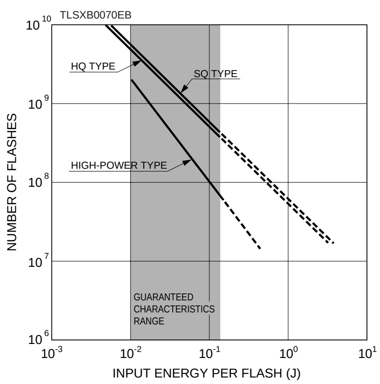
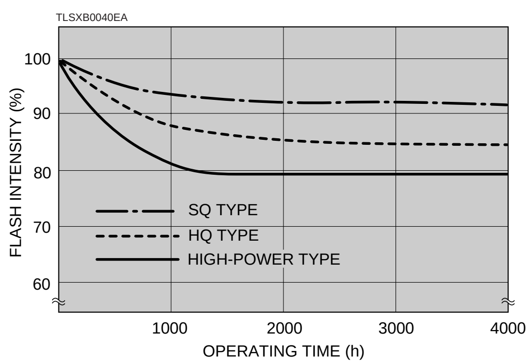


Figure 14: Life
(Flash intensity vs. operating time)



INDUCTION NOISE

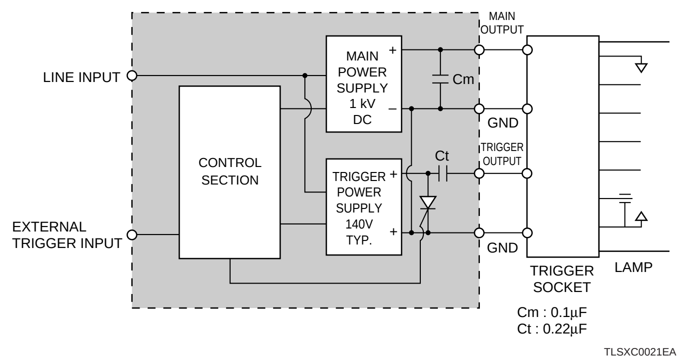
Xenon Flash Lamps require a high trigger voltage of 5 to 7 kVp per flash. Also, during discharge, an instantaneous current of several hundreds A flows, generating electromagnetic noise. Therefore, it is necessary to provide shielding against this noise when using these lamps as a light source for precision measuring instruments.
Noise is generated by the lamp itself, the trigger socket, cable and power supply; therefore, the following points should be taken into consideration.

(1) The lamp and trigger socket should be placed in a metal shield box.
(2) The trigger socket should have a shielded cable (-01).
(3) The case of the power supply should be grounded.

POWER SUPPLY

In order for Xenon Flash lamps to be suitable as a light source for photometry, the intensity must be uniform each time it flashes. Since intensity is almost proportional to the input energy, a stabilized power supply is required. Figure 15 shows a diagram of the basic power supply circuit consisting of a main supply section and trigger section. Flash pulse width and intensity vary depending on the supply voltage value between the cathode and anode and the value of the main discharge capacitance. Figure 15 shows the constants for the standard operating conditions of the C3684 and C4479 power supplies, designed especially for use with Xenon Flash Lamps.

Figure 15: Power Supply Circuit



1) Main Supply Section
This section provides a stable source of energy for the lamp. Since arc discharge is proportional to the input energy ($E = 1/2 \times CV^2$), a highly stabilized power supply and high-quality main discharge capacitor Cm are required.

2) Trigger Section
This supplies input energy to the trigger electrode. It consists of the trigger transformer inside the trigger socket, the power supply that drives it, and the control circuit. Like the main supply section, this section must also operate stably to provide a stable drive for the lamp.

TRIGGER SOCKETS

In order to light a flash mode SQ Xenon Lamp, it is necessary to apply a high voltage of 5 to 7 kV between the anode and cathode, and the trigger probes. Trigger sockets designed especially for Xenon Flash Lamps have built-in voltage-dividing resistors and capacitors to ensure that the optimum voltage is supplied to the high-voltage transformer, cathode, anode and trigger probes. (See page 10.)

Xenon Flash Lamps SQ (Super-Quiet) Type

The SQ type employs a high-performance BI cathode (impregnated electrode containing barium), which provides superb electron discharge. Other features of this type of electrode include a low operating temperature and strong resistance to ion impact.

Type No.	Arc Size (mm)	Dimensional Outline (P8, 9)	Window Material	Spectral Distribution (nm)	Recommended Supply Voltage (Vdc)	Trigger Voltage (kV)	Max. Average Input [Continuous] (W)	Max. Average Input Energy [Single] (J/flash)	Repetition Rate Max. (Hz)	Output Stability Ⓐ Ⓑ Jitter Typ. (nS)	Output Stability Ⓐ Ⓒ Output Fluctuation Max. (%)	Life Min. (number of flashes)	Orientation	Cooling	Applicable Trigger Sockets	Equivalent Lamps
22 mm Dia. Type																
*L2415	3.0 × 1.5	❶	Synthetic Silica	160 to 2000	700 to 1000	5 to 7	10	0.1	100	200	2.5	1.2×10^9	Optional	Not required	E2418	EG & G 9B Series
*L2416			UV Glass	185 to 2000												
L2417			Borosilicate Glass1	240 to 2000												
*L2439	1.5 × 1.5	❷	Synthetic Silica	160 to 2000	700 to 1000	5 to 7	10	0.1	100	200	3.5	1.2×10^9	Optional	Not required	E2442	EG & G 9B Series
*L2440			UV Glass	185 to 2000												
*L2441			Borosilicate Glass1	240 to 2000												
26 mm Dia. Type																
L2187	8.0 × 1.5	❸	Synthetic Silica	160 to 2000	700 to 1000	5 to 7	15	0.15	100	200	2.5	1.2×10^9	Optional	Not required	E2191 Series	–
L2188			UV Glass	185 to 2000												
L2189			Borosilicate Glass1	240 to 2000												
L2358	3.0 × 1.5	❹	Synthetic Silica	160 to 2000	700 to 1000	5 to 7	15	0.15	100	200	2.5	1.2×10^9	Optional	Not required	E2361 Series	–
L2359			UV Glass	185 to 2000												
L2360			Borosilicate Glass1	240 to 2000												
L2435	1.5 × 1.5	❺	Synthetic Silica	160 to 2000	700 to 1000	5 to 7	15	0.15	100	200	3.5	1.2×10^9	Optional	Not required	E2438 Series	–
L2436			UV Glass	185 to 2000												
L2437			Borosilicate Glass1	240 to 2000												
28 mm Dia. Type																
*L2443	8.0 × 1.5	❻	Synthetic Silica	160 to 2000	700 to 1000	5 to 7	15	0.15	100	200	2.5	1.2×10^9	Optional	Not required	E2446	EG&G 12BSeries
*L2444			UV Glass	185 to 2000												
*L2445			Borosilicate Glass1	240 to 2000												
*L2447	3.0 × 1.5	❼	Synthetic Silica	160 to 2000	700 to 1000	5 to 7	15	0.15	100	200	2.5	1.2×10^9	Optional	Not required	E2450	EG&G 12BSeries
*L2448			UV Glass	185 to 2000												
L2449			Borosilicate Glass1	240 to 2000												
*L2451	1.5 × 1.5	❽	Synthetic Silica	160 to 2000	700 to 1000	5 to 7	15	0.15	100	200	3.5	1.2×10^9	Optional	Not required	E2454	EG&G 12BSeries
*L2452			UV Glass	185 to 2000												
L2453			Borosilicate Glass1	240 to 2000												

Ⓐ Measured with power supply voltage of 1 kV, main supply capacitor of 0.1 µF and 50 Hz repetition rate.
Ⓑ Variation in delay from input of flash signal (trigger signal) to peak flash value (varies depending on main voltage value).
Ⓒ See stability of flash intensity on page 4.
*: Upon order

Xenon Flash Lamps
HQ (High-Quality) Type

The HQ model employs a low-cost cathode, making this a general-use lamp with all of the similar features to the SQ model but at a lower cost.

20mm Dia. Type

Type No.	Arc Size (mm)	Dimensional Outline (P8, 9)	Bulb Shape	Window Material	Spectral Distribution (nm)	Recommended Supply Voltage (Vdc)	Trigger Voltage (kV)	Max. Average Input [Continuous] (W)	Max. Average Input Energy [Single] (J/flash)	Repetition Rate Max. (Hz)	Output Stability Ⓐ: Ⓑ Jitter Typ. (ns)	Output Stability Ⓐ: Ⓒ Output Fluctuation Max. (%)	Life Min. (number of flashes)	Orientation	Cooling	Applicable Trigger Sockets	Equivalent Lamps
L4644	3.0 × 1.5	❾	Hemi-spherical	UV Glass	185 to 2000	700 to 1000	5 to 7	10	0.1	100	200	3	1×10^9	Optional	Not required	E2418	EG&G 9BSeries
L4646		⓫	Flat														
L4645		❾	Hemi-spherical	Borosilicate Glass 2	280 to 2000												
L4647		⓫	Flat	Borosilicate Glass 1	240 to 2000												
L4640	1.5 × 1.5	❿	Hemi-spherical	UV Glass	185 to 2000	700 to 1000	5 to 7	10	0.1	100	200	3.5	1×10^9	Optional	Not required	E2442	EG&G 9BSeries
L4642		⓬	Flat														
L4641		❿	Hemi-spherical	Borosilicate Glass 2	280 to 2000												
L4643		⓬	Flat	Borosilicate Glass 1	240 to 2000												

High-Power Xenon Flash Lamps
Built-in Reflector Type

26 mm Dia. Type

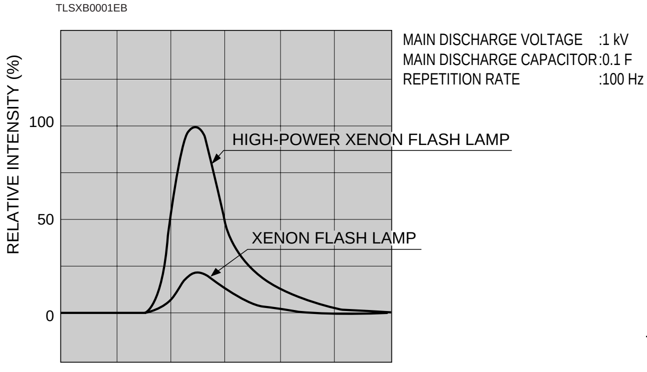
High-Power Xenon Flash Lamps are equipped with a built-in reflecting mirror which allows as much as 4 times the light to be obtained as that from conventional lamps. Two types of reflecting mirror are available for selection: a converging type and a collimating type.

Type No.	Arc Size (mm)	Dimensional Outline (P8, 9)	Bulb Shape	Window Material	Spectral Distribution (nm)	Recommended Supply Voltage (Vdc)	Trigger Voltage (kV)	Max. Average Input [Continuous] (W)	Max. Average Input Energy [Single] (J/flash)	Repetition Rate Max. (Hz)	Jitter Typ. (ns)	Output Fluctuation Max. (%)	Life Min. (number of flashes)	Orientation	Cooling	Applicable Trigger Sockets	Equivalent Lamps
L4633	1.5 × 1.5	⓭	Converging	Borosilicate Glass1	240 to 2000	700 to 1000	5 to 7	15	0.15	100	200	5	5×10^8	Optional	Not required	E4370-01	–
*L4633-01				UV Glass	185 to 2000												
L4634		⓮	Collimating	Borosilicate Glass1	240 to 2000												
*L4634-01				UV Glass	185 to 2000												

*: Upon order

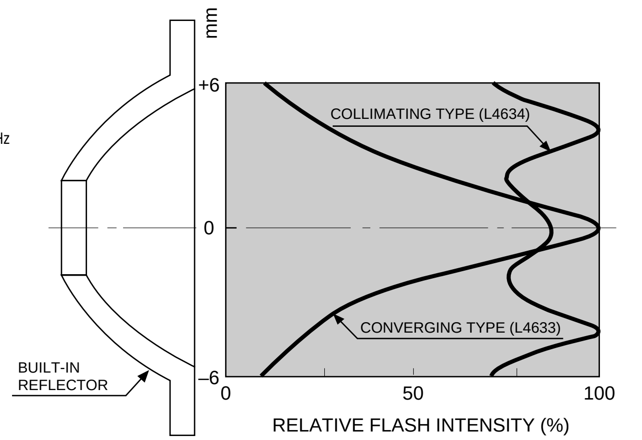
Comparison of Flash Intensities

The illustration below shows a comparison of relative intensities between conventional Xenon Flash Lamps and the High-Power Xenon Flash Lamp (L4633) with the converging mirror.



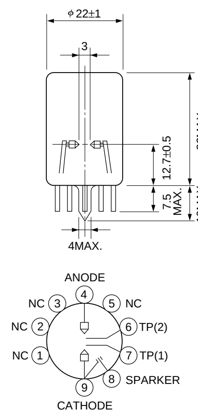
Light Distribution Characteristics

The following shows the light distribution of the flash output light for the converging type (L4633) and the collimating type (L4634).



Dimensional Outline

❶ L2415, L2416, L2417

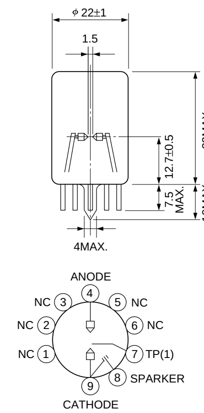


TP=Trigger Probe
NC=No Connection

TLSXA0023EB

(Weight 8 g)

❷ L2439, L2440, L2441

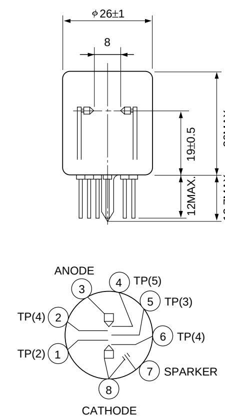


TP=Trigger Probe
NC=No Connection

TLSXA0024EB

(Weight 8 g)

❸ L2187, L2188, L2189

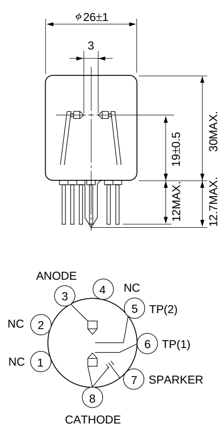


TP=Trigger Probe
NC=No Connection

TLSXA0025EA

(Weight 12 g)

❹ L2358, 2359, L2360

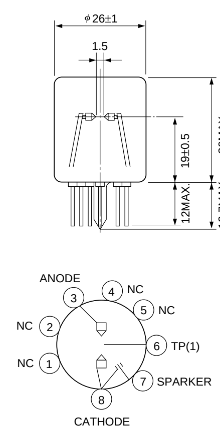


TP=Trigger Probe
NC=No Connection

TLSXA0026EA

(Weight 12 g)

❺ L2435, L2436, L2437

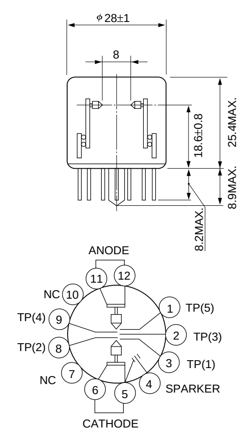


TP=Trigger Probe
NC=No Connection

TLSXA0027EA

(Weight 12 g)

❻ L2443, L2444, L2445

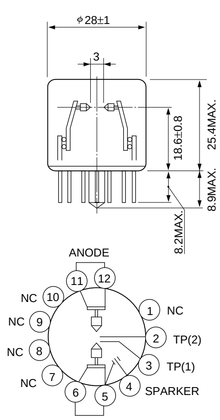


TP=Trigger Probe
NC=No Connection

TLSXA0028EA

(Weight 12 g)

❼ L2447, L2448, L2449

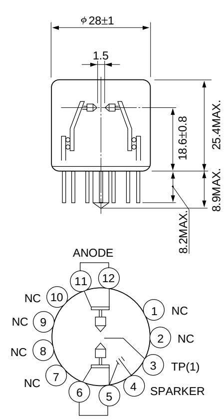


TP=Trigger Probe
NC=No Connection

TLSXA0029EB

(Weight 12 g)

❽ L2451, L2452, L2453

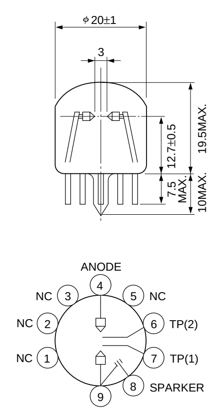


TP=Trigger Probe
NC=No Connection

TLSXA0030EA

(Weight 12 g)

❾ L4644, L4645



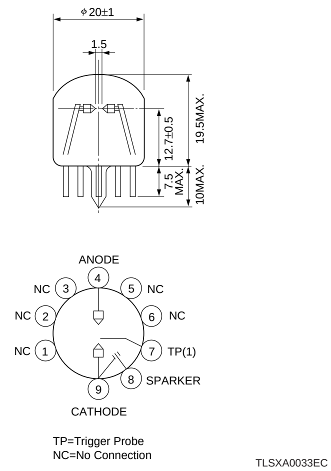
TP=Trigger Probe
NC=No Connection

TLSXA0032EC

(Weight 8 g)

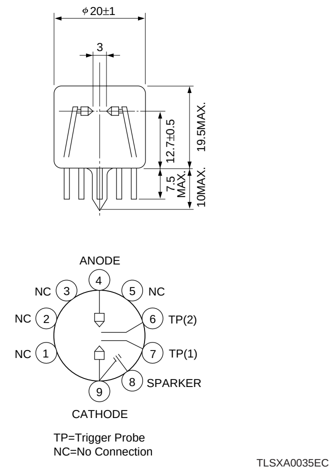
(UNIT: mm)

⑩ L4640, L4641



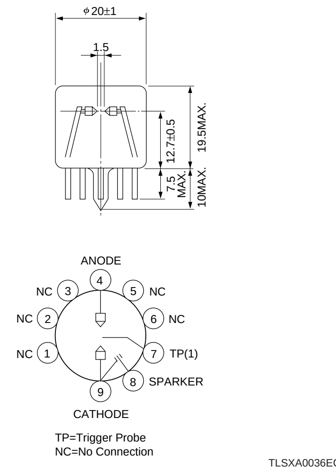
(Weight 8 g)

⑪ L4646, L4647



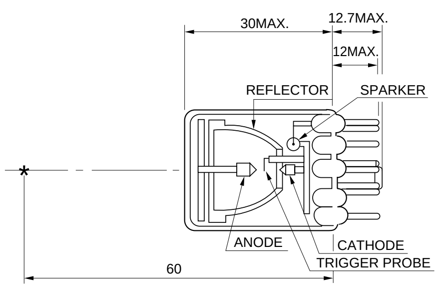
(Weight 8 g)

⑫ L4642, L4643

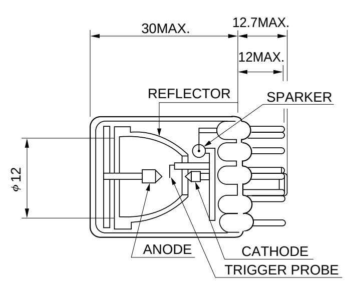


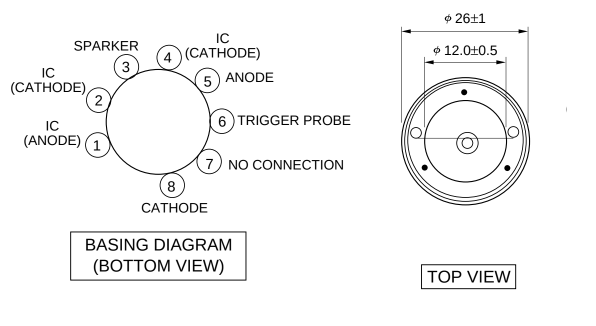
(Weight 8 g)

⑬ L4633, L4633-01



⑭ L4634, L4634-01





IC=Internal Connection

(Weight 13 g)

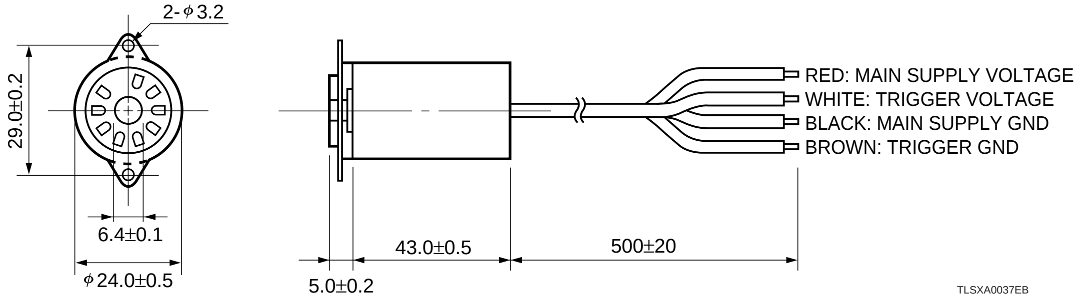
Options

Trigger Sockets

(UNIT: mm)

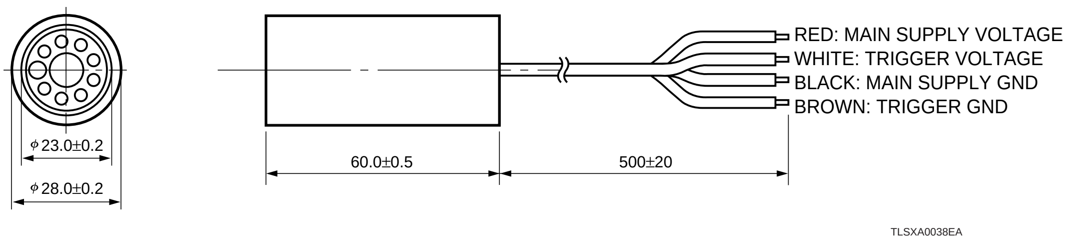
For 20 mm and 22 mm Dia. Type

E2418
E2442



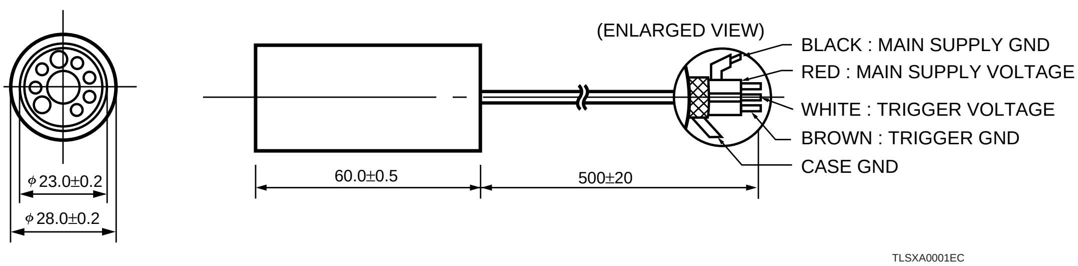
For 26 mm Dia. Type

E2191
E2361
E2438



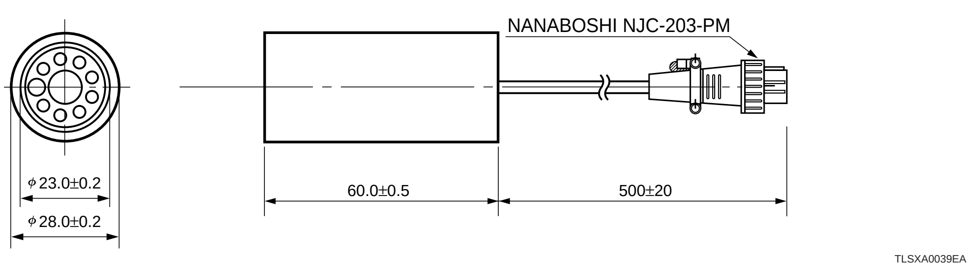
For 26 mm Dia. Shielded Wire Type

E2191-01
E2361-01
E2438-01
E4370-01



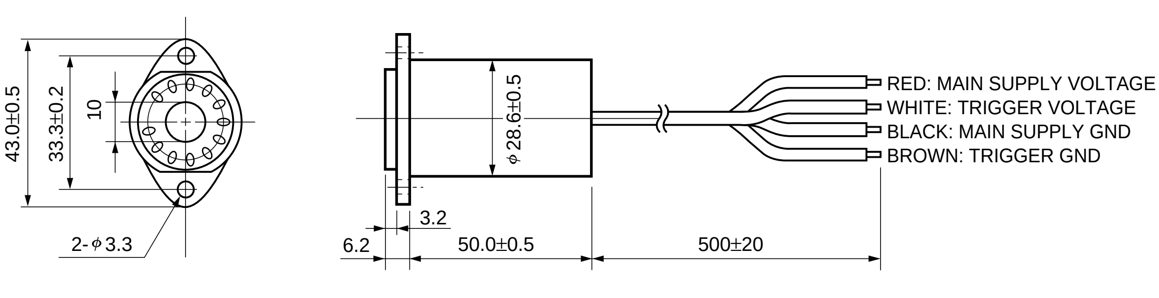
For 26 mm Dia. Type Connected to Special Power Supply (C4479)

E2191-03
E2361-03
E2438-03
E4370-03



For 28 mm Dia. Type

E2446
E2450
E2454



Lamp Power Supplies

With Xenon Flash Lamps, the flash intensity is almost proportional to the input energy, so that a high-stability power supply is required in order to obtain optimum performance from the lamp. The power supply designed by Hamamatsu for Xenon Flash Lamps is equipped with both a high-speed charging circuit and a discharge stop circuit, and uses a switching system to go from one to the other. This enables an extremely large capacity and stable light operation, while at the same time keeping the design small and compact.

Laboratory Type Power Supply C4479

The C4479 is a new product designed especially for use in such applications as product development and experiments. The flash repetition rate and supply voltage can be changed using the operation panel. An external trigger connector is also provided so that the flash repetition rate can be controlled externally.

Streamlined Power Supply C3684

The C3684 is designed as a simplified power supply and is available at low cost. Its compact size makes it ideal for combining with other products as a power supply.


C4479


C3684

Parameters \ Type No.		C4479	C3684	Unit
Main Power supply	Output voltage ⁕1	300 to 1000	300 to 1500	Vdc
	Output capacity ⁕2	15		W Max.
	Stability	±0.5		% Max.
	Main supply capacitor	0.1		µF
	Max. Repetition rate	300		Hz
Trigger Section	Output voltage	140		V Typ.
	Trigger capacitor	0.22		µF
Trigger Input section	Trigger type	Internal/External		–
	Repetition rate	10 to 100		Hz
	Trigger input impedance	100		Ω
	Input waveform	Rectangular waveform		–
	Input voltage	3.5 to 15		Vp.
Input voltage		85 to 264Vac	24Vdc	–
Power consumption		40	20	VA
Cooling		Not required		–
Dimensions (W) × (H) × (D)		210 × 60 × 265	102 × 45 × 157	mm
Weight		1.9	0.66	kg

⁕1 Recommended Supply voltage: 700 to 1000 Vdc
⁕2 Output capacity (W) $= 1/2 \times CmVm^2 \times f$
Cm : Main supply capacitor
Vm : Main supply voltage
f : Repetition rate

Shield Box E2608

(Lamp: ϕ26mm type; Applicable trigger sockets: -01,-03)

Xenon Flash Lamps are discharged by a trigger voltage of 5 to 7 kVp. The main power supply also delivers an instantaneous current of several hundreds A. This results in the generation of electromagnetic noise. Thus, when using such lamps with precision photometry instruments, it is necessary to eliminate this noise. To solve this problem, Hamamatsu has designed the E2608, a metal shield box with a window made of synthetic silica glass. The E2608 suppresses not only noise, but also the sound caused by the arc when the lamp is flashed.