

IMAGE INTENSIFIERS



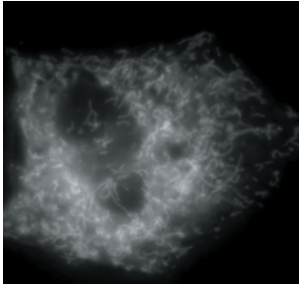
Image Intensifier

Image intensifiers (often abbreviated as I. I.) were primarily developed for nighttime viewing and surveillance under moonlight or starlight. Image intensifiers are capable of detecting and amplifying low-light-level images (weak emissions or reflected light) for bringing them into view as sharp contrast images. Image intensifier applications have spread from nighttime viewing to various fields including industrial product inspection and scientific research, especially when used with CCD cameras (intensified CCD or ICCD). Gate operation models are also useful for observation and motion analysis of high-speed phenomena (high-speed moving objects, fluorescence lifetime, bioluminescence and chemiluminescence images). Some major image intensifier applications are introduced here.

APPLICATION EXAMPLE

BIOTECHNOLOGY

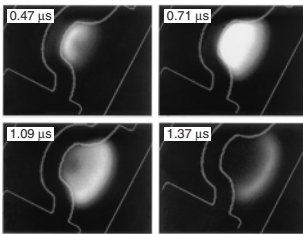
Fluorescence imaging



Mitochondria inside a nerve system culture cell NG108-15, specificity - labeled with fluorescent dye MITO TRACKER.

ELECTRONICS

PDP (Plasma display panel) emission

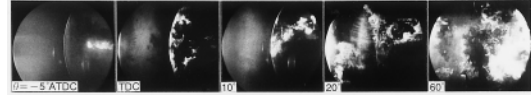


Very-low plasma emission occurring over an ultra-short duration can be observed. (*Plasma emission is superimposed on the PDP electrode. Top left shows elapsed time after applying a voltage to the each others electrode.

INDUSTRY

Observing engine combustion

Soot scattering images (taken by image intensifier)



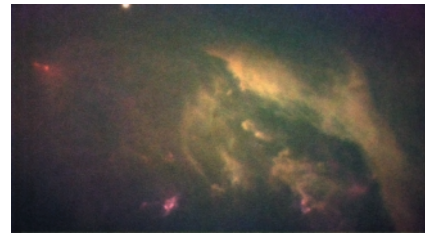
Direct flame images (taken by high-speed shutter camera)



ATDC: After Top Dead Center, θ : Crank angle with respect to ATDC
How soot is generated can be observed by viewing low-level scattering light resulting from laser irradiation.

ASTRONOMY

Celestial body observation



Star wind from the protostar L1551-IRS5 (red star at upper left), twinkling in yellowish green when it collides with surrounding gases.
Photo courtesy of National Astronomical Observatory in Japan/In cooperation with NHK (Nihon Hoso Kyokai)

OTHER-APPLICATIONS

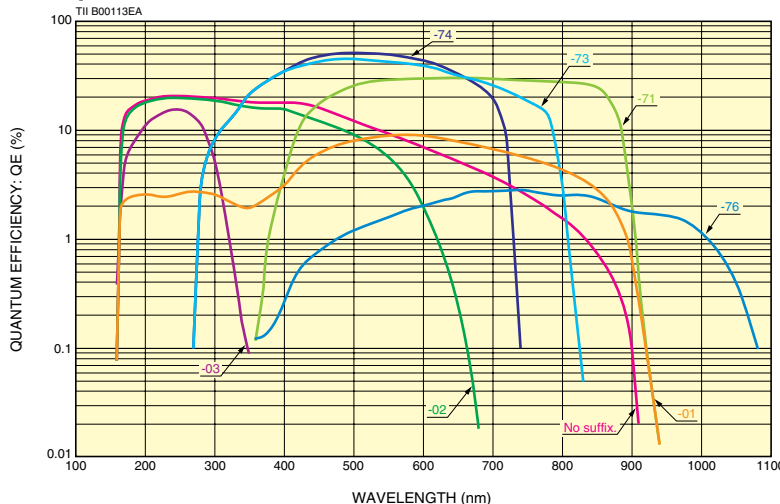
- Low-light-level imaging
- Multi-channel spectroscopy
- High-speed motion analysis
- Bioluminescence or chemiluminescence imaging
- UV range imaging (Corona discharge observation)

FEATURES

Feature 1 WIDE VARIATIONS

A wide variety of characteristics is presented including spectral response by choosing a photocathode and window material combination, photocathode size, the number of MCPs (gain) and gate time. You are sure to find the device that best matches your application from our complete lineup of standard or custom products.

■ Spectral Response Characteristics



Suffix	Photo Cathode	Input Window
-71	GaAs	Borosilicate Glass
-73	Extended Red GaAsP	Borosilicate Glass
-74	GaAsP	Borosilicate Glass
-76	InGaAs	Borosilicate Glass
Non	Multialkali	Synthetic Silica
-01	Extended Red Multialkali	Synthetic Silica
-02	Bialkali	Synthetic Silica
-03	Cs-Te	Synthetic Silica

The sensitivity at short wavelengths changes with typical transmittance of window materials. Please refer to figure 4 (P6).

NOTE: For Gen II, gate operation types may have slightly lower sensitivity in the ultraviolet region.

Feature 2 HIGH RESOLUTION

Clear, sharp images can be obtained with no chicken wire.

Feature 3 COMPACT AND LIGHTWEIGHT

Proximity-focused configuration is more compact and lightweight than inverter type.

Feature 4 NO DISTORTION

Images without distortion can be obtained even at periphery.

Feature 5 HIGH-SPEED GATE OPERATION

High-speed gated image intensifiers are available for imaging and motion analysis of high-speed phenomena.

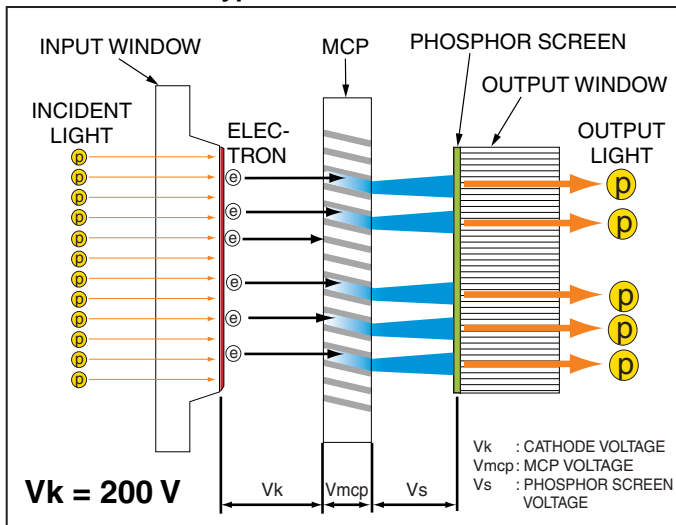
Feature 6 HIGH SENSITIVITY GaAs AND GaAsP PHOTOCATHODE

Excellent image intensification with an even higher signal-to-noise ratio is achieved by combining our filmless MCP fabrication technology with the high-sensitivity GaAs and GaAsP photocathode.

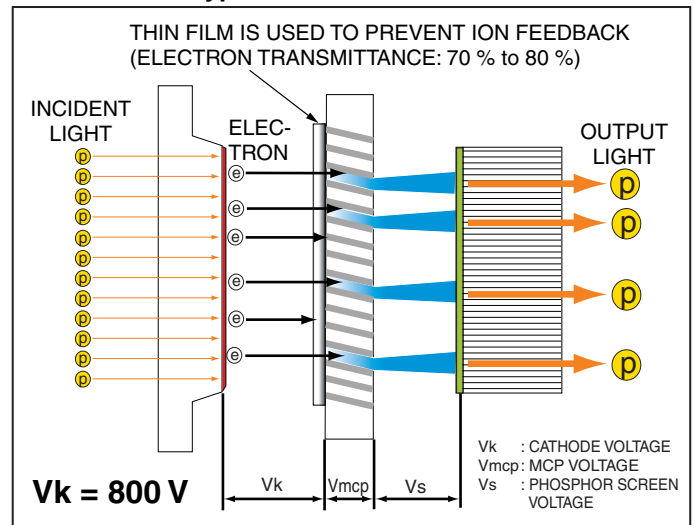
■STRUCTURE

In conventional image intensifiers having a crystalline photocathode, a thin film was deposited over the surface of the MCP (microchannel plate) to prevent ion feedback. Our improved fabrication method successfully eliminates this thin film. This filmless structure eliminates the loss of electrons passing through the MCP and therefore improves the signal-to-noise ratio more than 20% compared to filmed image intensifiers, and the life is longer.

●Filmless MCP Type



●Filmed MCP Type



SN Ratio 20% UP High Resolution 64 Lp/mm (Typ.) Cathode Voltage 200 V Long Life

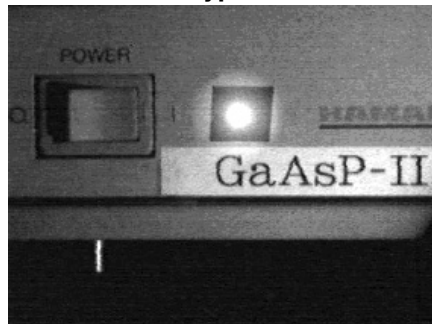
■Low "halo" effect

Minimizes the halo effect that makes annular light appear around bright spots.

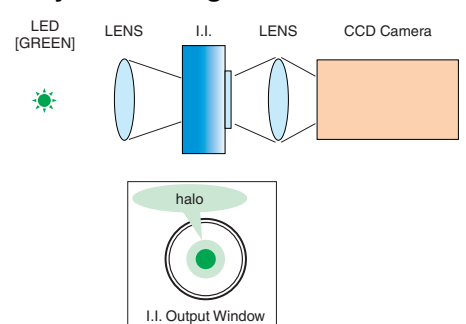
●Filmless MCP Type



●Filmed MCP Type



●System Configuration



STRUCTURE AND OPERATION

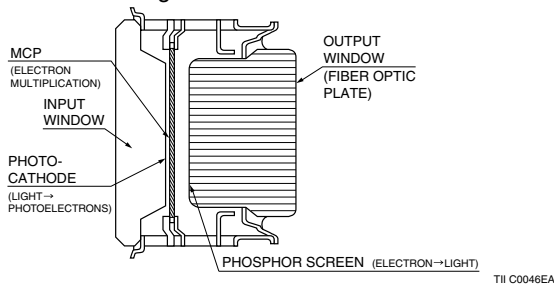
STRUCTURE

Figure 1 shows the structure of a typical image intensifier. A photocathode that converts light into photoelectrons, a microchannel plate (MCP) that multiplies electrons, and a phosphor screen that reconverts electrons into light are arranged in close proximity in an evacuated ceramic case. The close proximity design from the photocathode to the phosphor screen delivers an image with no geometric distortion even at the periphery.

Types of image intensifiers are often broadly classified by "generation". The first generation refers to image intensifiers that do not use an MCP and where the gain is usually no greater than 100 times. The second generation image intensifiers use MCPs for electron multiplication. Types using a single-stage MCP have a gain of about 10000.

A variety of photocathodes materials are currently in use. Of these, photocathodes made of semiconductor crystals such as GaAs and GsAsP are called "third generation". These photocathodes offer extremely high sensitivity. Among the first and second generation image intensifiers, there are still some inverter types in which an image is internally inverted by the electron lens, but these are rarely used now because of geometric distortion.

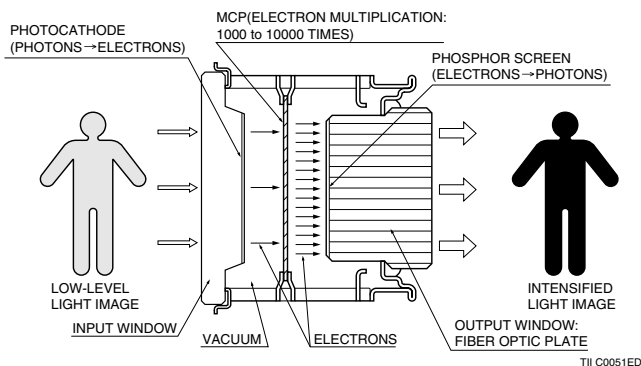
Figure 1: Structure of Image Intensifier



OPERATING PRINCIPLE

Figure 2 shows how light focused on the photocathode is converted into photoelectrons. The number of photoelectrons emitted at this point is proportional to the input light intensity. These electrons are then accelerated by a voltage applied between the photocathode and the MCP input surface (MCP-in) and enter individual channels of the MCP. Since each channel of the MCP serves as an independent electron multiplier, the input electrons impinging on the channel wall produce secondary electrons. This process is repeated several tens of times by the potential gradient across the both ends of the MCP and a large number of electrons are in this way released from the output end of the MCP. The electrons multiplied by the MCP are further accelerated by the voltage between the MCP output surface (MCP-out) and the phosphor screen, and strike the phosphor screen which emits light according to the amount of electrons. Through this process, an input optical image is intensified and appears as the output image on the phosphor screen.

Figure 2: Operating Principle



GATE OPERATION

An image intensifier can be gated to open or close the optical shutter by varying the potential between the photocathode and the MCP-in. Figure 3 shows typical gate operation circuits.

When the gate is ON, the photocathode potential is lower than the MCP-in potential so the electrons emitted from the photocathode are attracted

by this potential difference towards the MCP and multiplied there. An intensified image can then be obtained on the phosphor screen.

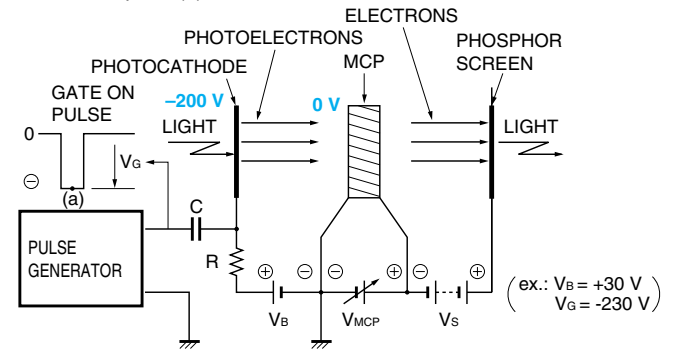
When the gate is OFF however, the photocathode has a higher potential than the MCP-in (reverse-biased) so the electrons emitted from the photocathode are forced to return to the photocathode by this reverse-biased potential and do not reach the MCP. In the gate OFF mode, no output image appears on the phosphor screen even if light is incident on the photocathode.

To actually turn on the gate operation, a high-speed, negative polarity pulse of about 200 volts is applied to the photocathode while the MCP-in potential is fixed. The width (time) of this pulse will be the gate time.

The gate function is very effective when analyzing high-speed optical phenomenon. Gated image intensifiers and ICCDs (intensified CCDs) having this gate function are capable of capturing instantaneous images of high-speed optical phenomenon while excluding extraneous signals.

Figure 3: Gate Operation Circuits

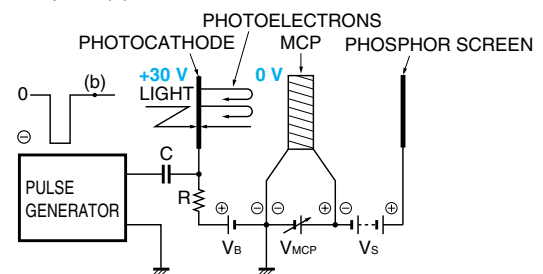
Gate ON at point (a)



- V_{MCP} MCP-in TO MCP-out VOLTAGE
- V_s MCP-out TO PHOSPHOR SCREEN VOLTAGE
- V_b BIAS VOLTAGE
- V_g GATE PULSE

TII C0047EA

Gate OFF at point (b)



TII C0048EA

GLOSSARY OF TERMS

Photocathode Sensitivity

Luminous Sensitivity: The output current from the photocathode per the input luminous flux from a standard tungsten lamp (color temperature: 2856 K), usually expressed in $\mu\text{A}/\text{lm}$ (microamperes per lumen). Luminous sensitivity is a term originally for sensors in the visible region and is used in this catalog as a guideline for sensitivity.

Radiant Sensitivity: The output current from the photocathode per the input radiant power at a given wavelength, usually expressed in A/W (amperes per watt).

Quantum Efficiency (QE): The number of photoelectrons emitted from the photocathode divided by the number of input photons, generally expressed in % (percentage). The quantum efficiency and radiant sensitivity have the following relation at a given wavelength λ .

$$\text{QE} = \frac{S \times 1240}{\lambda} \times 100 (\%)$$

S: Radiant sensitivity (A/W)
 λ : Wavelength (nm)

Luminous Emittance

This is the luminous flux density emitted from a phosphor screen and is usually expressed in lm/m^2 (lumens per square meter). The luminous emittance from a completely diffused surface emitting an equal luminance in every direction is equivalent to the luminance (cd/m^2) multiplied by π .

Gain

Gain is designated by different terms according to the photocathode spectral response range. Luminous emittance gain is used for image intensifiers having sensitivity in the visible region. Radiant emittance gain and photon gain are used for image intensifiers intended to detect invisible light or monochromatic light so that light intensity must be expressed in units of electromagnetic energy

Photon gain is also used to evaluate image intensifiers using a P-47 phosphor (see Figure 5) whose emission spectrum is shifted from the relative visual sensitivity.

Luminous Gain: The ratio of the phosphor screen luminous emittance (lm/m^2) to the illuminance (lx) incident on the photocathode.

Radiant Emittance Gain: The ratio of the phosphor screen radiant emittance density (W/m^2) to the radiant flux density (W/m^2) incident on the photocathode. In this catalog, the radiant emittance gain is calculated using the radiant flux density at the wavelength of maximum photocathode sensitivity and the radiant emittance density at the peak emission wavelength (545 nm) of a P-43 phosphor screen.

Photon Gain: The ratio of the number of input photons per square meter at a given wavelength to the number of photons per square meter emitted from the phosphor screen.

MTF (Modulation Transfer Function)

When a black-and-white stripe pattern producing sine-wave changes in brightness is focused on the photocathode, the contrast on the output phosphor screen drops gradually as the stripe pattern density is increased. The relationship between this contrast and the stripe density (number of line-pairs per millimeter) is referred to as the MTF.

Limiting Resolution

The limiting resolution shows the ability to delineate image detail. This is expressed as the maximum number of line-pairs per millimeter on the photocathode (1 line-pair = a pair of black and white lines) that can be discerned when a black-and-white stripe pattern is focused on the photocathode. In this catalog, the value at 5 % MTF is listed as the limiting resolution.

EBI (Equivalent Background Input)

This indicates the input illuminance required to produce a luminous emittance from the phosphor screen, equal to that obtained when the input illuminance on the photocathode is zero. This indicates the inherent background level or lower limit of detectable illuminance of an image intensifier.

Shutter Ratio

The ratio of the brightness on the phosphor screen during gate ON to that during gate OFF, measured when a gated image intensifier is operated under standard conditions.

Gate Operation

Most photocathodes have a high electrical resistance (surface resistance) and are not suited for gate operation when used separately. To allow gate operation at a photocathode, a low-resistance photocathode electrode (metallic thin film) is usually deposited between the photocathode and the incident window. Gate operation can be performed by applying a high-speed voltage pulse to the low-resistance photocathode electrode.

Since the semiconductor crystals of the GaAs and GaAsP photocathodes themselves have low resistance, no photocathode electrode film needs to be deposited for gate operation.

SELECTION CRITERIA (Factors for making the best choice)

Items	Selectable Range	Description/Value				
Effective Area ★Select the effective area that matches the readout method.	ϕ 18 mm (13.5 mm × 10 mm) ^(A)	The 25 mm (16 mm × 16 mm ^(A)) diameter type transfers a larger amount of image information to a readout device coupled by using a reduction optical system such as a relay lens and tapered FOP. This lets you acquire high resolution images. The 18 mm diameter type (13.5 mm × 10 mm) is compatible with 1-inch CCDs.				
	ϕ 25 mm (16 mm × 16 mm) ^(A)					
Input Window ★Select the window according to the required sensitivity at short wavelengths.	Window Type	Transmitting Wavelength	Features			
	Synthetic silica	160 nm or longer	Standard input window with high UV transmittance.			
	Fiber optic Plate (FOP)	350 nm or longer	Optical element that transmits an optical image with high efficiency and no distortion. An image should be focused on the front surface of FOP.			
	MgF ₂	115 nm or longer	Alkali halide crystal that transmits VUV radiation yet offers low deliquescence.			
	Borosilicate glass	300 nm or longer	Most common glass material used in the visible to near IR region. Not suitable for UV detection.			
Photocathode ★Select the photocathode according to the required sensitivity at long wavelengths.	Photocathode Type	Spectral Response	Features			
	Multialkali	Up to 900 nm	Made from 3 kinds of alkali metals, having high sensitivity from the UV through near IR region.			
	Extended red multialkali	Up to 950 nm	Made from 3 kinds of alkali metals, having high sensitivity extending to 950 nm in the near IR region. Ideal for nighttime viewing.			
	Bialkali	Up to 650 nm	Made from 2 kinds of alkali metals, having sensitivity from the UV to visible region. Background noise is low.			
	Cs-Te	Up to 320 nm	Having sensitivity only in the UV region and almost insensitive to wavelengths longer than 320 nm and visible light. Often called "solar blind photocathode".			
	GaAs	Up to 920 nm	Made from group III-V crystal having high sensitivity from the visible to near IR region. Spectral response curve is nearly flat from 450 to 850 nm.			
	GaAsP	Up to 720 nm	Made from group III-V crystal having very high sensitivity in the visible region (quantum efficiency 50 % Typ. at 530 nm).			
	InGaAs	Up to 1100 nm	Made from group III-V crystal having high sensitivity at 1 μ m. This photocathode is suitable for laser ranging application used by YAG laser.			
MCP ★Select the number of stages according to the required gain.	1 stage	Gain: about 10 ³				
	2 stage	Gain: about 10 ⁵				
Phosphor Screen ★Select the decay time that matches the readout method and application, and the spectral emission that matches the readout device sensitivity.	Phosphor Type	Peak Emission Wavelength [nm]	10 % Decay Time	Relative ^(C) Power Efficiency	Emission Color	NOTE
	P24	500	3 μ s to 40 μ s ^(B)	0.4	Green	
	P43	545	1 ms	1	Yellowish green	Standard
	P46	510	0.2 μ s to 0.4 μ s ^(B)	0.3	Yellowish green	Short decay time
	P47	430	0.11 μ s	0.3	Purplish blue	Short decay time
Output Window ★Select the window that matches the readout method.	Fiber optic plate (FOP)	Standard output window and ideal for direct coupling to a CCD with FOP input window, allowing highly efficient readout. If the phosphor screen is not at ground potential, a NESA (transparent conductive film) may be needed to prevent noise generated by a high voltage from getting into the CCD. When a relay lens is used, it should be focused on the edge of the FOP.				
	Borosilicate glass	For relay lens readout. The relay lens should be focused on the phosphor screen surface.				
	Inverting concave fiber optics	FOP twisted 180 ° to invert an image. This output window is only for nighttime viewing applications where the output image is directly viewed by eye. Using a twisted fiber optics reduces the eyepiece length, making the nighttime viewing unit more compact.				
Gate Time ★Select the gate time that matches the required time resolution.	5 ns	Metallic thin film type				
	10 ns					

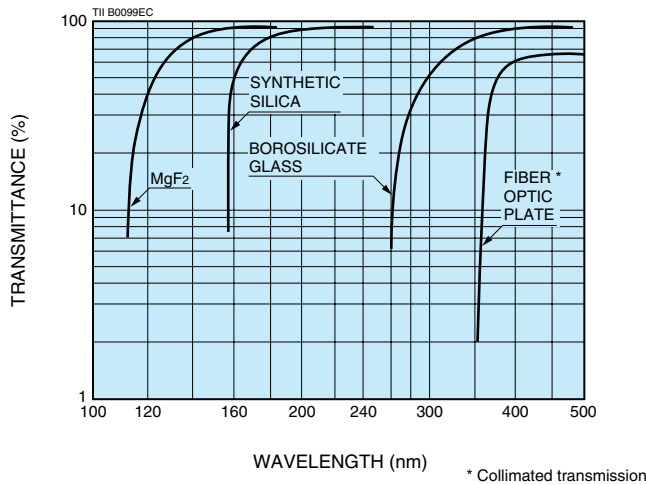
(A): at crystal photocathode

(B): Depends on the input pulse width. Refe to Figuer 6 on page 6.

(C): Relative value with output from P43 set as 1. Measured with 6 kV voltage applied.

INPUT WINDOWS

Figure 4: Typical Transmittance of Window Materials



PHOTOCATHODE

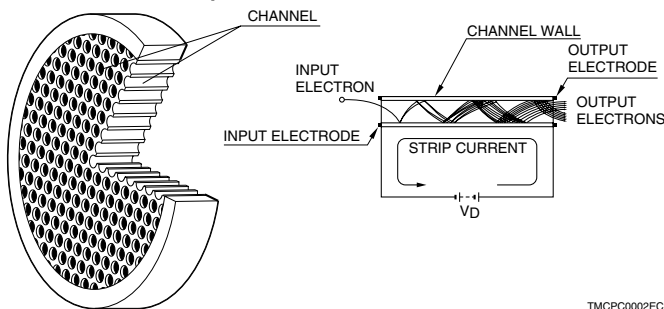
A photocathode converts light into electrons. This conversion efficiency depends on the wavelength of light. The relationship between this conversion efficiency (photocathode radiant sensitivity or quantum efficiency) and wavelength is called the spectral response characteristic. (See spectral response characteristics on page 1.)

MCP (MICROCHANNEL PLATE)

An MCP is a secondary electron multiplier consisting of an array of millions of very thin glass channels (glass pipes) bundled in parallel and sliced in the form of a disk. Each channel works as an independent electron multiplier. When an electron enters a channel and hits the inner wall, secondary electrons are produced. These secondary electrons are then accelerated by the voltage (V_{MCP}) applied across the both ends of the MCP along their parabolic trajectories to strike the opposite wall where additional secondary electrons are released. This process is repeated many times along the channel wall and as a result, a great number of electrons are output from the MCP.

The dynamic range (linearity) of an image intensifier depends on the so-called strip current which flows through the MCP during operation. When a higher linearity is required, using a low-resistance MCP is recommended so that a large strip current will flow through the MCP. The channel diameter of typical MCPs is 6 μm .

MCP Structure and Operation



PHOSPHOR SCREEN

The phosphor screen generally absorbs ultraviolet radiation, electron beams or X-rays and emits light on a wavelength characteristic of that material. An image intensifier uses a phosphor screen at the output surface to convert the electrons multiplied by the MCP into light. Phosphor screen decay time is one of the most important factors to consider when selecting a phosphor screen type. When used with a high-speed CCD or linear image sensor, a phosphor screen with a short decay time is recommended so that no afterimage remains in the next frame. For nighttime viewing and surveillance, a phosphor with a

long decay time is suggested to minimize flicker. Figure 5 shows typical phosphor spectral emission characteristics and Figure 6 shows typical decay characteristics.

We also supply phosphor screens singly for use in detection of ultraviolet radiation, electron beams and X-rays.

Figure 5: Typical Phosphor Spectral Emission Characteristics

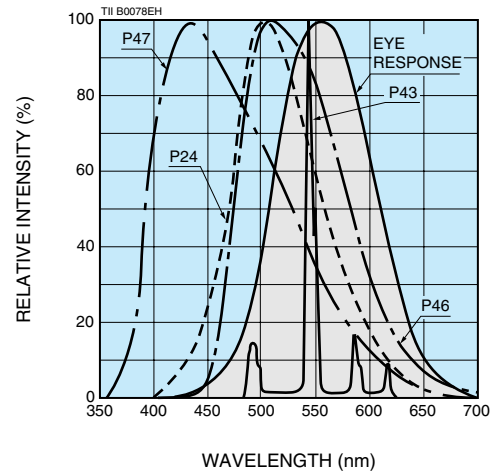
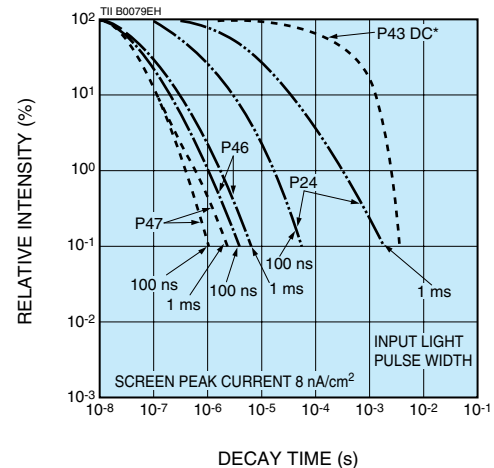


Figure 6: Typical Decay Characteristics



* Decay time obtained following to the continuous input light removal.

OUTPUT WINDOW MATERIAL

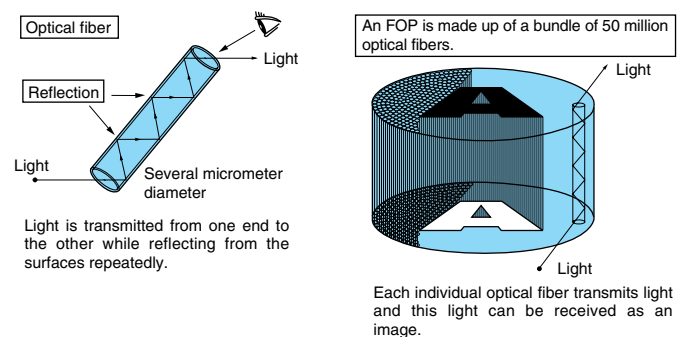
Please select the desired type according to the readout method.

FIBER OPTIC PLATE (FOP)

The FOP is an optical plate comprising some millions to hundreds of millions of glass fibers with several micrometer diameter, bundled parallel to one another.

The FOP is capable of transmitting an optical image from one surface to another without causing any image distortion.

Structure of FOP



SELECTION GUIDE (by wavelength)

THIRD GENERATION

Type No.	Spectral Response Range (nm)	Wavelength of Peak Response ^(A) (nm)	Input Window ^(C)	Photocathode	Effective Photocathode Area (mm)	Number of MCP
V7090○-71	370 to 920	600 to 700	Borosilicate Glass	GaAs	13.5 × 10	1 stage MCP 2 stage MCP
V9569○-71					16 × 16	1 stage MCP 2 stage MCP
V8070○-73	280 to 820	480 to 530	Borosilicate Glass	Extended Red GaAsP	13.5 × 10	1 stage MCP 2 stage MCP
V9501○-73					16 × 16	1 stage MCP 2 stage MCP
V8070○-74	280 to 720	480 to 530	Borosilicate Glass	GaAsP	13.5 × 10	1 stage MCP 2 stage MCP
V9501○-74					16 × 16	1 stage MCP 2 stage MCP
V8071○-76	360 to 1100	700 to 800	Borosilicate Glass	InGaAs	13.5 × 10	1 stage MCP 2 stage MCP
V6833P	370 to 920	600 to 700	Borosilicate Glass	GaAs	φ17.5	1 stage MCP
V6833P-G						1 stage MCP
V7090P						1 stage MCP

SECOND GENERATION

Suffix	Spectral Response Range (nm)	Wavelength ^(B) of Peak Response (nm)	Input Window	Photocathode	Effective Photocathode Area		
					Gate Function ^(D)	φ18 mm	
						non	
					NOTE	High Resolution	—
					1 stage MCP	V6886U	—
					2 stage MCP	—	V4170U
—	160 to 900	430	Synthetic Silica	Multialkali	1 stage MCP	○	/
					2 stage MCP	/	○
-01	160 to 950	630	Synthetic Silica	Extended Red Multialkali	1 stage MCP	○*	/
					2 stage MCP	/	○*
-02	160 to 650	400	Synthetic Silica	Bialkali	1 stage MCP	○*	/
					2 stage MCP	/	○*
-03	160 to 320	230	Synthetic Silica	Cs-Te	1 stage MCP	○*	/
					2 stage MCP	/	○*

○...Standard product *: Manufactured upon receiving your order

NOTE: (A) This value is for quantum efficiency.

(B) This value is for radiant sensitivity.

(C) Feel free to contact our sales office for availability of FOP or MgF₂ input window.

(D) Minimum gate time

TYPE NO. GUIDE

Hamamatsu second generation image intensifiers are classified by series type No. and suffix No. When you consult with our sales office about a product or place an order, please carefully refer to the characteristics listed in the spec table.

If you need custom devices (using a different window or phosphor screen material, low resistance MCP, transparent conductive film (NESA), special case potting), please let us know about your special requests.

V○○○○U - ○○
Series Type No. Suffix No.

THIRD GENERATION

Type No.		Suffix	Spectral Response Range (nm)	Stage of MCP	Gate ③ Function	Input Window ⑤ /Index of Refraction n	Photocathode Material	Standard Phosphor Screen	Standard Output Window	Luminous Sensitivity (μA/lm)
Effective Photocathode Area										
13.5 mm × 10 mm ^①	16 mm × 16 mm ^①									
V7090U/D	—	-71	370 to 920	1	Both types are available	Borosilicate Glass /1.49 *1	GaAs	P43	FOP	1500
—	V9569U/D	-71	370 to 920	2						
—	V9569U/D	-71	370 to 920	1	Both types are available	Borosilicate Glass /1.49 *1	GaAs	P43	FOP	1100
V8070U/D	—	-73	280 to 820	1	Both types are available	Borosilicate Glass /1.49 *1	Extended Red GaAsP	P43	FOP	800
		-74	280 to 720	1						
—	V9501U/D	-73	280 to 820	1	Both types are available	Borosilicate Glass /1.49 *1	Extended Red GaAsP	P43	FOP	750
		-74	280 to 720	1						
V8071U/D	—	-76	360 to 1100	1	Both types are available	Borosilicate Glass /1.49 *1	InGaAs	P43	FOP	200
V6833P, V7090P ^②		Non-Suffix	370 to 920	1	×	Borosilicate Glass /1.49 *1	GaAs	P43	FOP	1500
V6833P-G ^②					○ ^④					

SECOND GENERATION

Type No.		Suffix	Spectral Response Range (nm)	Stage of MCP	Gate ③ Function	Input Window ⑤ /Index of Refraction n	Photocathode Material	Standard Phosphor Screen	Standard Output Window	Luminous Sensitivity (μA/lm)
Effective Photocathode Area										
φ18 mm	φ25 mm									
V6886U	V7669U	Non-Suffix	160 to 900	1	×	Synthetic Silica /1.46 *2	Multialkali	P43	FOP	280
V6887U	V7670U				○					230
V4170U	V10308U			×	170					
V4183U	V10309U			○	150					
V6886U	V7669U	-01	160 to 950	1	×	Synthetic Silica /1.46 *2	Extended red Multialkali	P43	FOP	550
V6887U	V7670U				○					360
V4170U	V10308U			×	360					
V4183U	V10309U			○	250					
V6886U	V7669U	-02	160 to 650	1	×	Synthetic Silica /1.46 *2	Bialkali	P43	FOP	50
V6887U	V7670U				○					40
V4170U	V10308U			×	50					
V4183U	V10309U			○	40					
V6886U	V7669U	-03	160 to 320	1	×	Synthetic Silica /1.51 *3	Cs-Te	P43	FOP	—
V6887U	V7670U				○					—
V4170U	V10308U			×	—					
V4183U	V10309U			○	—					

Above characteristics are measured using a P43 phosphor screen.

NOTE: ① Photocathode area other than effective area is not guaranteed.

② Effective Photocathode Area: φ17.5 mm

③ ○: available, ×: not available

④ Auto gating function

⑤ Wavelength used measure refractive index: *1: 588 nm, *2: 589.6 nm, *3: 254 nm

⑥ Typical values measured at the wavelength of peak response (-76 at 1 μm)

⑦ Typical values measured at 20 °C

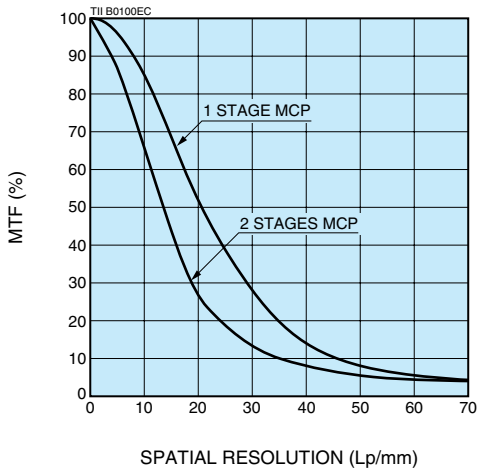
(These specifications shown in this table are typical value.)

Wavelength of Peak Response				Gain		Equivalent Background Input (EBI) ^⑦		Limiting Resolution (Lp/mm)	Operation Storage Ambient Temperature (°C)	Maximum Shock	Maximum Vibration		
Radiant Sensitivity		Quantum Efficiency (QE)		Luminous Gain	Radiant Emittance Gain ^⑥	(lm/cm ²)	(W/cm ²) ^⑥						
(mA/W)	(nm)	(%)	(nm)	[(lm/m ²)/lx]	[(W/m ²)/(W/m ²)]								
170	700 to 800	30	600 to 700	4.0 × 10 ⁴	1.2 × 10 ⁴	2 × 10 ⁻¹¹	4 × 10 ⁻¹⁴	64	-20 to +40 -55 to +60	300 m/s ² (30G), 18 ms	10 Hz to 55 Hz 0.7 mm (p-p)		
				9.6 × 10 ⁶	2.7 × 10 ⁶			57					
147	700 to 800	22	600 to 700	3.3 × 10 ⁴	9.0 × 10 ³			57					
192	530 to 580	45	480 to 530	2.5 × 10 ⁴	1.3 × 10 ⁴	3 × 10 ⁻¹²	8 × 10 ⁻¹⁵	64					
				5.7 × 10 ⁶	3.0 × 10 ⁶			57					
214	530 to 580	50	480 to 530	2.2 × 10 ⁴	1.4 × 10 ⁴								64
				5.0 × 10 ⁶	3.4 × 10 ⁶			57					
171	530 to 580	40	480 to 530	2.3 × 10 ⁴	1.2 × 10 ⁴								57
192	530 to 580	45	480 to 530	2.0 × 10 ⁴	1.3 × 10 ⁴								57
8	750 to 850	1	700 to 800	7.0 × 10 ³	4.6 × 10 ²	3 × 10 ⁻¹⁰	9 × 10 ⁻¹²	64					
170	700 to 800	30	600 to 700	4.0 × 10 ⁴	1.2 × 10 ⁴	2 × 10 ⁻¹¹	4 × 10 ⁻¹⁴	64					

Wavelength of Peak Response				Gain		Equivalent Background Input (EBI) ^⑦		Limiting Resolution (Lp/mm)	Operation Storage Ambient Temperature (°C)	Maximum Shock	Maximum Vibration
Radiant Sensitivity		Quantum Efficiency (QE)		Luminous Gain	Radiant Emittance Gain ^⑥	(lm/cm ²)	(W/cm ²) ^⑥				
(mA/W)	(nm)	(%)	(nm)	[(lm/m ²)/lx]	[(W/m ²)/(W/m ²)]						
62	430	18	410	1.2 × 10 ⁴	8.7 × 10 ³	1 × 10 ⁻¹¹	3 × 10 ⁻¹⁴	64	-20 to +40 -55 to +60	300 m/s ² (30G), 18 ms	10 Hz to 55 Hz 0.7 mm (p-p)
53		15		1.1 × 10 ⁴	6.8 × 10 ³						
60		17		5 × 10 ⁶	4 × 10 ⁶						
47		14		4 × 10 ⁶	3 × 10 ⁶			57			
45	630	9.3	600	2.5 × 10 ⁴	6.2 × 10 ³	3 × 10 ⁻¹¹	2 × 10 ⁻¹⁴	64			
42		8.7		2.1 × 10 ⁴	5.3 × 10 ³						
43		8.9		1 × 10 ⁷	3 × 10 ⁶						
40		8.3		8 × 10 ⁶	2 × 10 ⁶			57			
50	400	14	380	3.1 × 10 ³	7 × 10 ³	5 × 10 ⁻¹³	5 × 10 ⁻¹⁶	50			
40		12		2.5 × 10 ³	5.9 × 10 ³						
50		14		1 × 10 ⁶	4 × 10 ⁶						
40		12		1 × 10 ⁶	3 × 10 ⁶			45			
20	230	11	220	—	2.6 × 10 ³	—	1 × 10 ⁻¹⁵	40			
15		8		—	2 × 10 ³						
20		11		—	1 × 10 ⁶						
15		8		—	7.5 × 10 ⁵			28			

Figure 7: MTF

Second Generation



Third Generation

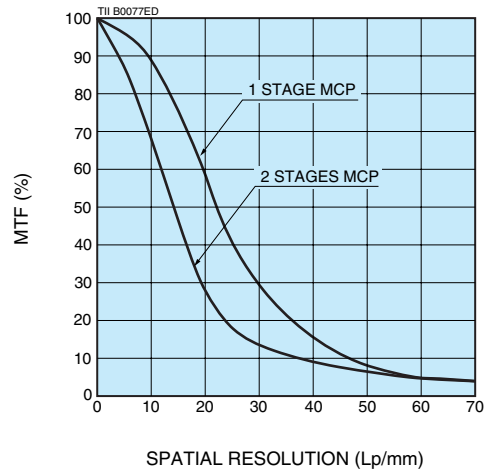


Figure 8: Luminous Gain vs. MCP Voltage (V8070 Series)

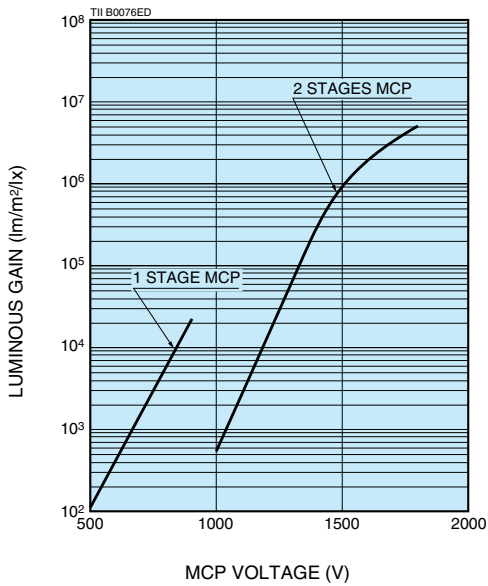


Figure 9: Equivalent Background Input (EBI) vs. Temperature

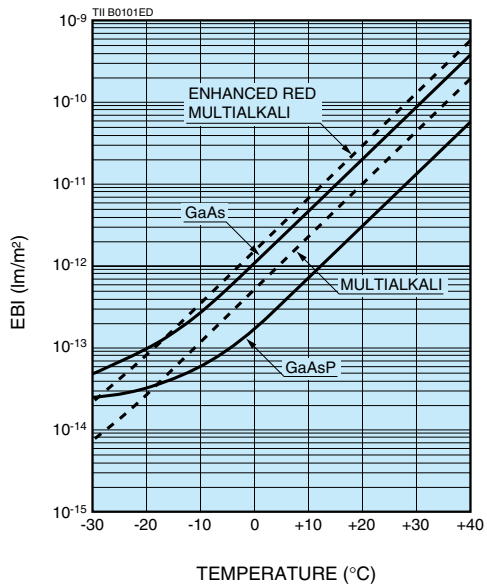


Figure 10: Photocathode Illuminance vs. Phosphor Screen Luminous Emittance

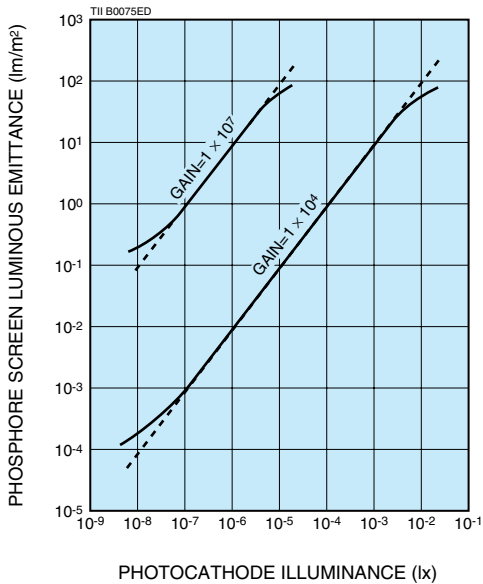
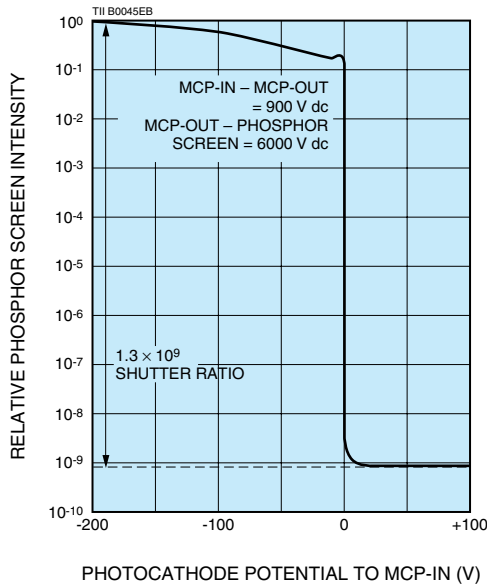


Figure 11: Shutter Ratio (color temperature: 2856 K)



Recommended Operation (Example)

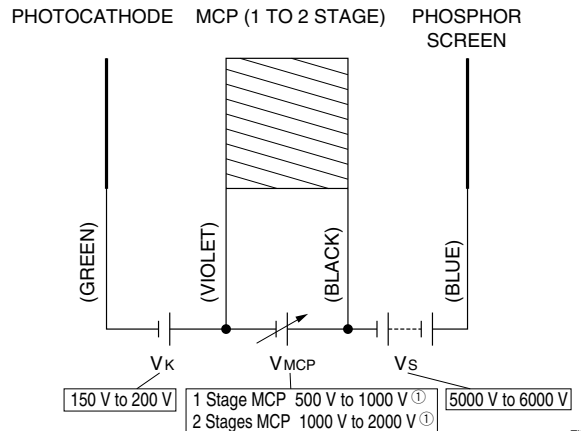
Normal Operation

Supply Voltage (See Figure 12.)

Photocathode – MCP-in (V_k)	150 V to 200 V
MCP-in – MCP-out (V_{MCP}) ^① 1 Stage MCP	500 V to 1000 V
 2 Stages MCP	1000 V to 2000 V
MCP-out – Phosphor Screen (V_s)	5000 V to 6000 V

NOTE: ① The maximum supply voltage and recommended supply voltage for the MCP-in and MCP-out are noted on the test data sheet when the products is delivered. Please refer to the test data sheet for these values.

Figure 12: Normal Operation



NOTE: A compact high-voltage power supply is available. (See page 15.) Any electrode (for photocathode, MCP and phosphor screen) can be connected to ground potential.

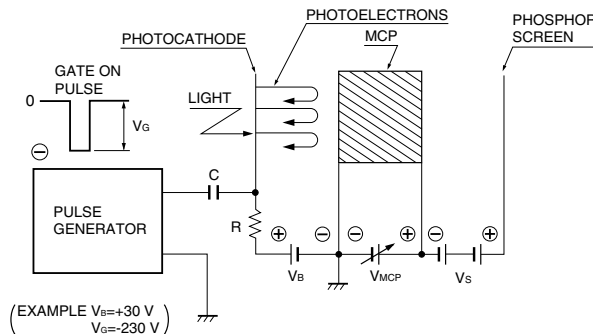
Gate Operation

There are two basic circuits for gate operation as shown in Figure 13 below. The supply voltages V_{MCP} and V_s are the same as those in normal operation. Gate operation is controlled by changing the bias voltage (V_B) between the photocathode and MCP-in.

Figure 13: Gate Operation

Normally-OFF mode

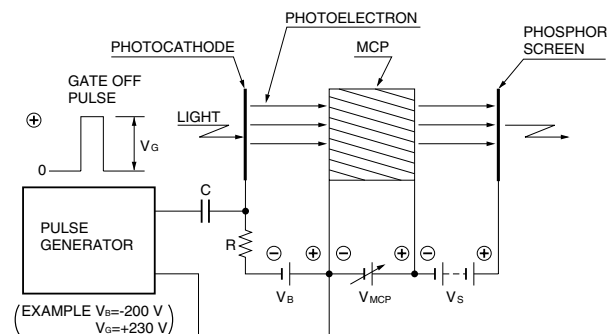
The V_B is constantly applied as a reverse bias to the photocathode, so no image appears on the phosphor screen. An image appears only when a gate pulse (V_G) is applied to the photocathode.



TII C0018EC

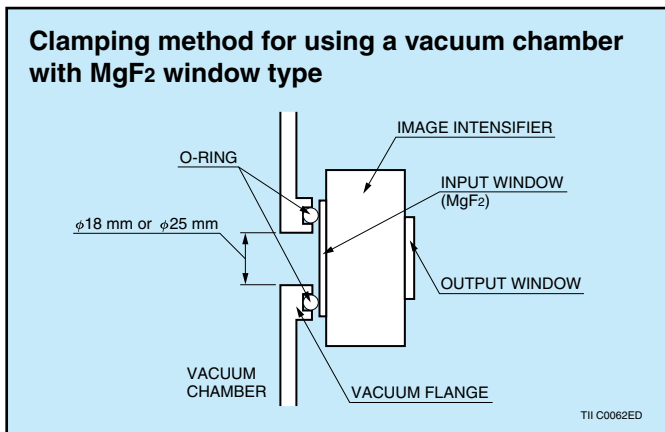
Normally-ON mode

The V_B is constantly applied as a forward bias to the photocathode, so an image is always seen on the phosphor screen during operation. The image disappears only when a gate pulse (V_G) is applied to the photocathode.



TII C0019EF

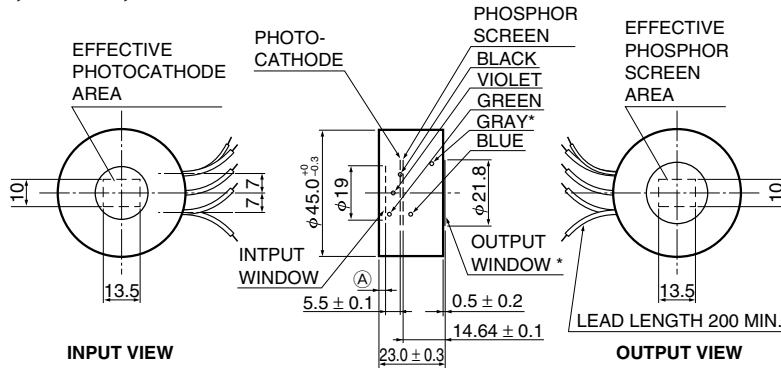
C, R: Chose the value in consideration of pulse width and repetition rate.
C: High voltage type.



TII C0062ED

V7090U/D series, V8070U/D series, V8071U/D series (Effective photocathode area: 13.5 mm × 10 mm)

V7090U, V8070U, V8071U series

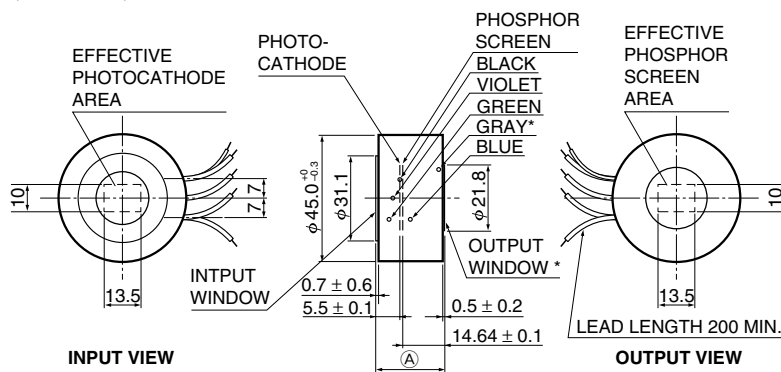


MCP	(A)
1 stage	1.8 ± 0.6
2 stages	1.3 ± 0.6

LEAD (COVER: PTFE [Polytetrafluoroethylene])
 GREEN (PHOTOCATHODE)
 VIOLET (MCP-IN)
 BLACK (MCP-OUT)
 BLUE (PHOSPHOR SCREEN)
 GRAY (NESA/GND)*
 *ONLY WITH TRANSPARENT CONDUCTIVE COATING (NESA)
 CASE MATERIAL: POM (POLY OXY METHYIENE)

TII A0043EE

V7090D, V8070D, V8071D series



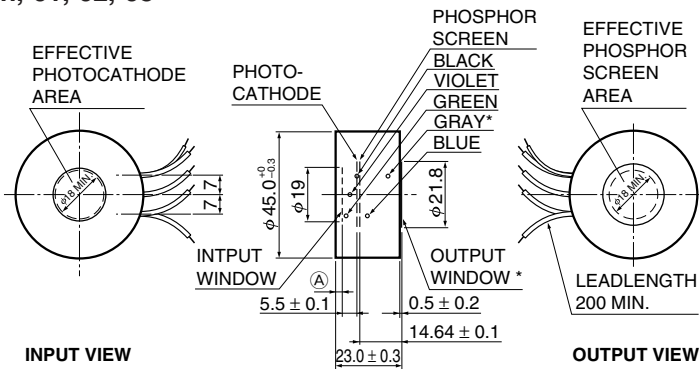
MCP	(A)
1 stage	21.2 ± 0.5
2 stages	21.7 ± 0.5

LEAD (COVER: PTFE [Polytetrafluoroethylene])
 GREEN (PHOTOCATHODE)
 VIOLET (MCP-IN)
 BLACK (MCP-OUT)
 BLUE (PHOSPHOR SCREEN)
 GRAY (NESA/GND)*
 *ONLY WITH TRANSPARENT CONDUCTIVE COATING (NESA)
 CASE MATERIAL: POM (POLY OXY METHYIENE)

TII A0059EG

V6886U, V6887U, V4170U, V4183U series

Suffix: Non,-01,-02,-03

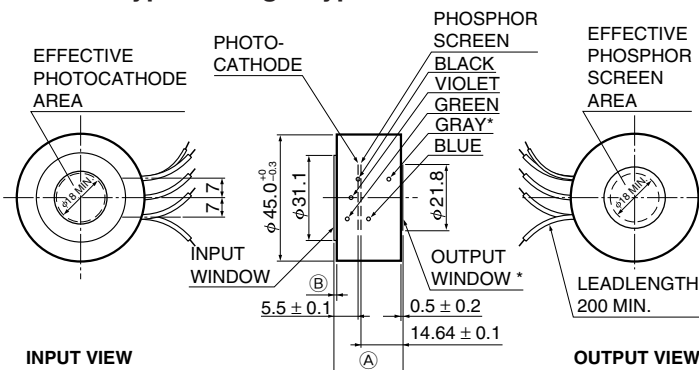


TYPE No.	(A)
V6886U, V6887U	1.7 ± 0.6
V4170U, V4183U	1.3 ± 0.7

LEAD (COVER: PTFE [Polytetrafluoroethylene])
 GREEN (PHOTOCATHODE)
 VIOLET (MCP-IN)
 BLACK (MCP-OUT)
 BLUE (PHOSPHOR SCREEN)
 GRAY (NESA/GND)* *ONLY WITH TRANSPARENT CONDUCTIVE COATING (NESA)
 CASE MATERIAL: POM (POLY OXY METHYIENE)

TII A0033EF

Input window: FOP type and MgF₂ type



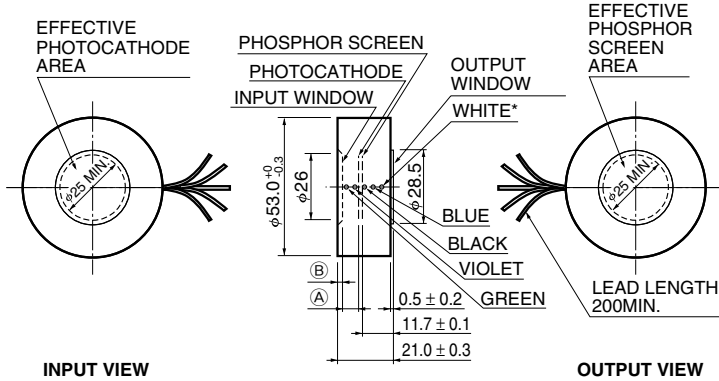
TYPE No.	(A)	(B)
V6886U, V6887U	21.3 ± 0.5	0.8 ± 0.6
V4170U, V4183U	21.7 ± 0.6	0.7 ± 0.7

LEAD (COVER: PTFE [Polytetrafluoroethylene])
 GREEN (PHOTOCATHODE)
 VIOLET (MCP-IN)
 BLACK (MCP-OUT)
 BLUE (PHOSPHOR SCREEN)
 GRAY (NESA/GND)* *ONLY WITH TRANSPARENT CONDUCTIVE COATING (NESA)
 CASE MATERIAL: POM (POLY OXY METHYIENE)

TII A0034EG

V7669U, V7670U, V10308U, V10309U series

Suffix: Non,-01,-02,-03



TYPE No.	A	B
V7669U, V7670U	5.94 ± 0.1	2.2 ± 0.6
V10308U, V10309U	5.53 ± 0.1	2.1 ± 0.7

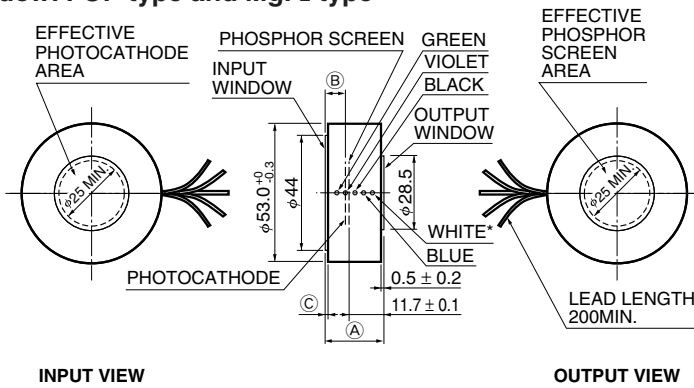
LEAD (COVER: PTFE [Polytetrafluoroethylene])
 GREEN (PHOTOCATHODE)
 VIOLET (MCP-IN)
 BLACK (MCP-OUT)
 BLUE (PHOSPHOR SCREEN)
 WHITE (NESA/GND)*

*ONLY WITH TRANSPARENT CONDUCTIVE COATING (NESA)

CASE MATERIAL: POM (POLY OXY METHYLENE)

TII A0018ED

Input window: FOP type and MgF₂ type



TYPE No.	A	B	C
V7669U, V7670U	18.8 ± 0.5	5.94 ± 0.1	0.8 ± 0.6
V10308U, V10309U	18.9 ± 0.6	5.53 ± 0.1	0.9 ± 0.7

LEAD (COVER: PTFE [Polytetrafluoroethylene])
 GREEN (PHOTOCATHODE)
 VIOLET (MCP-IN)
 BLACK (MCP-OUT)
 BLUE (PHOSPHOR SCREEN)
 GRAY (NESA/GND)*

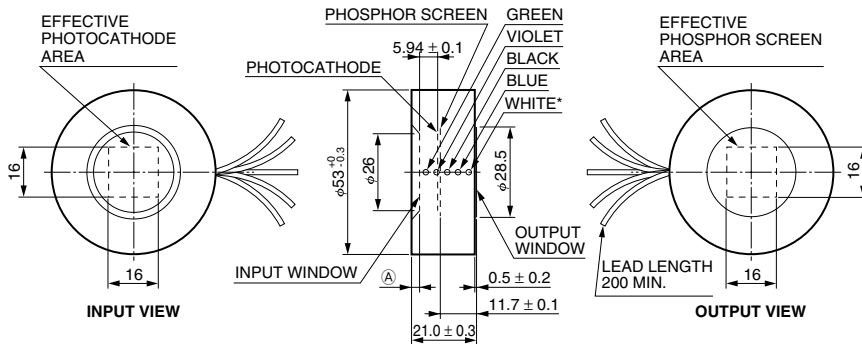
*ONLY WITH TRANSPARENT CONDUCTIVE COATING (NESA)

CASE MATERIAL: POM (POLY OXY METHYLENE)

TII A0046EC

V9501U/D series, V9569U/D series (Effective photocathode area: 16 mm × 16 mm)

V9501U, V9569U series



MCP	A
1 stage	2.2 ± 0.6
2 stage	1.9 ± 0.6

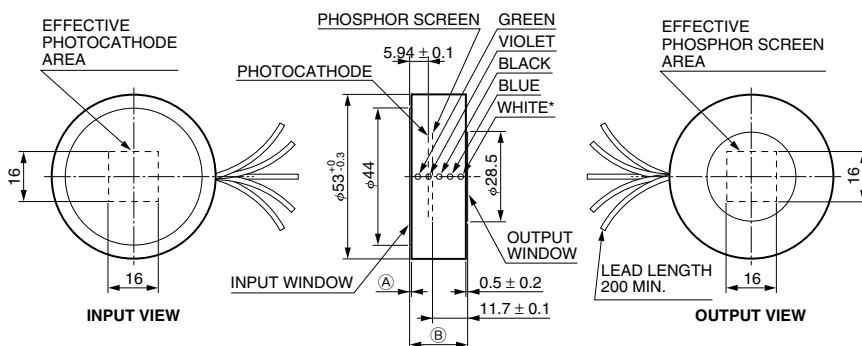
LEAD (COVER: PTFE [Polytetrafluoroethylene])
 GREEN (PHOTOCATHODE)
 VIOLET (MCP-IN)
 BLACK (MCP-OUT)
 BLUE (PHOSPHOR SCREEN)
 WHITE (NESA/GND)*

* ONLY WITH TRANSPARENT CONDUCTIVE COATING (NESA)

CASE MATERIAL: POM (POLY OXY METHYLENE)

TII A0063EB

V9501D, V9569D series



MCP	A	B
1 stage	0.8 ± 0.6	18.8 ± 0.5
2 stage	0.6 ± 0.6	19.1 ± 0.5

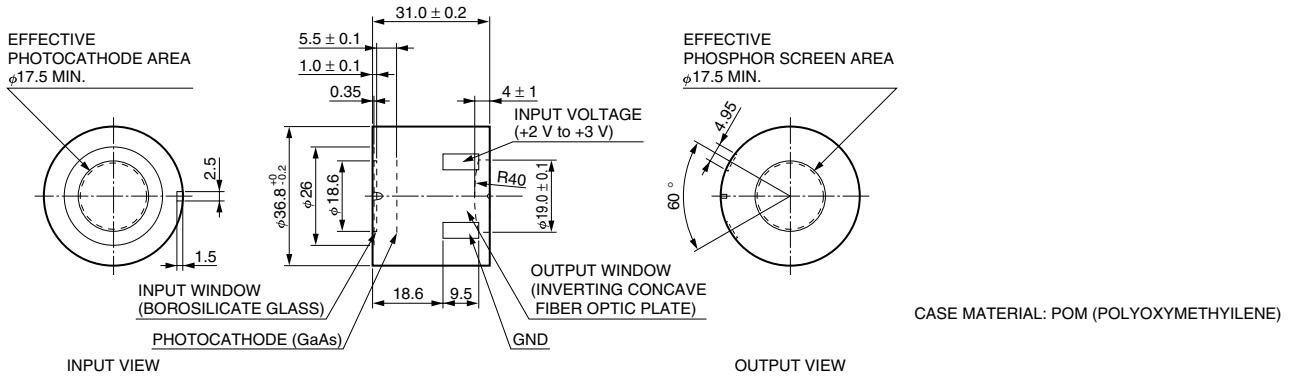
LEAD (COVER: PTFE [Polytetrafluoroethylene])
 GREEN (PHOTOCATHODE)
 VIOLET (MCP-IN)
 BLACK (MCP-OUT)
 BLUE (PHOSPHOR SCREEN)
 WHITE (NESA/GND)*

* ONLY WITH TRANSPARENT CONDUCTIVE COATING (NESA)

CASE MATERIAL: POM (POLY OXY METHYLENE)

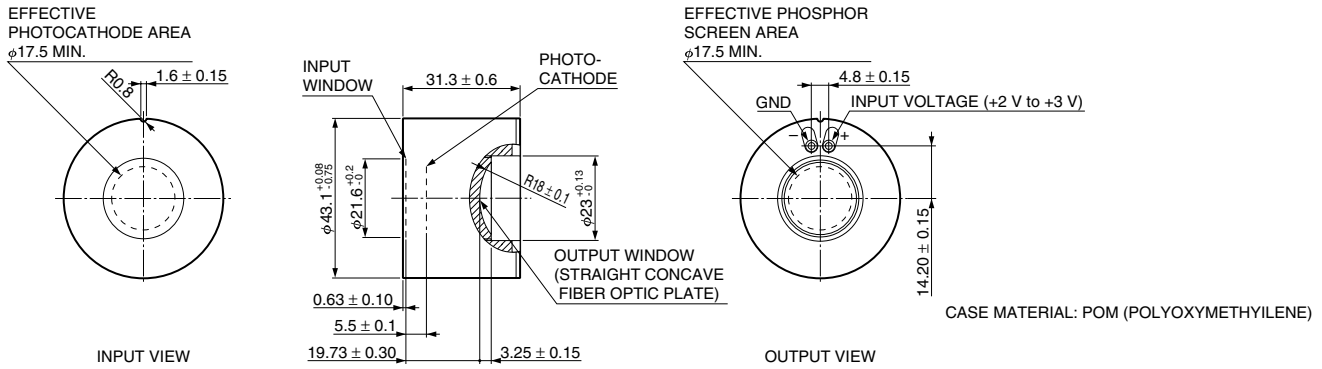
TII A0064EB

V6833P, V6833P-G (Built-in power supply)



TII A0031EE

V7090P (Built-in power supply)



TII A0048EE

● HANDLING PRECAUTIONS AND WARRANTY

HANDLING PRECAUTIONS

- Do not apply excessive shocks or vibrations during transportation, installation, storage or operation. Image intensifiers are an image tube evacuated to a high degree of vacuum. Excessive shocks or vibrations may cause failures or malfunctions. For reshipping or storage, use the original package received from Hamamatsu.
- Never touch the input or output window with bare hands during installation or operation. The window may become greasy or electrical shocks or failures may result.
Do not allow any object to make contact with the input or output window. The window might become scratched.
- Dust or dirt on the input or output window will appear as black blemishes or smudges. To remove dust or dirt, use a soft cloth to wipe the windows thoroughly before operation. If fingerprints or marks adhere to the windows, use a soft cloth moistened with alcohol to wipe off the windows. Never attempt cleaning any part of image intensifiers while it is in operation.
- Never attempt to modify or to machine any part of image intensifiers or power supplies.
- Do not store or use in harsh environments. If image intensifiers is left in a high-temperature, salt or acidic atmosphere for a long time, the metallic parts may corrode causing contact failure or a deterioration in the vacuum level.
- Image intensifiers are extremely sensitive optical devices. When applying the MCP voltage without using an excessive light protective circuit, always increase it gradually while viewing the emission state on the phosphor screen until an optimum level is reached.
- Do not expose the photocathode to strong light such as sunlight regardless of whether in operation or storage.
Operating the image intensifiers while a bright light (e.g. room illumination) is striking the photocathode, might seriously damage the photocathode.
The total amount of photocurrent charge that flows in the photocathode while light is incident during operation has an inverse proportional effect on photocathode life. This means that the amount of incident light should be kept as small as possible.
- Never apply the voltage to image intensifiers exceeds the maximum rating. Especially if using a power supply made by another company, check before making connections to the image intensifier, that the voltage applying to each electrode is correct.
If a voltage in excess of the maximum rating is applied even momentarily, the image intensifier might fail and serious damage might occur.
- Use only the specified instructions when connecting an image intensifier to a high-voltage power supply module.
If the connections are incorrect, image intensifiers might be instantly damaged after the power is turned on. Use high-voltage connectors or solder having a high breakdown voltage. When soldering, provide sufficient insulation at the solder joint by using electrical insulation tape capable of withstanding at least 10 kV or silicon rubber that hardens at room-temperature and withstands at least 20 kV/mm.

WARRANTY

Hamamatsu image intensifiers are warranted for one year from the date of delivery or 1000 hours of actual operation, whichever comes first. This warranty is limited to repair or replacement of the product. The warranty shall not apply to failure or defects caused by natural disasters, misused or incorrect usage that exceeds the maximum allowable ratings.
When ordering, please double-check all detailed information.

SEPARATE POWER SUPPLIES

Hamamatsu offers various types of separate modular power supplies designed to provide the high voltages needed for image intensifier operation. These power supplies are compact, lightweight and operate on a low voltage input. Image intensifier gain is easily controlled by adjusting the control voltage for the MCP voltage or the control resistance. Please select the desired product that matches your application.

FOR DC OPERATION

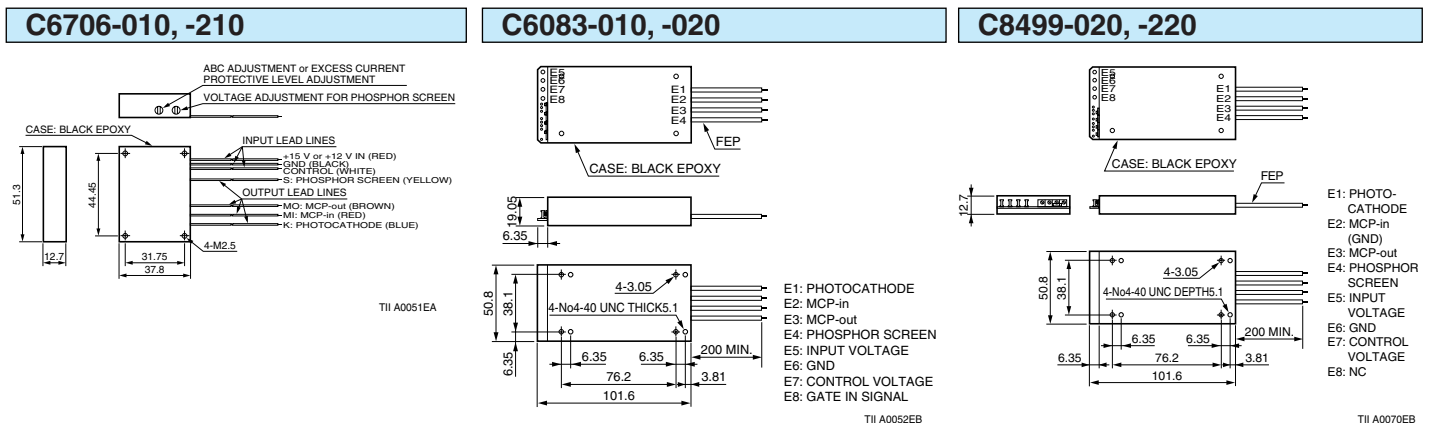
Type No.	Input		MCP Control Voltage (V)	Output				Ground ①	Features	Applicable I.I.				
	Voltage (V)	Max. Current (mA)		Photocathode-MCP-In Voltage (V)	MCP-In-MCP-Out Voltage (V)	Max. Current (μA)	MCP-Out-Phosphor Screen Voltage (V)				Max. Current (μA)			
C6706-010	+15±1.5	60	+5 to +10	-200	500 to 1000	20	6000	MCP-in	ABC (Automatic Brightness Control) ② Excess current (excess light) protective function	V6886U, V7669U V7090○-7○-N1○○○ V8070○-7○-N1○○○ V8071○-7○-N1○○○				
C6706-210	+12±1.2									0.25 to 0.75 0.1 to 1				
C8499-020	+10±0.5	150								1000 to 2000	100	0.05 to 5	ABC (Automatic Brightness Control) ② Excess current (excess light) protective function	V4170U, V10308U V7090○-7○-N2○○○ V8070○-7○-N2○○○
C8499-220														

FOR GATE OPERATION (100 ns to DC operation at maximum repetition rate of 1 kHz)

Type No.	Input		MCP Voltage Control Voltage (V)	Gate Signal Input Level		Output				Ground ①	Features	Applicable I.I.	
	Voltage (V)	Current (mA Max.)		Gate On Voltage (V)	Gate Off Voltage (V)	Photocathode-MCP-In Voltage (V)	MCP-In-MCP-Out Voltage (V)	Max. Current (μA)	MCP-Out-Phosphor Screen Voltage (V)				Max. Current (μA)
C6083-010	+10±0.5	200	+5 to +10	0 (TTL Low)	+5 (TTL High)	-200	500 to 1000	50	6000	0.05 to 5	MCP-in	ABC ②	V6887U, V7670U V7090○-7○-G1○○○ V8070○-7○-G1○○○ V8070○-7○-G1○○○
C6083-020													1000 to 2000

NOTE: ① Other ground terminal types and other input voltage types are also available. Please consult our sales office. ② ABC: Automatic Brightness Control

Dimensional Outlines (Unit: mm)



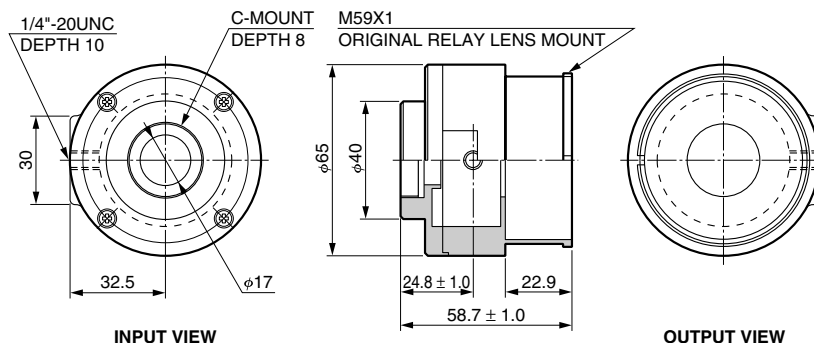
HOUSING CASE A10505

A10505 is a Housing case for easy to use 45mm outer diameter of Image Intensifier (output window: FOP, MCP: 1 stage).

It is available for 1 stage MCP type of V7090U/D, V8070U/D, V8071U/D, V6886U and V6887U series.

Input: C-mount, Output: Hamamatsu's relay lens mount. Screw hole for a tripod can be used for holding.

Dimensional Outlines (Unit: mm)



HIGH-SPEED GATED IMAGE INTENSIFIER UNITS

High-speed gated Image Intensifier (I.I.) unit comprises proximity focused I.I., high voltage power supply and gate driver circuit. Depending on application, a best gated I.I. unit can be selected from among various models.

The built-in I.I. is available with GaAsP photocathode, multialkali photocathode or GaAs photocathode. The GaAsP photocathode type delivers very high quantum efficiency in visible region ideal for bio-/fluorescence imaging application under a microscope. The multialkali photocathode type offers a wide spectral range from UV (Ultra Violet) to NIR (Near Infrared Region). The GaAs photocathode type has high sensitivity from visible region to NIR.

All of gated I.I. units can be operated and controlled from a remote controller or a PC (Personal Computer) via the USB interface. HAMAMTSU also provides suitable relay lenses or CCD camera with FOP window for C9016/C9546 series.



SELECTION GUIDE

Type No.	C9016 -01, -02	C9016 -03, -04	C9016 -05, -06	C9546 -01, -02	C9546 -03, -04	C9546 -05, -06	C9547 -01, -02	C9547 -03, -04	C9547 -05, -06	Unit
Effective Area	φ17 ^①			φ17 ^①			φ25 ^②			mm
Gate Time	10 μs			3 ns			5 ns	10 ns	5 ns	—
Gate Repetition Rate	200 Hz			30 kHz			30 kHz			—
Spectral Response	280 to 720	185 to 900	370 to 920	280 to 720	185 to 900	370 to 920	280 to 720	185 to 900	370 to 920	nm
Photocathode Material	GaAsP	Multialkali	GaAs	GaAsP	Multialkali	GaAs	GaAsP	Multialkali	GaAs	—
Peak QE ^③	50	17	30	50	14	30	45	14	22	%

NOTE: ① Effective output area is 12.8 mm × 9.6 mm. Take the effective area of the camera and reduction rate of the relay lens to be used into account.

② Effective output area is 16 mm × 16 mm. Take the effective area of the camera and reduction rate of the relay lens to be used into account.

③ Typical at peak wavelength.

ICCD CAMERA WITH HIGH-SPEED ELECTRONIC SHUTTER C10054 SERIES

The C10054 series is an easy to use compact camera housing an image intensifier fiber-coupled to a CCD, as well as a CCD drive circuit, high-voltage power supply and high-speed gate circuit. The C10054 series makes it easy to measure low-light-levels and capture images of various high-speed phenomena.

A wide lineup of 18 models are currently provided allowing you to select multialkali, GaAs or GaAsP photocathodes and the number of MCPs.



SELECTION GUIDE

Type No.			Photocathode Material	Photocathode	Spectral Response (nm)	Stage of MCP	Limiting Resolution (TV line)
TV Format EIA	TV Format CCIR	Non TV Format Progressive Scan					
C10054-01	C10054-11	C10054-21	Borosilicate glass	GaAsP	280 to 720	1	470
C10054-02	C10054-12	C10054-22				2	450
C10054-03	C10054-13	C10054-23	Synthetic silica	Multialkali	185 to 900	1	480
C10054-04	C10054-14	C10054-24				2	420
C10054-05	C10054-15	C10054-25	Borosilicate glass	GaAs	370 to 920	1	470
C10054-06	C10054-16	C10054-26				2	450

HAMAMATSU

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

www.hamamatsu.com

Main Products

Electron Tubes

Photomultiplier Tubes
Photomultiplier Tube Modules
Microchannel Plates
Image Intensifiers
Xenon Lamps / Mercury Xenon Lamps
Deuterium Lamps
Light Source Applied Products
Laser Applied Products
Microfocus X-ray Sources
X-ray Imaging Devices

Opto-semiconductors

Si photodiodes
APD
Photo IC
Image sensors
PSD
Infrared detectors
LED
Optical communication devices
Automotive devices
X-ray flat panel sensors
Mini-spectrometers
Opto-semiconductor modules

Imaging and Processing Systems

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