PROXITRONIC

High Performance

Image Intensifiers

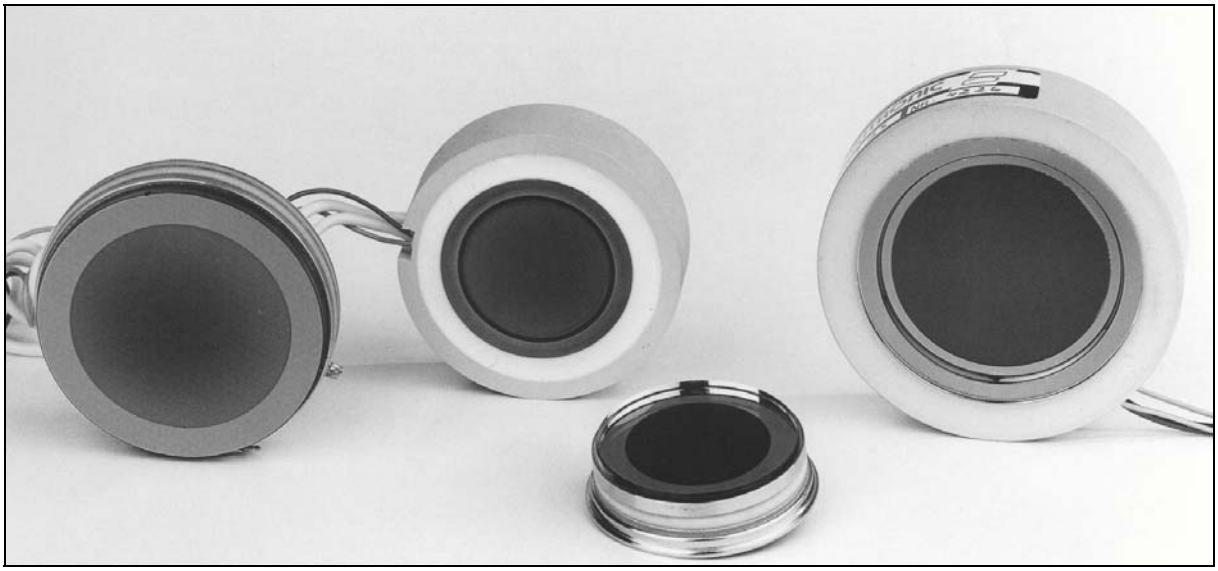


Image Intensifier Diodes PROXIFIER® and MCP Image Intensifiers MCP-PROXIFIER®

Features

- Outstanding gain up to > 10^8 W/W
- Excellent Resolution up to 80 Line Pairs/mm
- Ultra Short Gating from < 3 ns
- Completely Distortion Free Image Amplification and Spectral Conversion
- High Uniformity of Gain and Resolution Over the Entire Useful Area
- Proximity Focused Imaging
- 0,1, 2, or 3 Stack MCPs
- High Quantum Efficiency up to 35 %
- Wide Spectral Sensitivity from Vacuum Ultraviolet (110 nm / 165 nm) to Near Infrared (900 nm)
- Large Dynamic Range up to 10^6:1
- Absolutely Unaffected by Electromagnetic Stray Fields
- Direct Fiber Optic Coupling to Any CCD Possible
- Useful Diameters 25 mm and 40 mm
- (Please note: Not all features can be realized in one single image intensifier.)

Applications

- Low Light Level Imaging
- Spectroscopy
- Fluorescence
- Astronomy
- High Speed Imaging
- Single Photon Counting
- Defense / Missile Warning
- UV / Solar Blind Detection

Introduction

PROXITRONIC is the world wide leading manufacturer of proximity focus image intensifiers. Since the establishment of the company in 1978 more than 50.000 image intensifier diodes, PROXIFIER®, and MCP image intensifiers MCP-PROXIFIER® have been manufactured.

PROXIFIERS® and MCP-PROXIFIERS® are the first image intensifiers available which successfully achieve an absolutely distortion-free image conversion with high gain, high resolution, and high contrast in the spectral range from vacuum UV to near infrared over the entire 25 mm and 40 mm, respectively, useful diameter.

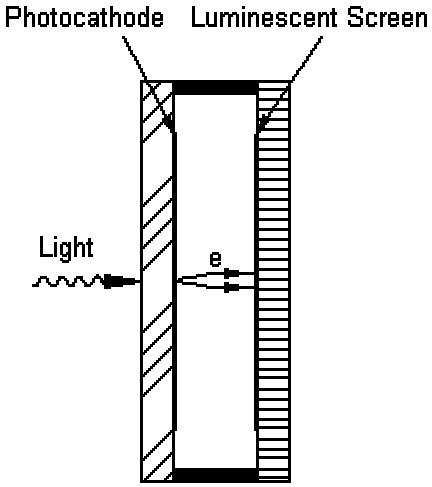
PROXITRONIC successfully succeeded in applying safely electrical voltages of up to 15 kV between the photocathode and the phosphor screen of the image intensifier diodes PROXIFIER®. Special materials and manufacturing processes ensure that light passing through the semitransparent photocathode is wide-band absorbed by an absorption layer and is not reflected back to the photocathode.

High field strengths and efficient light absorption in the entire spectral range enable spectral conversion and image intensification of outstanding quality.

Operational Principle

Proximity focus image intensifier diodes, PROXIFIER®, and MCP image intensifiers, MCP-PROXIFIER®, are high vacuum tubes which consist of a photocathode and a fluorescent screen (phosphor screen). MCP-PROXIFIERS® possess an additional 1 to 3 microchannel plates (MCPs). The operation is based on

- the photoelectric effect in the photocathode,
- electron multiplication in a microchannel plate (MCP-PROXIFIERS® only),
- the reinforcement of the kinetic energy of the photoelectrons in an electrical acceleration field, and
- the production of light by fluorescence in the phosphor screen.



Proximity focus image intensifier PROXIFIER® (1st generation image intensifier)

Light impinges upon the photocathode through the input window of the image intensifier. Due to the photoelectric effect, electrons are produced which escape from the photocathode with very little energy. By a high potential electrical acceleration field between photocathode and phosphor screen of 10 kV to 15 kV, the electrons are strongly accelerated and, at the same time, closely focused. They strike the phosphor screen with high kinetic energy and stimulate fluorescence.

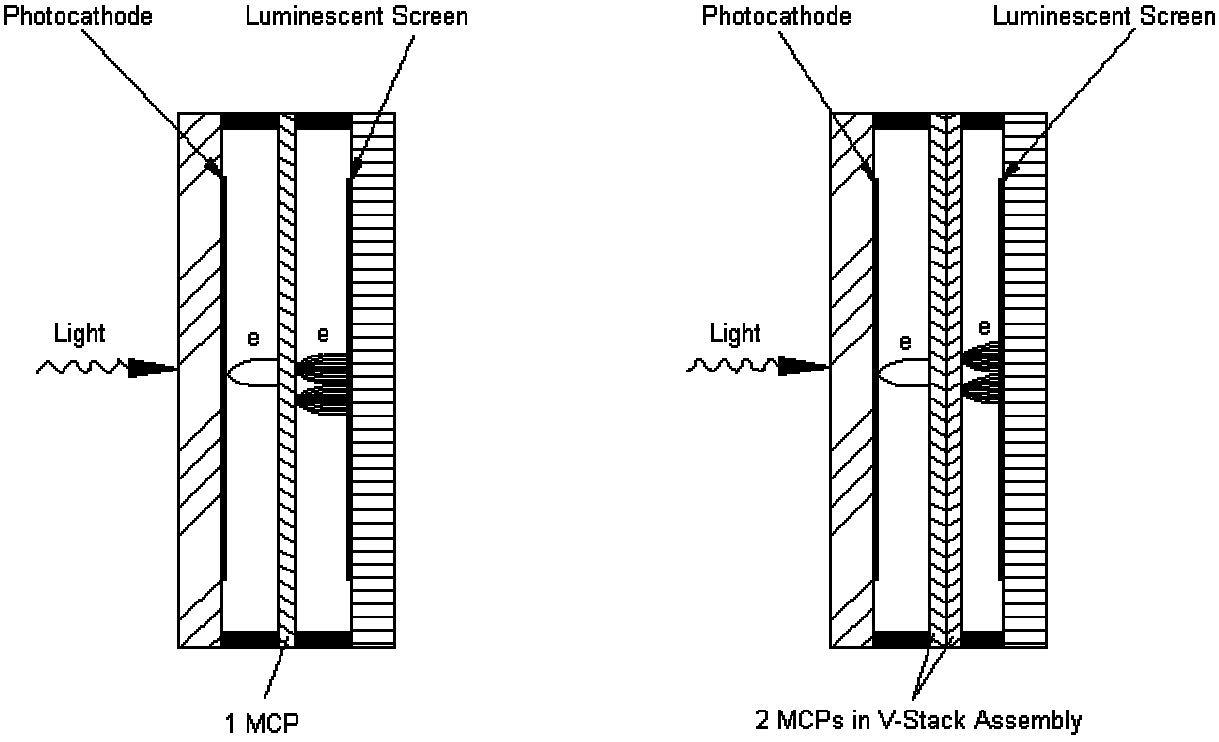
The fluorescent screen is covered on its upper side, which is turned facing the photocathode, with two layers:

1. An aluminum reflection layer deposited directly on the phosphor screen which prevents fluorescence light which is emitted from the phosphor screen to be returned to the photocathode, and which, at the same time, increases the luminous efficiency.
2. A special absorption layer above the aluminum reflection layer which gathers in the light passing through the semitransparent photocathode wide-band and suppresses unwanted reflections.

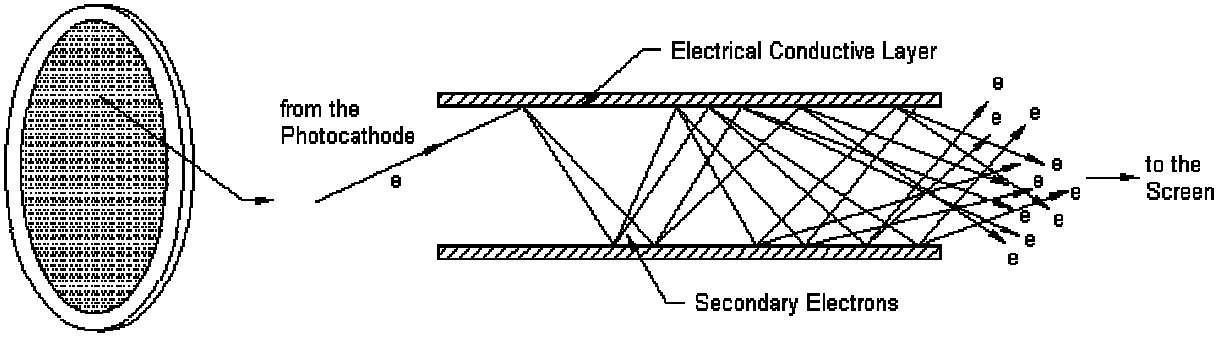
The photoelectrons lose about 3 keV kinetic energy when penetrating these two layers.

The photocathode of a proximity focus image intensifier diode, PROXIFIER®. is normally at ground potential. Thus, unwanted high voltage excitations of air molecules, which lead to UV emission (Corona effect), are avoided. As a result, PROXIFIERS® can be also used problem-free in the UV range. Depending upon version, 10 kV to 15 kV are applied to the phosphor screen.

MCP image intensifiers, MCP-PROXIFIER®, correspond to diode image intensifiers, PROXIFIERS®, in their structure and operation principle. By installation of up to 3 microchannel plates between photocathode and phosphor screen, the number of electrons which impinge upon the phosphor screen is multiplied up to 1000 electrons/electron per MCP by secondary electron emission in the channels of the MCP. Thus, a spectral gain up to > 10^8 W/W may be achieved. The dynamic range and the resolution are reduced, however, because a MCP shows saturation at high photo current and at high MCP voltage. In addition, the channels of a MCP have 10 µm (standard MCPs) or 6 µm (high resolution MCPs) diameter.



Proximity focus MCP image intensifiers MCP-PROXIFIER®
(2nd generation image intensifiers)



Electron multiplication in a microchannel plate (MCP)

The photocathode is at -200 V so that Corona effects cannot occur.

The accelerating voltage between MCP output and phosphor screen is 6 kV.

Basic Versions

PROXITRONIC manufactures proximity focus image intensifiers, PROXIFIER®, and MCP image intensifiers, MCP-PROXIFIER®, with 25 mm and 40 mm useful diameters. Different basic versions are available which are characterized by the possible combinations of the window materials - optical clear glass (hard glass, quartz, or magnesium fluorid) and fiber optic (plate or taper).

Besides, each proximity focus image intensifier, PROXIFIER®, is offered in 3 versions which differ by their spacing between photocathode and phosphor screen as well as by the maximum permitted acceleration voltages.

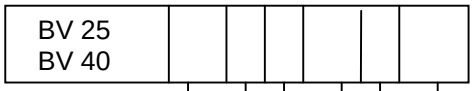
Type	Spacing	Maximum Acceleration Voltage	Resolution	Gain
BV ... 08	0,8 mm	10 kV	maximum	good
BV ... 10	1,0 mm	12 kV	very good	very good
BV ... 18	1,8 mm	15 kV	good	maximum

Details can be inferred from the type key.

Available photocathode types are: Advanced Solar Blind, Bialkali, UV Enhanced S 20, S 25, and Red Enhanced S 25 which can be combined in any way with the standard phosphor screens P 43, P 46, P 47, P 20, and P 11.

PROXITRONIC is able to supply each customer with the image intensifier best suited for his application.

Type Nomenclature



Diameter
Useful diameter 25 mm
Useful diameter 40 mm

PROXIFIER® Diodes	Without Power Supply	0
	With Integrated Power Supply	3
MCP-PROXIFIER®	Without Power Supply	6
	With Integrated Power Supply	8

Input Window	**Output Window**	
Clear Glass, Quartz, MgF_2	Clear Glass	1
Clear Glass, Quartz, MgF_2	Fiber Optic	2
Fiber Optic	Fiber Optic	3
Fiber Optic	Clear Glass	4
Clear Glass, Quartz, MgF_2	Taper	5
Fiber Optic	Taper	6

Photocathodes	Advanced Solar Blind / Quartz	C
	UV Enhanced S 20 / Quartz or Fiber Optic	T
	Bialkali / Quartz or Fiber Optic	B
	S 20 / MgF_2	V
	S 20 / Quartz	Q
	S 20 / Clear Glass or Fiber Optic	M
	S 25 / Quartz	F
	S 25 / Clear Glass or Fiber Optic	E
	S 25 Red Enhanced / Clear Glass or Fiber Optic	N

Gateability	5 ns	5N
	10 ns	10N
	100 ns	100N
	1000 ns	1000N

Phosphor Screens	P 43	Z
	P 46	X
	P 47	Y
	P 20	G
	P 11	B

Direct Coupling with CCD Sensor (PROXIFIER® diodes only) — Index $_D$, e.g. Z_D

PROXIFIER® (internal operating voltage / photocathode-screen distance)	10 kV / 0,8 mm	08
	12 kV / 1,0 mm	10
	15 kV / 1,8 mm	18

MCP-PROXIFIER®	Double MCP in V-Stack Assembly	-V
	Triple MCP in Z-Stack Assembly	-Z
	High Resolution	-HR
	Extended Dynamic Range	-EDR

Remarks:

- PROXIFIER® diodes are not available with integrated fiber optic taper.
- 40 mm PROXIFIER® diodes are currently manufactured only with photocathode-screen gaps of 1,0 mm and 1,8 mm.
- Gateable PROXIFIER® diodes are offered only with 1,0 mm gaps. In contrast to non-pulsed operation, the operating voltage will be 10 kV instead of 12 kV. The shortest pulse duration is 1 µs.
- The shortest pulse duration of 40 mm MCP-PROXIFIERS® is 10 ns.
- S 20 photocathodes on MgF_2 input window (nomenclature "V") are only available on 25 mm PROXIFIER® diodes.
- Only MCP-PROXIFIER® types BV 2561, BV 2562, BV 2581 and BV 2582 are produced with High Resolution MCPs.

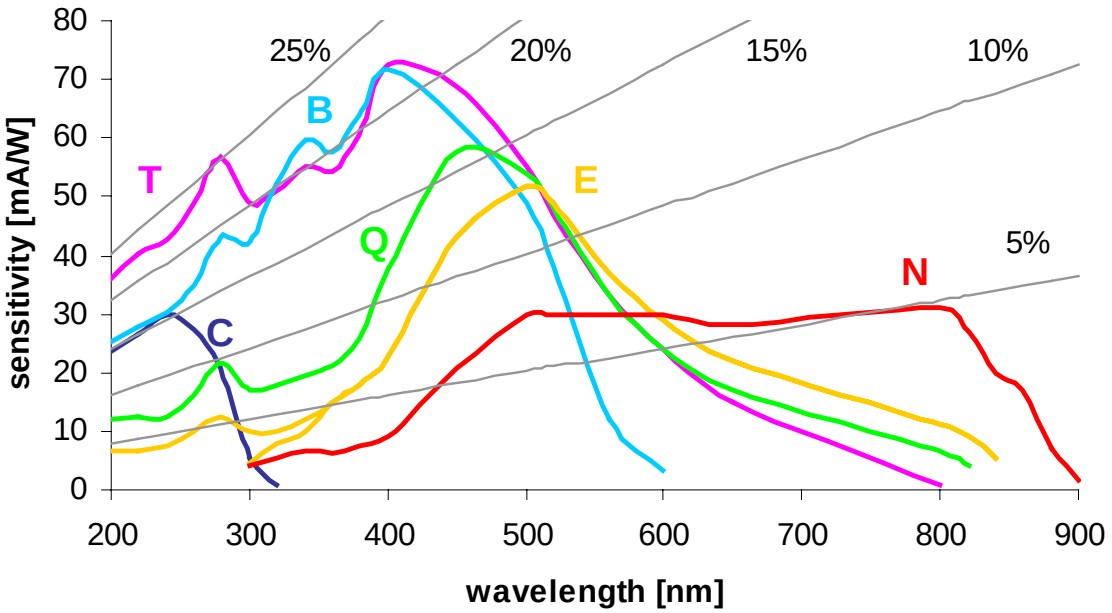
Type Nomenclature Example

BV 2581 QY-V 5N

BV 25	Image intensifier with 25 mm useful diameter
8	MCP image intensifier MCP-PROXIFIER® with integrated power supply
1	Clear input window, clear output window
Q	S 20 photocathode on quartz input window
Y	P 47 phosphor screen
-V	Double MCP in V-stack-assembly
5N	Gateable down to 5 ns

Photocathodes

Spectral Sensitivity *S* (mA/W)



Typical spectral sensitivities of non-gateable photocathodes on clear glass and quartz input windows, respectively

Photocathode / Substrate	Code	Composition	Dark Emission Rate (Electrons/cm^2/sec)
Advanced Solar Blind / Quartz	C	CsTe	3
Bialkali / Quartz	B	K_2SbCs	15
UV Enhanced S 20 / Quartz	T	$(Na_2KSb)Cs$	500
S 20 / Quartz	Q	$(Na_2KSb)Cs$	1500
S 20 / Clear Glass	M	$(Na_2KSb)Cs$	1500
S 25 / Quartz	F	$(Na_2KSb)Cs$	10000
S 25 / Clear Glass	E	$(Na_2KSb)Cs$	10000
Red Enhanced S 25 / Clear Glass	N	$(Na_2KSb)Cs$	30000

- Deviations of up to ± 25 % from the above typical spectral sensitivity curves are possible. The position of the curves can vary ± 20 nm.
- The input window material limits the spectral response of the photocathode in the shorter wavelengths. The window materials and their transmission limits are:
  MgF_2 (110 nm), quartz (165 nm), clear glass (300 nm) and fiber optic (380 nm)
- With the exception of the Advanced Solar Blind all photocathodes are available with fiber optic input windows. As a result of the ratio between core and clad glass of 70:30 there is an approximate 30 % reduction in sensitivity and a spectral response only to wavelengths $\lambda > 380$ nm.
- All photocathodes may be manufactured with an undercoating of an electrically conductive Nickel layer to allow pulsed operation of PROXIFIER® diodes from 1 µs and of MCP-PROXIFIERS® from < 3 ns. Since Nickel absorbs some light, a reduction of 10 % to 15 % will be experienced in the visible spectrum and 30 % to 60 % in UV from 400 nm to 200 nm. The greater the UV sensitivity of a photocathode is, the larger the loss of spectral sensitivity.
- The above referenced dark current values are given for an environmental temperature of 20°C (68°F). A significant reduction in dark current is obtained by cooling at the rate of approximately one-half for each 10°C (18°F) reduction in temperature.
- The spectral sensitivity of an intensifier with Advanced Solar Blind photocathode lies completely inside the shown characteristic curve.
- The Quantum Efficiency *Q* may be calculated from the Spectral Sensitivity *S* as follows
  $Q(\%) = 124 * S(\text{mA/W}) / \lambda(\text{nm})$

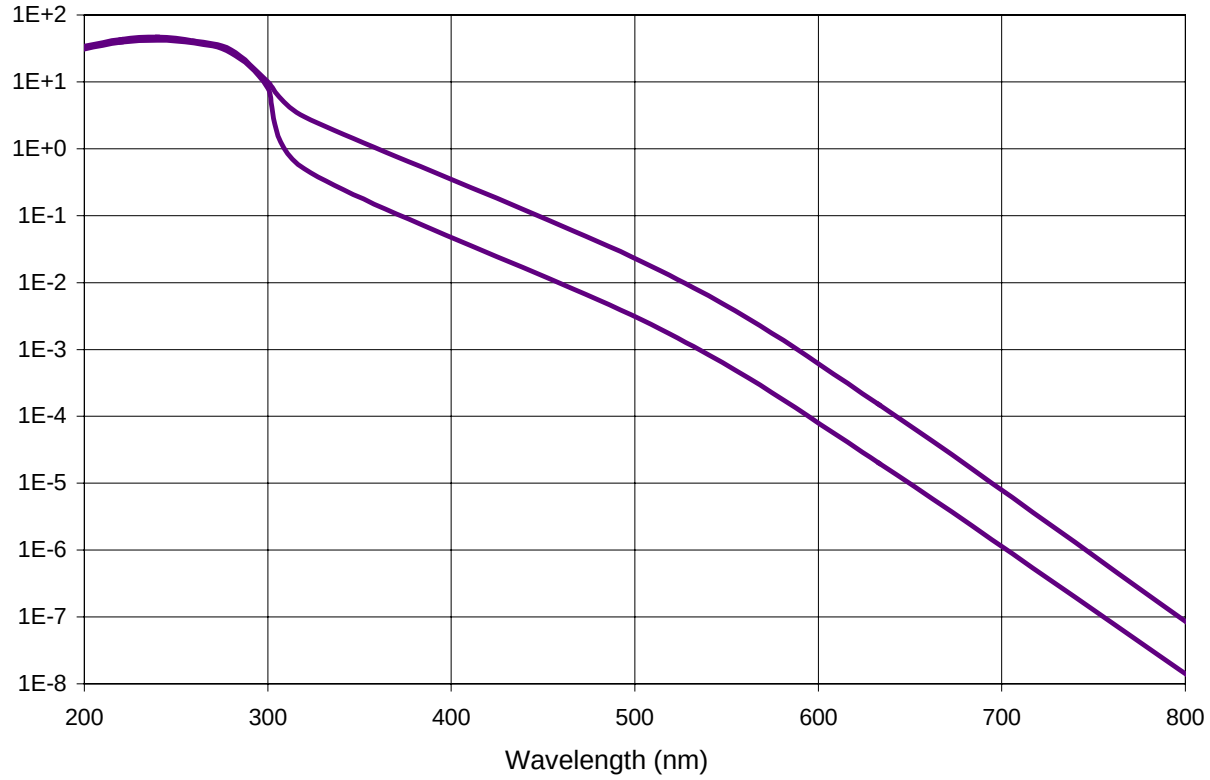
Photocathodes: Typical Spectral Sensitivity *S* (mA/W)

λ (nm)	200	220	240	260	280	300	320	340	360	380	400	450	500	520	560	600	650	800	820	840	860	880	900
C	24	27	30	27	21	5	1																
T	36	40	43	49	57	49	51	55	54	61	72	69	55	47	33	24	15	1					
B	25	28	30	35	43	42	52	60	58	64	72	63	49	38	12	3							
Q	12	12	13	16	21	17	18	20	21	26	38	58	54	48	33	24	17	7	4				
F	7	7	7	10	13	10	10	12	15	18	23	43	52	49	37	29	22	11	9	6			
E						5	8	10	15	18	23	43	52	49	37	29	22	11	9	6			
N						4	5	7	6	7	9	21	30	30	30	30	28	31	27	20	17	7	2

When delivered, the Spectral Sensitivity *S* and the Quantum Efficiency *Q* of an image intensifier are documented from 200 nm to 800 nm (for image intensifiers with quartz input window) and from 400 nm to 800 nm (for image intensifiers with clear glass or fiber optic input window), respectively.

Advanced Solar Blind Photocathode

Spectral Sensitivity *S* (mA/W)



The spectral sensitivity of an intensifier with Advanced Solar Blind photocathode lies completely inside the shown characteristic curve.

Wavelength (nm)	Minimum Sensitivity (mA/W)	Maximum Sensitivity (mA/W)
200	31	34
220	39	43
240	42	47
260	38	41
280	27	30
300	8	10
320	0,5	3
514	$2 \cdot 10^{-3}$	$1{,}5 \cdot 10^{-2}$
633	$2 \cdot 10^{-5}$	$1{,}5 \cdot 10^{-4}$
808	$1 \cdot 10^{-8}$	$6 \cdot 10^{-8}$

The Quantum Efficiency *Q* may be calculated from the Spectral Sensitivity *S* as follows:

$$Q[\%] = S[\mathrm{mA/W}] \cdot \frac{124}{\lambda[\mathrm{nm}]}$$

Phosphor Screens

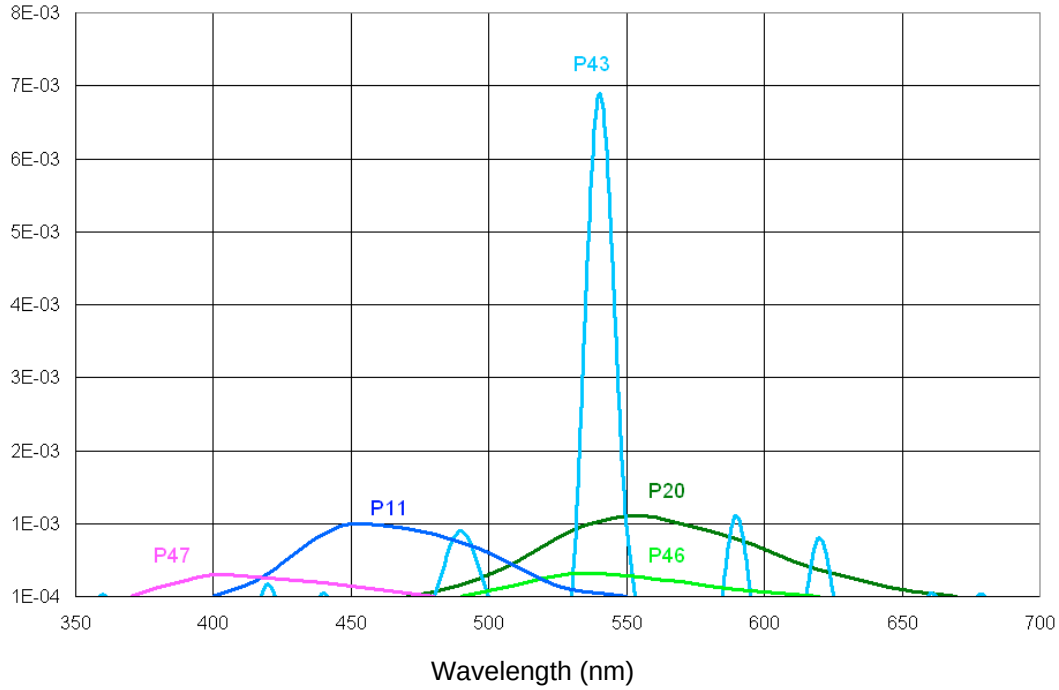
There are three important considerations in choosing a luminous (phosphor) output screen. These are: spectral emission range, efficiency, and phosphor decay time.

Type	Composition	Light Emission				Decay Time	
		Range		Maximum	Color	Decay of Light Intensity	
		from	to	typically at		from 90 % to 10 % in	from 10 % to 1 % in
P 43	Gd_2O_2S:Tb	360 nm	680 nm	545 nm	green	1 ms	1,6 ms
P 46	$Y_3Al_5O_{12}$:Ce	490 nm	620 nm	530 nm	yellow green	300 ns	90 µs
P 47	Y_2SiO_5:Ce,Tb	370 nm	480 nm	400 nm	blue white	100 ns	2,9 µs
P 20	(Zn,Cd)S:Ag	470 nm	670 nm	550 nm	yellow green	4 ms	55 ms
P 11	ZnS:Ag	400 nm	550 nm	450 nm	blue	3 ms	37 ms

Type	Efficiency (lm/µA)				Efficiency (W/mA)				Efficiency (ph/el)			
	6kV	10kV	12kV	15kV	6kV	10kV	12kV	15kV	6kV	10kV	12kV	15kV
P 43	0,24	0,43	0,54	0,71	0,43	0,77	0,97	1,28	185	330	420	550
P 46	0,08	0,15	0,19	0,25	0,22	0,39	0,49	0,65	90	160	200	265
P 47	0,06	0,11	0,14	0,18	0,62	1,35	1,71	2,24	212	380	480	630
P 20	0,25	0,45	0,57	0,75	0,59	1,05	1,33	1,74	240	430	115	715
P 11	0,06	0,10	0,13	0,17	0,56	1,00	1,26	1,66	200	360	455	600
	MCP	PROXIFIER			MCP	PROXIFIER			MCP	PROXIFIER		

Energy conversion of luminous screens (efficiency) as used in MCP-PROXIFIERS® with 6 keV and in PROXIFIER® diodes with 10 keV, 12 keV or 15 keV electron acceleration potentials. (Screen thickness approximately 4-5 µm with an average grain size of 1 µm). The above values are given for fiber optic output screens. A roughly 40 % higher efficiency is obtained with clear glass output screens. The efficiency is subject to a ±15 % variation. (MCP = MCP-PROXIFIER®, ph = photons, el = electron)

Energy Conversion ((W/nm)/W)



General Data of Image Intensifier Diodes PROXIFIER® and MCP Image Intensifiers MCP-PROXIFIER®

Image intensifier type	**BV 25...**	**BV 40...**
Useful diameter	25 mm	40 mm
Magnification	1:1	1:1
Input window	∅ 38 mm ∗ 4 mm or 5,5 mm	∅ 55 mm ∗ 5,5 mm
Clear glass	BK 7	BK 7
Quartz	Suprasil standard	Suprasil standard
MgF_2	MgF_2 (for PROXIFIER® only)	
Fiber optic	Schott 73A-6µ, Philips SQ053, INCOM MEGAdraw MDL	Schott 73A-6µ, Philips SQ053, INCOM MEGAdraw MDL
Output window	∅ 28,5 mm ∗ 5,2 mm / 15 mm	∅ 48 mm ∗ 8 mm / 15 mm
Clear glass	BK 1	BK 1
Fiber optic	Schott 73A-6µ, Philips SQ053, INCOM MEGAdraw MDL	Schott 73A-6µ, Philips SQ053, INCOM MEGAdraw MDL
Diameter	∅ 50 mm or ∅ 75 mm	∅ 70 mm or ∅ 95 mm
Height	19,5 mm or 23 mm	20,8 mm to 23,8 mm
Housing	Noryl plastic	Noryl plastic

All surfaces are grounded. On the output windows grounding is accomplished through the use of an electrically conductive transparent ITO (Indium Tin Oxide) coating. Fiber optic output windows protrude at least 0,2 mm.

Gain

As an example, the characteristics of proximity focused image intensifier diode PROXIFIER® type BV 2502 BZ 10 follows (for explanation of the nomenclature please refer to the section entitled “Type Nomenclature”):

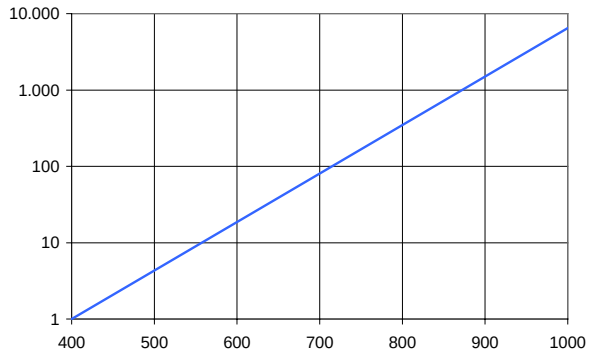
Spectral sensitivity of the Bialkali photocathode at 400 nm	S_B (400 nm) = 104,1 mA/W
Efficiency of the P 43 phosphor screen at 12 kV	E_{P43} (12 kV) = 0,97 W/mA
Spectral amplification at 400 nm $G = S * E$	G = 101 W/W

Thus, it is possible for all other wavelengths, photocathodes, phosphor screens, and acceleration voltages to calculate the light amplification. The amplification of a proximity focused MCP image intensifier MCP-PROXIFIER® type BV 2562 BZ containing 1 microchannel plate (MCP) is:

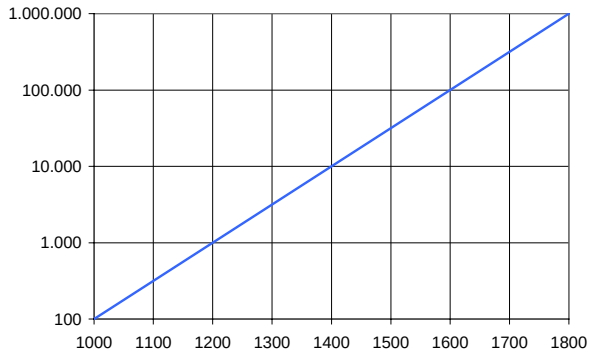
Spectral sensitivity of the Bialkali photocathode at 400 nm	S_B (400 nm) = 104,1 mA/W
Efficiency of the P 43 phosphor screen at 6 kV	E_{P43} (6 kV) = 0,43 W/mA
MCP gain at 800 V	V (800 V) = 350 el/el
Spectral amplification at 400 nm $G = S * E * V$	G = 15670 W/W

If the MCP image intensifier type BV 2562 BZ-V, which employs 2 MCPs in V-stack assembly, utilizes the recommended maximum MCP voltage of 1800 V (MCP gain = 10^6 el/el), the spectral amplification at 400 nm is $G = 4,5 * 10^7$ W/W.

Typical Electron Gain in 1 MCP (el/el)



Typical Electron Gain in 2 MCPs (el/el)



The electron amplification may vary by a factor of 3, either higher or lower. A possible lower electron amplification of the MCP can easily be compensated by a slight increase of the MCP voltage. The maximum possible and recommended MCP voltages are:

MCP Voltage	1 MCP	2 MCPs	3 MCPs
Recommended	800 V	1800 V	2700 V
Maximum Possible	1000 V	2000 V	3000 V

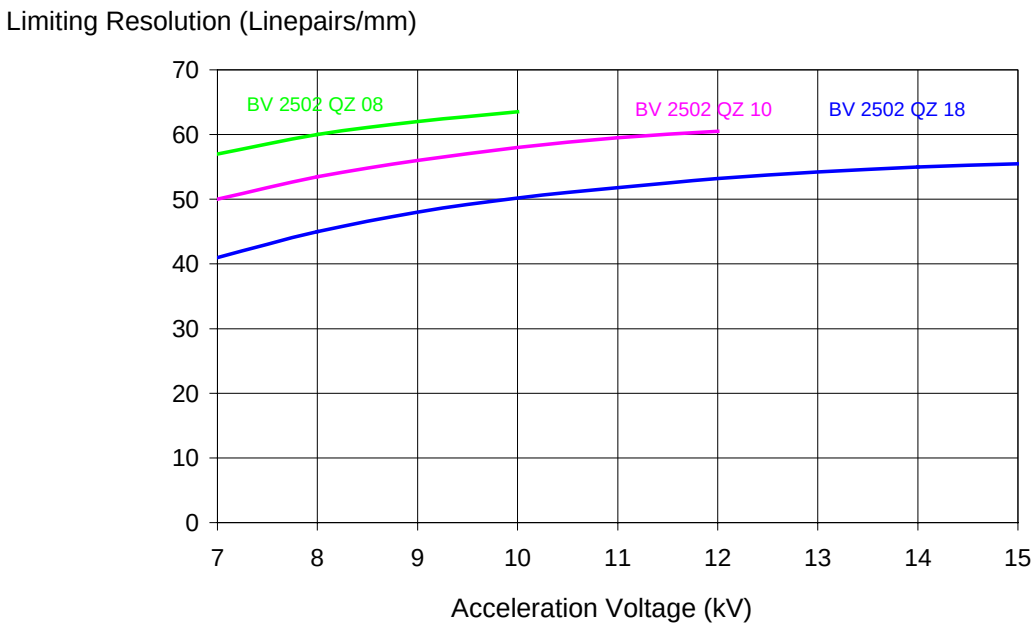
Image intensifiers should be used at the maximum recommended acceleration voltages, respectively recommended MCP voltages, to achieve the best resolution, highest light amplification, and the longest lifetime.

Limiting Resolution and Contrast Transfer Function

The Limiting Resolution R_L is defined as the spatial frequency measured in linepairs/mm (lp/mm) at which the Contrast-Transfer-Function (CTF) is 3 %. This contrast can be just noticed by the human eye.

The limiting resolution of image intensifier diodes PROXIFIER® depends mainly on the electrical field strength which is given by the distance d between photocathode and phosphor screen and by the applied acceleration voltage V. The smaller the distance and the higher the voltage, the better will be the limiting resolution R_L:

$$R_L \propto \frac{\sqrt{V}}{d}$$

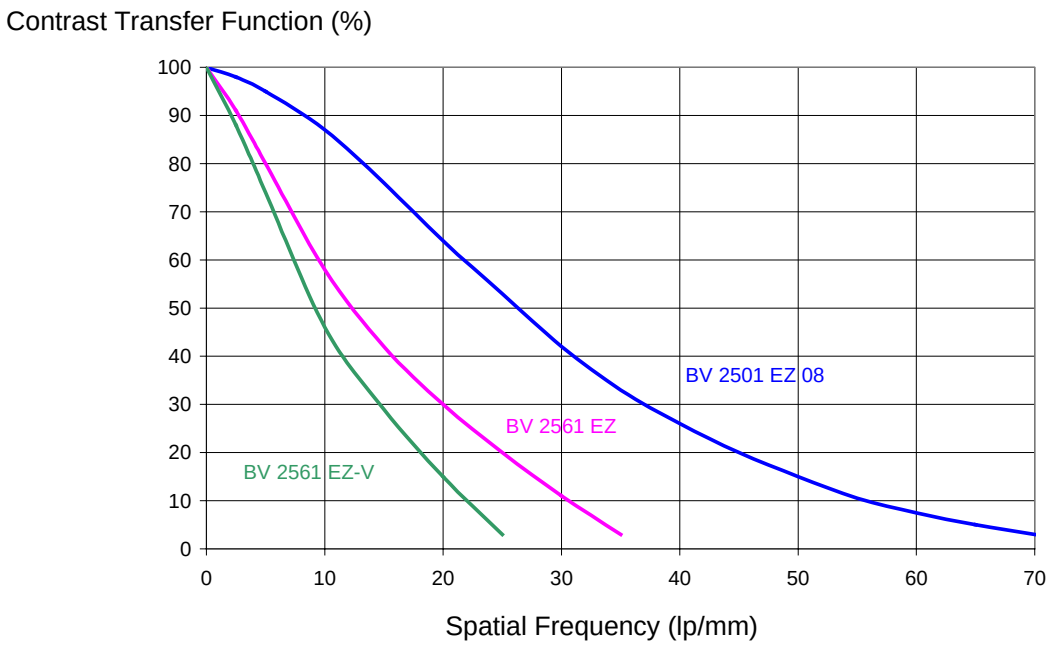


Limiting resolution of proximity focused image intensifier diodes PROXIFIER® (types BV 2502 QZ 08, BV 2502 QZ 10 and BV 2502 QZ 18), with fiber optic output windows. The gap between photocathode and luminous screen is 0,8 mm for 10 kV accelerating voltage, 1,0 mm for 12 kV, and 1,8 kV for 15 kV. Image intensifies with a clear glass output window have an approximately 10 % higher limiting resolution. Compared to the corresponding 25 mm tube, PROXIFIER® diodes with 40 mm useful diameter show almost 15 % lower limiting resolution.

The limiting resolution of MCP image intensifiers MCP-PROXIFIER® will be mainly determined by the diameter and spacing of the individual channels of the MCP. The resolution will also be influenced by the gap and the acceleration voltage between the photocathode, MCP, and phosphor screen as well as by the material used in the input and output windows. Typical limiting resolution values for 25 mm MCP image intensifiers are:

25 mm MCP Image Intensifier with	**Limiting Resolution**
1 High Resolution MCP	40 lp/mm ... 45 lp/mm
1 Standard MCP	32 lp/mm ... 36 lp/mm
2 Standard MCPs (V-Stack)	24 lp/mm ... 28 lp/mm
3 Standard MCPs (Z-Stack)	16 lp/mm ... 20 lp/mm

The limiting resolution of 40 mm MCP image intensifiers is roughly 20 % lower due to properties of the microchannel plates. 40 mm high resolution MCPs are currently not available so far.



Contrast Transfer Function of an image intensifier diode PROXIFIER® (BV 2501 EZ 08) and of MCP image intensifiers MCP-PROXIFIER® with 1 (BV 2561 EZ) and 2 MCPs (BV 2561 EZ-V) along the preferred orientation

Dynamic Range

The dynamic range of PROXIFIER® diodes reaches 10^6:1. The phosphor screen shows saturation effects only when the input illumination becomes very high. Besides the higher limiting resolution, this is the major advantage over MCP image intensifiers.

For MCP image intensifiers MCP-PROXIFIER®, the dynamic range is limited to approximately 10^4:1 to 10^5:1, i.e. 14 bit to 16 bit. In the case of high input illumination and therefore high photo current, the MCP output screen current does not increase linearly any longer with the photo current.

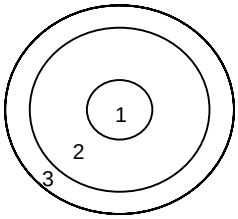
The maximum output brightness of a MCP-PROXIFIER® with a P 43 or P 20 phosphor screen during linear operation is roughly 300 lx. This is equal to a light power per area of approximately 70 µW/cm^2. In case of over-exposure of the image intensifier, 1000 lx (overcast day) are possible.

In low light level applications, the dynamic range is not limited by the image intensifier and dark current electrons from the photocathode but is limited to a few bit by the photon statistic itself. The conversion of photons by the photocathode into electrons is a statistical process which happens with a certain probability (= quantum efficiency of the photocathode). If the event observed consists of 1000 photons and if we assume a quantum efficiency of 10 % (which is typical for many photocathodes for green light), the mean value of photoelectrons produced will be N = 100. According to the Poisson statistic, the standard deviation $\sigma = \sqrt{N} = 10$. The ratio of the mean value to the standard deviation is only 10, i.e. approximately 4 bit. This ratio is also valid for the phosphor screen image at the output of the image intensifier. Therefore, to digitize with 8 bit is absolutely sufficient.

Blemish Specification and Uniformity

Zones

Zone	25 mm Image Intensifiers	40 mm Image Intensifiers
1	∅ 0 mm ... ∅ 7,5 mm	∅ 0 mm ... ∅ 12 mm
2	∅ 7,5 mm ... ∅ 20 mm	∅ 12 mm ... ∅ 32 mm
3	∅ 20 mm ... ∅ 25 mm	∅ 32 mm ... ∅ 40 mm



Number of Allowed Blemishes

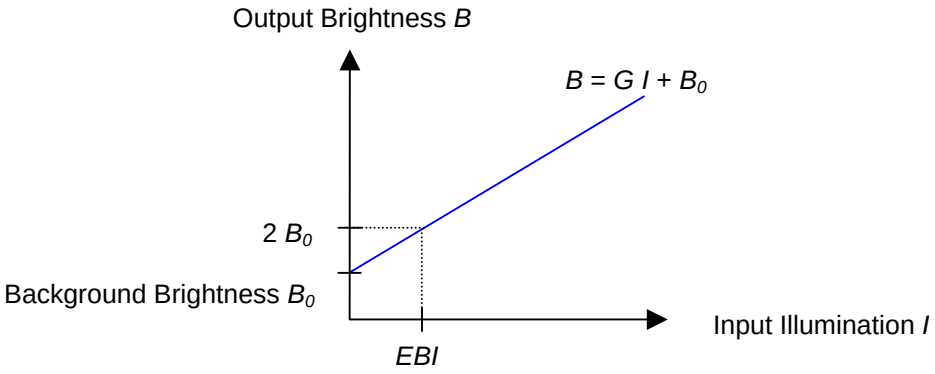
	Maximum Blemish Size					
	In Zone 1		In Zone 2		In Zone 3	
Image Intensifier Types*	75 µm	150 µm	75 µm	150 µm	75 µm	150 µm
BV 2501, BV 2531 BV 2561, BV 2581	4	2	8	4	12	6
BV 2502, BV 2532 BV 2562, BV 2582	minimal	2	minimal	5	minimal	6
BV 2503, BV 2533 BV 2563, BV 2583 BV 2566, BV 2586	minimal	4	minimal	10	minimal	12
BV 2504, BV 2534 BV 2564, BV 2584	minimal	2	minimal	5	minimal	6
BV 4001, BV 4031 BV 4061, BV 4081	10	5	10	5	30	15
BV 4002, BV 4032 BV 4062, BV 4082 BV 4065, BV 4085	minimal	5	minimal	6	minimal	15
BV 4003, BV 4033 BV 4063, BV 4083 BV 4066, BV 4086	minimal	10	minimal	12	minimal	30
BV 4004, BV 4034 BV 4064, BV 4084	minimal	5	minimal	6	minimal	15

* See section “Type Nomenclature“

- The sum of all blemish areas must not exceed 1 % of the zone area.
- With long blemishes the area is calculated using the area of an equivalent circle.
- Blemishes with a diameter larger than 150 µm are not allowed.
- Bright spots visible with a microscope and dark adapted eyes are not allowed at the recommended intensifier voltages inside the useful area of 25 mm and 40 mm, respectively.
- The local non-uniformity of luminous screens is less than ± 10 % for 25 mm PROXIFIER® diodes; less than ± 15 % for 40 mm PROXIFIER® diodes and 25 mm MCP-PROXIFIER®; and less than ± 25 % for 40 mm MCP-PROXIFIER®.

Equivalent Background Illumination (EBI)

With the operation voltages applied to an image intensifier and no input illumination, I, on the photocathode, the phosphor screen will still show a definite background brightness, B_0, mainly due to dark emission electrons from the photocathode. Additional sources contributing to the background brightness are ion events, electrostatic discharges and afterglow of the phosphor screen. Equivalent Background Illumination (EBI) is commonly used to describe the integral noise of image intensifiers. It corresponds to the input illumination, I, necessary to double the background output brightness, B_0:



EBI is independent of the gain *G* of an image intensifier. It is measured using Standard Light A (radiation of a black body with 2856 K) as input illumination. Maximum EBI values of photocathodes with certain red sensitivity are:

Photocathode	Maximum EBI (µlx)
UV Enhanced S 20	0,2
S 20	0,2
S 25	0,25
Red Enhanced S 25	1,5

Lifetime

The lifetime of an image intensifier is defined as the sum of the operating hours until the photocathode has lost 50 % of its initial sensitivity when measured with Standard Light A:

$T = C / (S * E)$

T = Lifetime in h
S = Spectral sensitivity in A/lm
E = Input illuminance in lx
C = 0,011 for MCP image intensifiers MCP-PROXIFIER®
C = 0,11 for image intensifier diodes PROXIFIER®

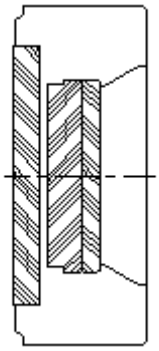
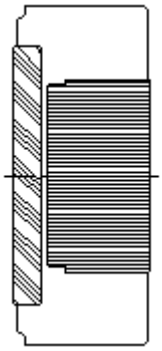
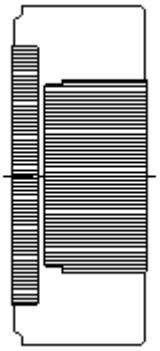
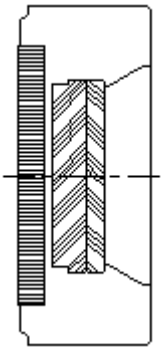
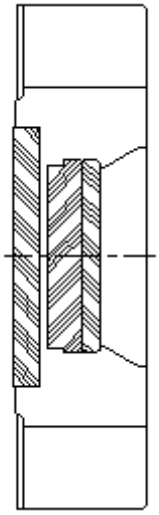
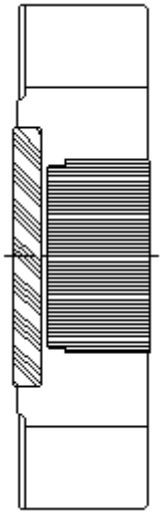
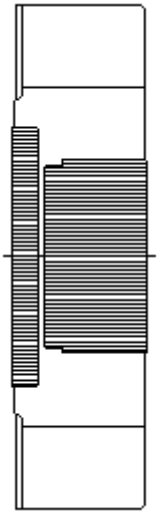
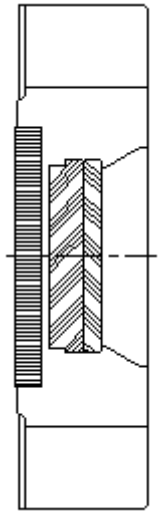
The greater the sensitivity of a photocathode for red and infrared light is, the greater the sensitivity (measured in µA/lm) will be for Standard Light A since it contains mostly infrared radiation.

Photocathode	Spectral Sensitivity for Standard Light A (µA/lm)
Advanced Solar Blind	< 0,1
Bialkali	60
UV Enhanced S 20	170
S 20	200
S 25	250
Red Enhanced S 25	350

For image intensifiers with a S 20 photocathode, the following table gives the expected average lifetime.

Luminance	Natural Scene Illuminance	Average Lifetime of Image Intensifier Diodes PROXIFIER®	Average Lifetime of MCP Image Intensifiers MCP-PROXIFIER®
100 mlx	Full moon	5500 h	
10 mlx	Quarter moon	55000 h	5500 h
1 mlx	Star light		55000 h

Schematic Drawings and Dimensions of Image Intensifier Diodes PROXIFIER®

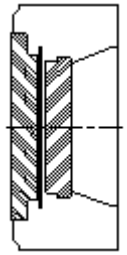
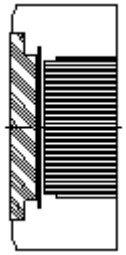
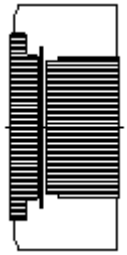
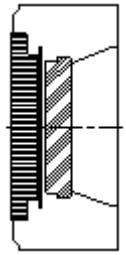
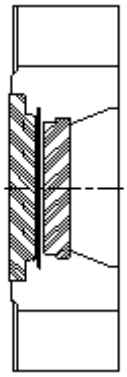
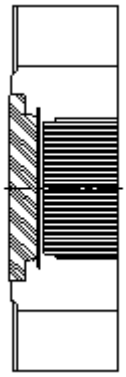
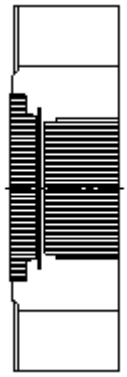
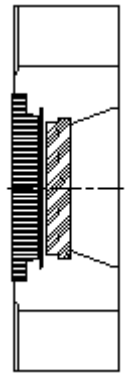
BV 2501 ... 10 ∅ 50 mm ∗ 19,7 mm **BV 4001 ... 10** ∅ 70 mm ∗ 21 mm	**BV 2502 ... 10** ∅ 50 mm ∗ 20 mm **BV 4002 ... 10** ∅ 70 mm ∗ 21,5 mm	**BV 2503 ... 10** ∅ 50 mm ∗ 20 mm **BV 4003 ... 10** ∅ 70 mm ∗ 21,5 mm	**BV 2504 ... 10** ∅ 50 mm ∗ 19,7 mm **BV 4004 ... 10** ∅ 70 mm ∗ 21 mm
			
			
BV 2531 ... 10 ∅ 75 mm ∗ 19,7 mm **BV 4031 ... 10** ∅ 95 mm ∗ 21 mm	**BV 2532 ... 10** ∅ 75 mm ∗ 20 mm **BV 4032 ... 10** ∅ 95 mm ∗ 21,5 mm	**BV 2533 ... 10** ∅ 75 mm ∗ 20 mm **BV 4033 ... 10** ∅ 95 mm ∗ 21,5 mm	**BV 2534 ... 10** ∅ 75 mm ∗ 19,7 mm **BV 4034 ... 10** ∅ 95 mm ∗ 21 mm

clear glass

fiber optic

The indicated heights apply to proximity focus image intensifier diodes with 1,0 mm distance between photocathode and phosphor screen. The overall height of the image intensifiers with 0,8 mm distance is reduced accordingly by 0,2 mm or increased by 0,8 mm for the image intensifiers with 1,8 mm distance.

Schematic Drawings and Dimensions of MCP Image Intensifiers MCP-PROXIFIER®

BV 2561 ... ∅ 50 mm ∗ 21,7 mm **BV 4061 ...** ∅ 70 mm ∗ 22,5 mm	**BV 2562 ...** ∅ 50 mm ∗ 22 mm **BV 4062 ...** ∅ 70 mm ∗ 22,8 mm	**BV 2563 ...** ∅ 50 mm ∗ 22 mm **BV 4063 ...** ∅ 70 mm ∗ 22 mm	**BV 2564 ...** ∅ 50 mm ∗ 21,7 mm **BV 4064 ...** ∅ 70 mm ∗ 20,8 mm
			
			
BV 2581 ... ∅ 75 mm ∗ 21,7 mm **BV 4081 ...** ∅ 95 mm ∗ 22,5 mm	**BV 2582 ...** ∅ 75 mm ∗ 22 mm **BV 4082 ...** ∅ 95 mm ∗ 22,8 mm	**BV 2583 ...** ∅ 75 mm ∗ 22 mm **BV 4083 ...** ∅ 95 mm ∗ 22 mm	**BV 2584 ...** ∅ 75 mm ∗ 21,7 mm **BV 4084 ...** ∅ 95 mm ∗ 20,8 mm

 clear glass

 fiber optic

The indicated heights apply to MCP-PROXIFIERS® with one microchannel plate. The overall height of the MCP-PROXIFIERS® which have a fiber optic output window increases per additionally inserted MCP by 0,43 mm (thickness of the MCP). The overall height of the MCP-PROXIFIERS® which have a clear glass output window is not changed by additionally inserted MCPs. The output window, however, is shifted per further MCP by 0,43 mm to the rear.

Intensified CCDs with Direct Fiber Optical Coupling

PROXITRONIC is the only manufacturer of image intensifiers which offers direct fiber optical coupling for proximity focus image intensifiers, PROXIFIER®, to CCDs for the purpose of making intensified CCDs (ICCDs). Thus, the otherwise insertion of an additional fiber optic plate is eliminated.

The fiber optic output window of the image intensifier is ground and prepared in such a manner that the image intensifier can be directly coupled to a line CCD.

The advantages of direct fiber optical coupling are remarkable:

- maximum possible light transfer of 70 % from the output phosphor screen of the image intensifier onto the CCD
- high gain
- optimum resolution and contrast transfer function
- avoidance of Moiré effects.

High Voltage Power Supplies

The operation voltages of the PROXIFIERS® are:

Type Series	Distance *	Photocathode	Phosphor Screen
BV 250... 08, BV 400... 08 BV 253... 08, BV 403... 08	0,8 mm	0 V	+ 10 kV
BV 250... 10, BV 400... 10 BV 253... 10, BV 403... 10	1,0 mm	0 V	+ 12 kV
BV 250... 18, BV 400... 18 BV 253... 18, BV 403... 18	1,8 mm	0 V	+ 15 kV

* internal distance between photocathode and phosphor screen

The operating voltages of the MCP-PROXIFIERS® are:

Type Series	Number of MCPs	Photo-cathode [1]	MCP Input	MCP Output [1]	Phosphor Screen [2]
BV 256... BV 406...	1	- 200 V	0 V	+ 400 V ... + 800 V (+ 1000 V) [3]	+ 6 kV
BV 258... BV 408...	1	- 200 V	0 V	+ 400 V ... + 800 V	+ 6 kV
BV 256...-V BV 406...-V	2	- 200 V	0 V	+ 1000 V ... + 1800 V (+ 2000 V) [3]	+ 6 kV
BV 258...-V BV 408...-V	2	- 200 V	0 V	+ 1000 V ... + 1800 V	+ 6 kV
BV 256...-Z BV 406...-Z	3	- 200 V	0 V	+ 1500 V ... + 2700 V (+3000 V) [3]	+ 6 kV
BV 258...-Z BV 408...-Z	3	- 200 V	0 V	+ 1500 V ... + 2700 V	+ 6 kV

1 reference to MCP input
2 reference to MCP output
3 The MCP voltage indicated in parentheses is the maximum possible, however, it is not recommend.

The PROXIFIERS® of the type series BV 253... and BV 403... as well as the MCP-PROXIFIERS® of the type series BV 258... and BV 408... are equipped with integrated circular power supplies. The overall diameter is 75 mm for the 25 mm image intensifiers and 95 mm for the 40 mm image intensifiers. Although this may be too large for some applications, the types with an integrated power supply may be preferred since they ensure simple and safe use.

Each input voltage between + 10 V and + 15 V DC voltage (maximum 75 mA) supplies the necessary output voltage.

The MCP voltage of the MCP-PROXIFIERS® with integrated power supplies is regulated by a control voltage (0 V to + 5 V).

Modification of the accelerating voltage between photocathode and phosphor screen in image intensifier diodes, PROXIFIER®, with integrated power supplies is possible only on special request.

The PROXIFIERS® without integrated high voltage power supplies (type series BV 250... and BV 400...) are equipped with a silicone cable for the high voltage to the phosphor screen and a teflon cable to the photocathode (ground).

The MCP-PROXIFIERS® without integrated high voltage power supplies (type series BV 256... and BV 406...) have teflon isolated copper cables to photocathode, MCP input, MCP output and phosphor screen.

Image intensifiers with fiber optic output windows have a further cable which is connected to the outer surface of the fiber optic. The surface is coated with transparent and electrically conductive ITO (Indium Tin Oxide). The optical transmission is better than 95 % and the electrical resistance is in the kΩ range. Thus, it is guaranteed that all image intensifiers with fiber optic output window can be fiber optically coupled safely to a CCD.

Connection Cable	PROXIFIER®	MCP-PROXIFIER®
Photocathode	blue	blue
MCP input		red
MCP output		black
Phosphor screen	white	yellow
ITO layer	green	green

The recommended separate PROXITRONIC power supplies have mumetal housings with dimensions of 91,3 mm x 46,3 mm x 21,5 mm. Any input voltage between + 10 V and + 15 V DC voltage (maximum 75 mA) supplies the necessary output voltage. The standard length of all cables is approximately 30 cm. Other lengths are possible on request.

Pulse Generators and Pulse Amplifiers

Instead of DC power supplies, pulse generators and amplifiers are used for the pulsed operation of image intensifier diodes and MCP image intensifiers.

For gating of image intensifier diodes, PROXIFIER®, with 10 kV pulses between 1 µs and continuous operation, PROXITRONIC offers the pulse amplifier type IV 1000N. PROXIFIERS® with 1,0 mm spacing between the photocathode and the phosphor screen which have no integrated power supply (types BV 2501 ... 10 to BV 2504 ... 10 and BV 4001 ... 10 to BV 4004 ... 10) are suitable for gated operation.

MCP image intensifiers MCP PROXIFIER® without integrated power supplies can be gated by PROXITRONIC pulse generators IP 5N and IP 100N down to 5 ns and 100 ns, respectively. For MCP-PROXIFIERS® with integrated power supplies, the pulse generators IG 5N (shortest gate time 5 ns) and IP 100N (shortest gate time 100 ns) are available.

Safety Precautions and Warranty

It is recommended to operate image intensifiers in a darkened room. The operating voltage should be gradually increased with a low light level input, until the output screen begins to illuminate. MCP-PROXIFIERS® should be operated with no less than 50 % of the maximum allowed MCP gain voltage to avoid possible damage to the photocathode through exposure to light having a too high intensity to achieve a long operating life. The recommended maximum output screen brightness is 1000 lx (typical of the sky on a cloudy day).

In case you do not use an original PROXITRONIC power supply, the warranty against electrical damage is void. To avoid damages by using another power supply, you should make sure that the MCP is always grounded during operation. ***Voltage peaks may seriously damage the MCP****.*

A strong point light (e.g. by a laser) can destroy a photocathode.

Storage is recommended in a dry, darkened room at normal room temperature.

PROXIFIER® diodes and MCP-PROXIFIER® do not have any built-in overload protection.

05.06.2001

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