Instruction manual of O/E converter - Overview

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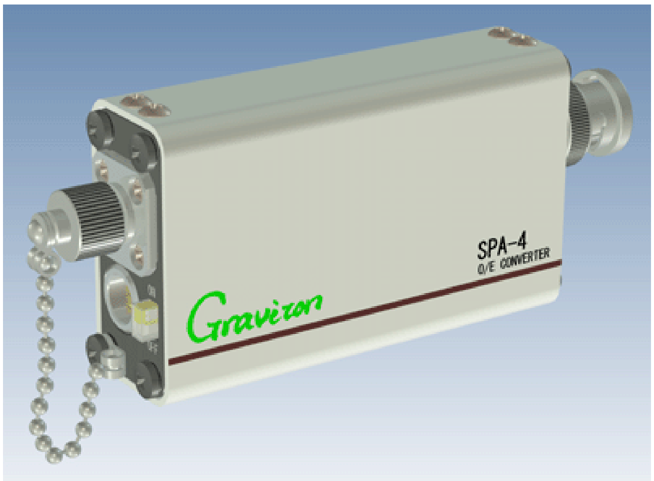


Overview

Graviton's O/E converter allows the measurement of the optical signal, by attaching to the input terminal of the customer's measurement equipment.

*** Small size, light weight, easy to attach**

*** Large detection diameter and NA**

*** Covers wide band from DC to GHz**

*** Many types of optical connector option**

Read this instruction manual carefully before use.

Selection guide

Graviton offers a variety of O/E converter models, by the requested features of; Wavelength range, Reference wavelength, Acceptable core diameter, Input NA, and Conversion frequency bandwidth.

*** Converter for visible light (Si photodetector is used)**

Model name	Wavelength range	Reference wavelength	Sensitivity	Max. core diameter	Max.NA	Bandwidth	tr/tf
SPD-1_650nm	320nm〜1000nm	650nm	500V/W	0.8mm	0.2	DC〜1.2GHz	290ps
SPD-1_850nm	320nm〜1000nm	850nm	500V/W	0.8mm	0.2	DC〜1.2GHz	290ps
SPD-2_650nm	380nm〜1000nm	650nm	1000V/W	1.0mm	0.25	DC〜1.2GHz	290ps
SPD-2_850nm	380nm〜1000nm	850nm	1000V/W	1.0mm	0.25	DC〜1.2GHz	290ps
SPD-3	380nm〜950nm	850nm	500V/W	0.5mm	0.25	DC〜2.0GHz	190ps
SPD-4	380nm〜950nm	850nm	300V/W	0.5mm	0.25	DC〜3.0GHz	150ps
SPA-2_650nm	400nm〜1000nm	650nm	1000V/W	1.0mm	0.5	DC〜1.0GHz	370ps
SPA-3	380nm〜950nm	850nm	500V/W	0.25mm	0.5	DC〜2.0GHz	190ps
SPA-4	380nm〜950nm	850nm	300V/W	0.25mm	0.5	DC〜3.0GHz	150ps
SPS-1_10KV/W	320nm〜1000nm	850nm	10KV/W	0.8mm	0.2	DC〜100MHz	3.6ns
SPS-1 100KV/W	320nm〜1000nm	850nm	100KV/W	0.8mm	0.2	DC〜15MHz	28ns
SPS-2_10KV/W	400nm〜1000nm	850nm	10KV/W	1.0mm	0.5	DC〜100MHz	3.6ns
SPS-S_100KV/W	400nm〜1000nm	850nm	100KV/W	1.0mm	0.5	DC〜15MHz	28ns

*** Converter for long wavelength (InGaAs photodetector is used)**

Model name	Wavelength range	Reference wavelength	Sensitivity	Max core diameter	Max.NA	Bandwidth	tr/tf
LPD-1	900nm〜1650nm	1310nm	500V/W	0.08mm	0.2	DC〜1.5GHz	250ps
LPD-2	950nm〜1650nm	1310nm	1000V/W	0.5mm	0.25	DC〜1.5GHz	250ps
LPS-1_20KV/W	900nm〜1650nm	1310nm	20KV/W	0.08mm	0.2	DC〜100MHz	3.5ns
LPS-2_20KV/W	950nm〜1650nm	1310nm	20KV/W	0.5mm	0.25	DC〜100MHz	3.5ns

**** For 650nm standard model and 850nm standard model ****

Photodetector, which is currently build in **SPD-1**, **SPD-2**, and **SPA-2**, has the wavelength dependency of a frequency characteristic, and the frequency characteristic of photodetector changes in the range of, approximately, 1MHz to 100MHz.

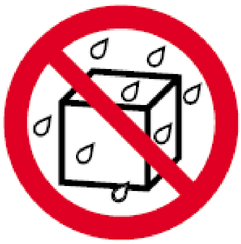
Therefore, a frequency characteristic of **SPD-1_650nm**, **SPD-2_650nm**, and **SPA-2_650nm**, is designed and tuned to be flat at 650 nm. Also, the frequency characteristic of **SPD-1_850nm** and for **SPD-2_850nm** is designed to be flat at 850 nm.

For customers who need several wavelengths measurements, it is recommend the use of **SPD-3**, **SPD-4**, **SPA-3**, **SPA-4** with PD which has less frequency characteristic dependence on the wavelength.

**** About the minimum fiber diameter ****

The core diameter of the fiber, to be connected to the **SPA-2_650nm**, is 100um diameter or more. When a fiber with a thin fiber core diameter is used, the optical spot at the photodetector becomes so small, that the frequency characteristics of the product is not maintained.

Precautions



*** DANGER: Avoid water, liquid or the wet**

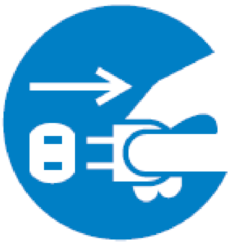
When the product gets wet, this may cause irreparable damage to the internal optical system or electronic circuit. In addition , it may cause a fire when the power is supplied to the wetted product. Avoid the wet, absolutely.

*** DANGER: No wet hand(s)**

If the equipment is touched by wet hands , it may not only to cause a malfunction to the product, but to cause an electric shock on human body. Avoid the wet, absolutely.

*** DO NOT disassemble**

Some part of the O/E converter is designed and engineered with high-precision. If the product is disassembled, it may cause spoiling a performance of the product.



*** CAUTIONS when attaching or detaching a connector**

When an optical connector or a power cord is detached or attached, be sure to perform attachment or detachment by holding plug with hands. Avoid to pull a power cord or a fiber optic cable.

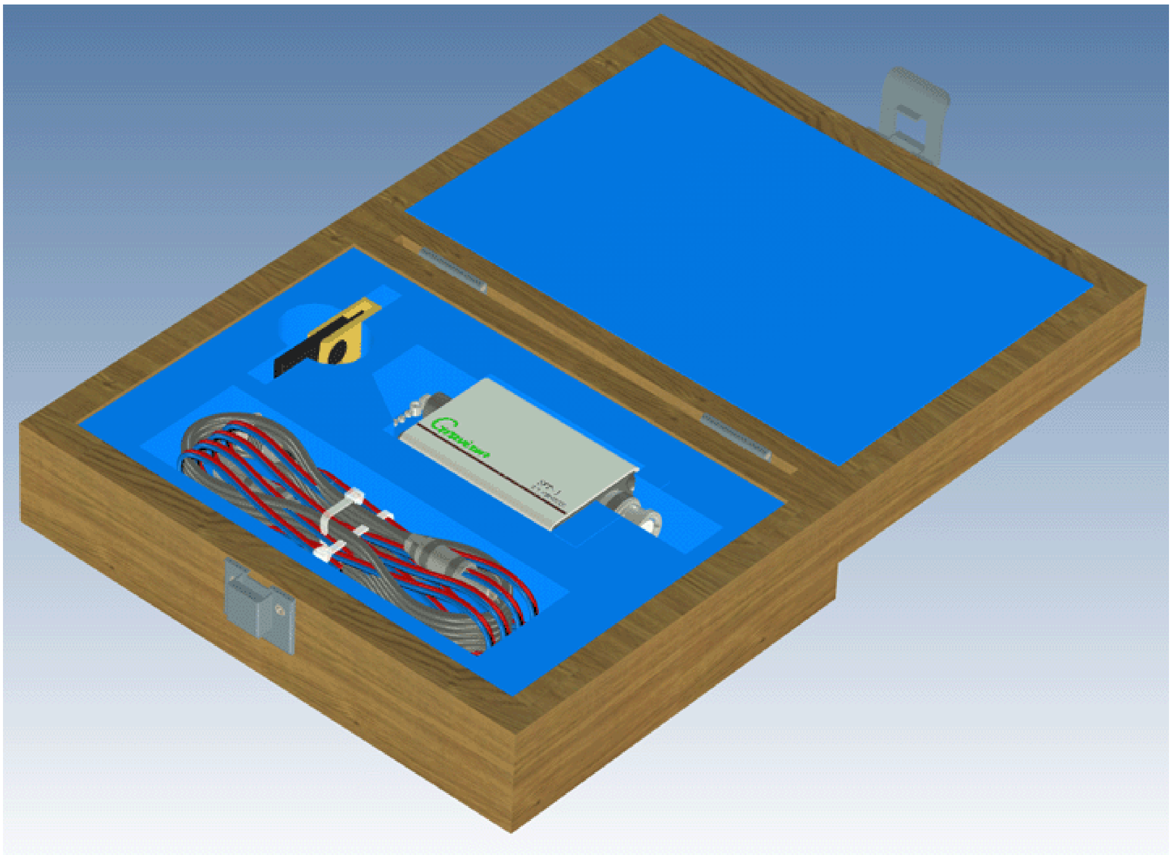
*** NOT TO APPLY the external force to the unit.**

Take caution not to apply external force to the unit, attached to such as test equipment or measurement instrument, optical fiber cord ,or power cord. It may cause damage to the converter, an electronic measuring instrument, or a code.

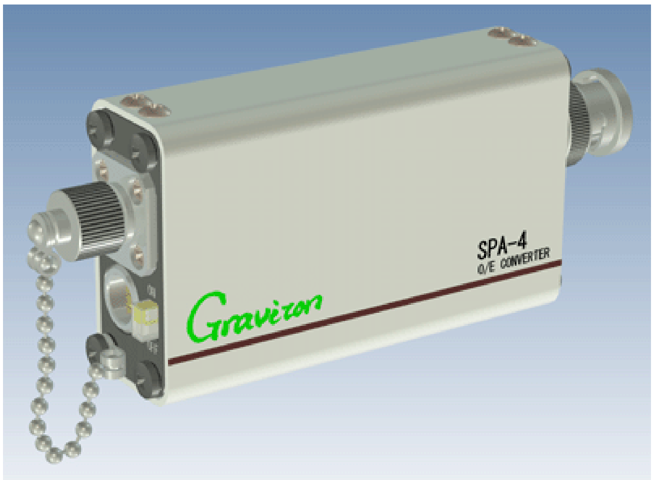
*** CAUTIONS for a laser beam**

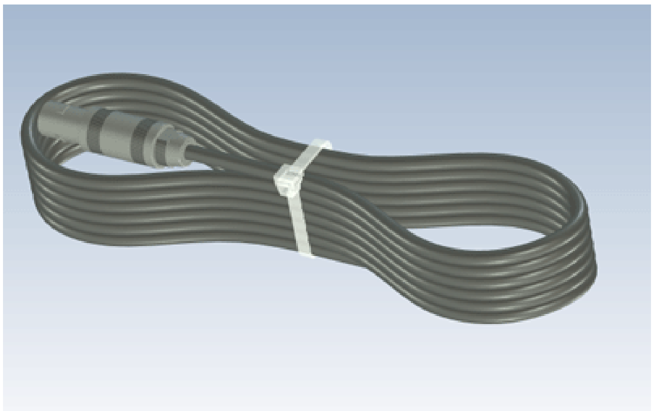
When using a laser beam, take enough precautions for the safety of the eyes and skin. Do not view the beam directly.

Contents of the package



** As soon as opening a package, first check all items are present in the package.
** In the event where any items are missing or damaged , please contact us immediately.

	*** O/E converter unit**

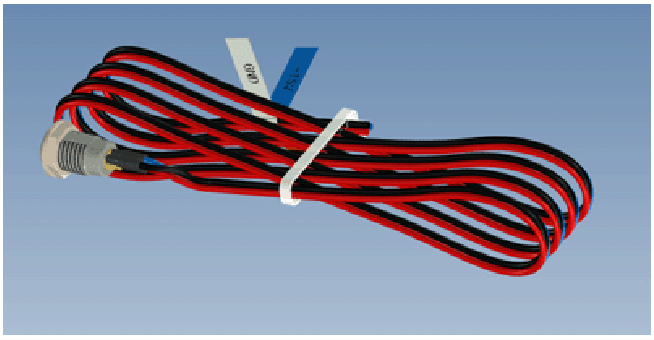


*** Dedicated power cable**

Dedicated power cable for supplying DC power to the O/E converter.

The plug is LEMO 0S 4P type, and the pin assignments of the connector are P1:OPEN, P2:GND, P3:-15V, and P4:+15V.

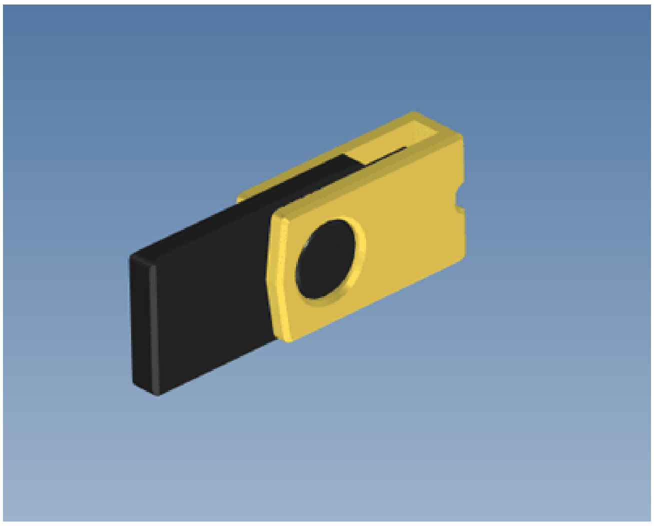
Some electronic instruments, to be used at the same time, are equipped with a power supply connector that can be connected to this connector.



*** Auxiliary power cable**

When the customer does not equip with a power supply, that can be connected directly to the converter using the dedicated power cable, use the auxiliary power cable in order to connect the O/E converter and the DC power supply.

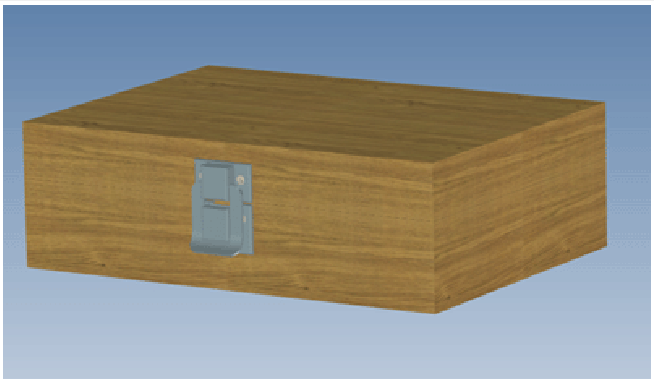
In addition, Graviton offers a small-sized DC power supply, suitable for our O/E converter products.



*** USB memory**

The characteristics of the Graviton's O/E converter is measured individually at the time of shipment, and the result is written on the USB memory. This USB memory is included in the product. Calibration and repair history are also stored on this USB memory.

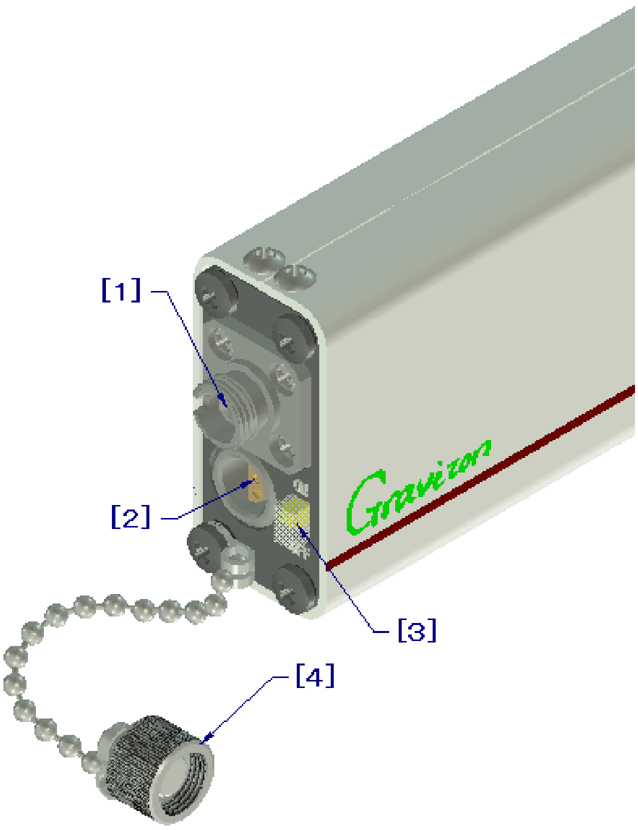
Moreover, a user's manual of the product and a catalog are stored on this USB memory.



*** Wooden box**

Stores the product and accessories.

Part names and functions

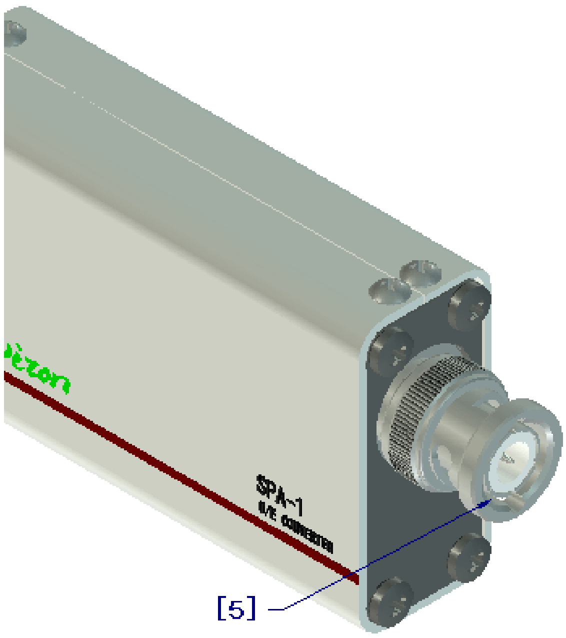


[1] Optical input connector
Inputs an optical signal for the measurement to the O/E converter. A standard product is equipped with receptacle of FC type, however, a product, equipped with other type of optical connector is available when the customer specifies an option when ordering..

[2] DC power input connector
Supplies required DC power voltage for the O/E converter from this connector.

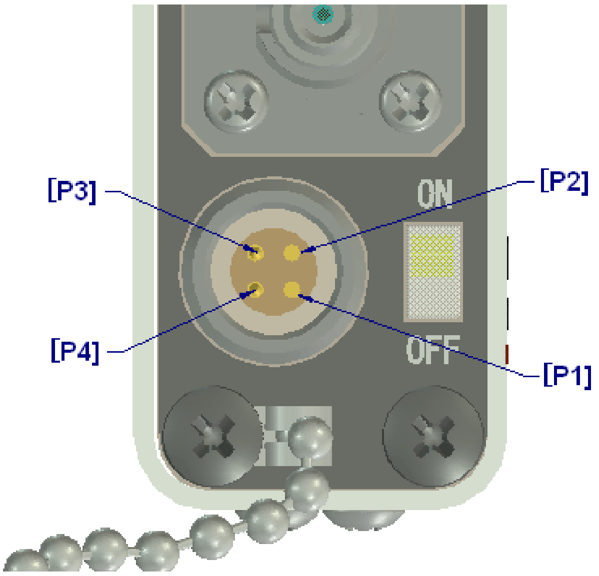
[3] Power switch

[4] Dust cap
The product with FC receptacle has duct-cap to prevent a dust, which go into the optical input connector.



[5] Electrical output connector
After the O/E conversion is performed, a voltage signal is outputted from this connector. This connector also has a feature which secures the unit to an input terminal of electronic measuring instrument.

The standard product is equipped with the BNC type plug, as shown in the figure. A product, equipped with other types, such as SMA, of electric output connector is available upon customer's optional specification when ordering..



*** Pin assignment of a DC power connector**

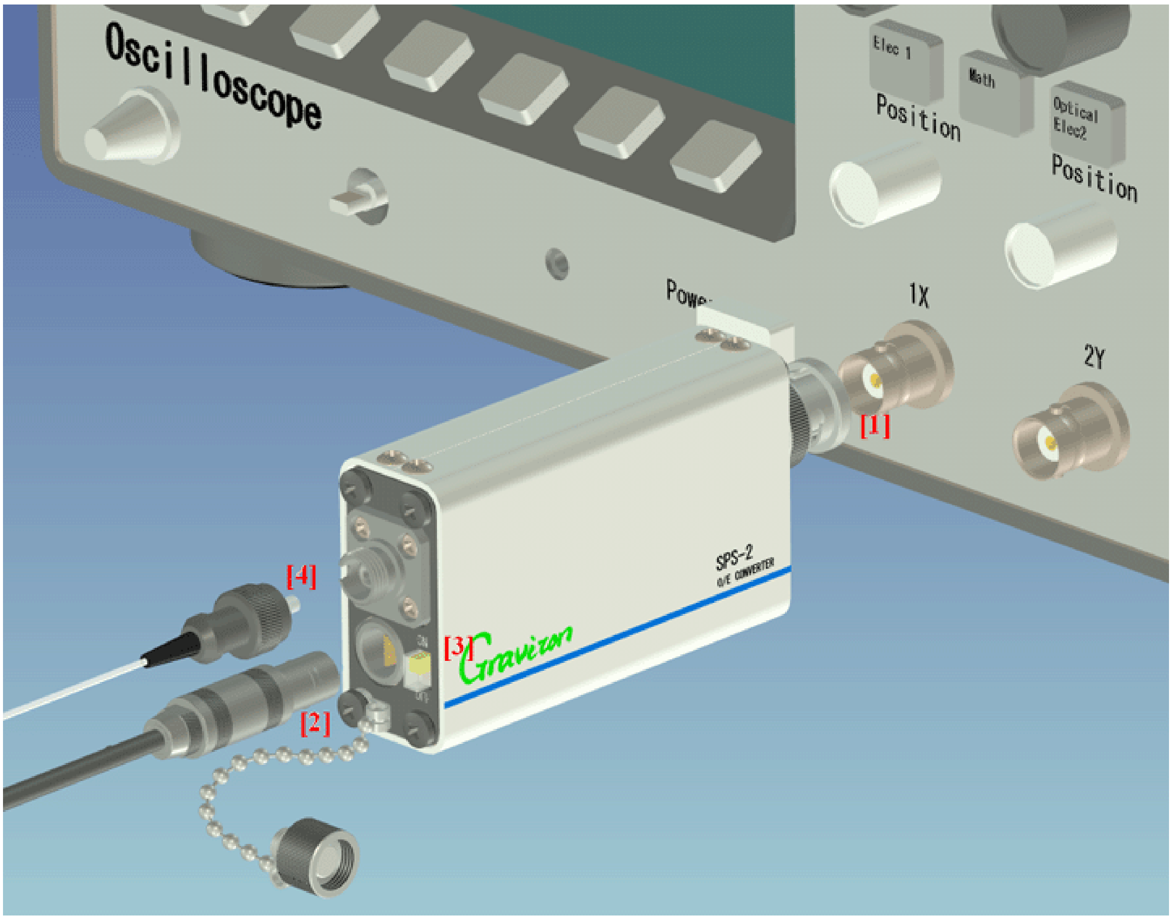
[P1] : OPEN
This pin is not connected internally.

[P2] : GND pin
This pin is connected to the chassis internally.

[P3] : Minus 15V input pin
Minus 15V power source of a product is supplied from this pin.
** However, since the negative supply voltage for **SPA-2_650nm** is not used, this pin is not connected internally.

[P4] : Puls 15V input pin
Plus 15V power supply to the product is supplied from this pin.

Mount and connection



[1] Attach the O/E converter to an electronic measuring instrument.

Since O/E converter is designed with small size and light weight, the converter can be attached and fixed by connecting directly to the input connector of the measuring instruments, as shown in the figure.

The measuring instrument, shown, is equipped with BNC jack. How to connect directly to the O/E converter of standard type, equipped with BNC plug is shown. When an input connector of an electronic measuring instrument does NOT have a BNC jack, use a off-the-shelf coaxial adapter in order for the instrument to fit with O/E converter.

[2] Connect the power cable.

Plug a dedicated power cable into the power input connector of the O/E converter. Insert the power cable when the power switch [3] is at the OFF position. Further, it is desirable to supply the power from the external power supply after the power cable has been connected.

[3] Turn the power switch ON.

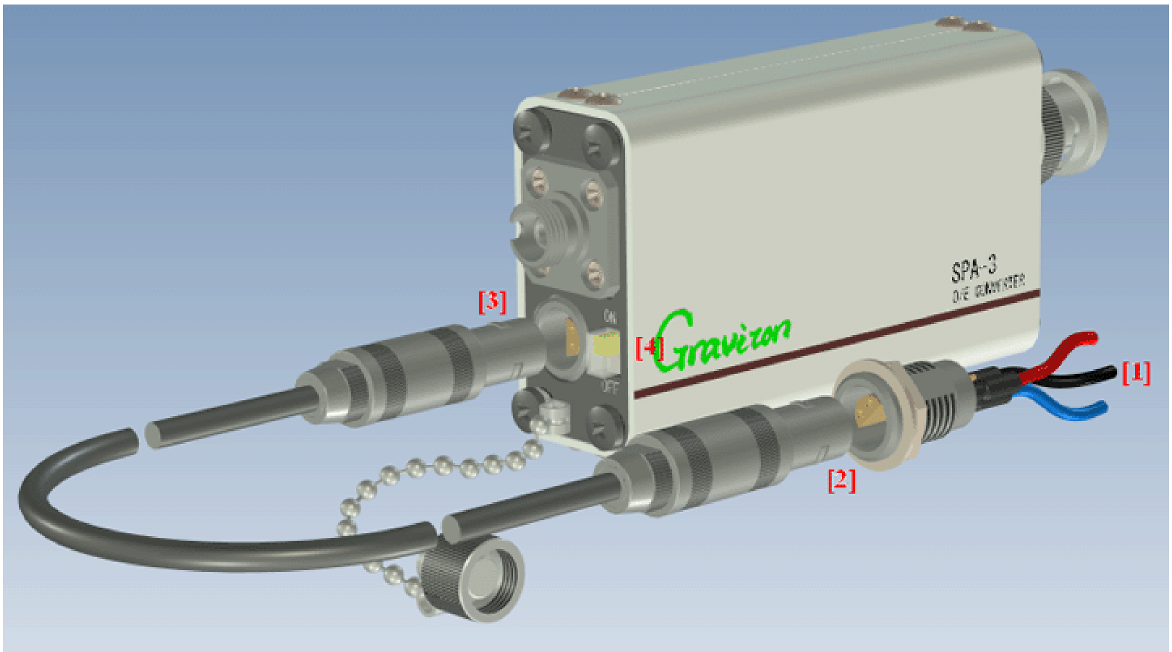
[4] Insert a optical signal line to the connector.

Insert and secure the optical connector ferrule of an optical signal line to be measured to the optical input connector of the O/E converter. The O/E converter of standard model has equipped the panel with the FC type receptacle. The figure shows how to insert FC type optical connector plug.

If a connector other than the FC type is equipped with the customer's instrument, either use an off-the-shell connector-adapter, or specify the connector option when the customer places an order of an O/E converter. Currently, the products for SC connector, (F) SMA connector, ST connector, and F05 connector are available.

In addition, when a diameter of the customer's connector ferrule is 2.5mm, a product with G-OCN type connector, which is connectable to any type, is available. Please contact us about G-OCN-type related information.

*** Auxiliary power cable**



Some of the electronic instruments, used together with the O/E converter, does not have a DC power supply output connector that can be fitted to the dedicated power cable. In such a case , using the auxiliary power cable, supply ± 15V DC power to O/E converter from such as the external off-the-shell power supply.

** Graviton has Cosel's power supply - G1W-15 in stock.

[1] Connect an auxiliary power cable to the external power supply.

After checking the output of the power supply is off, connect the power supply and auxiliary power cable. Connect the **RED** wire of auxiliary power cable to **+15V**, the **BLACK** wire to **GND**, and the **BLUE** wire to **-15V**.

<u>The faulty wiring of a power supply cable causes failure to the O/E converter. Work carefully so as not to make connection mistake.</u>

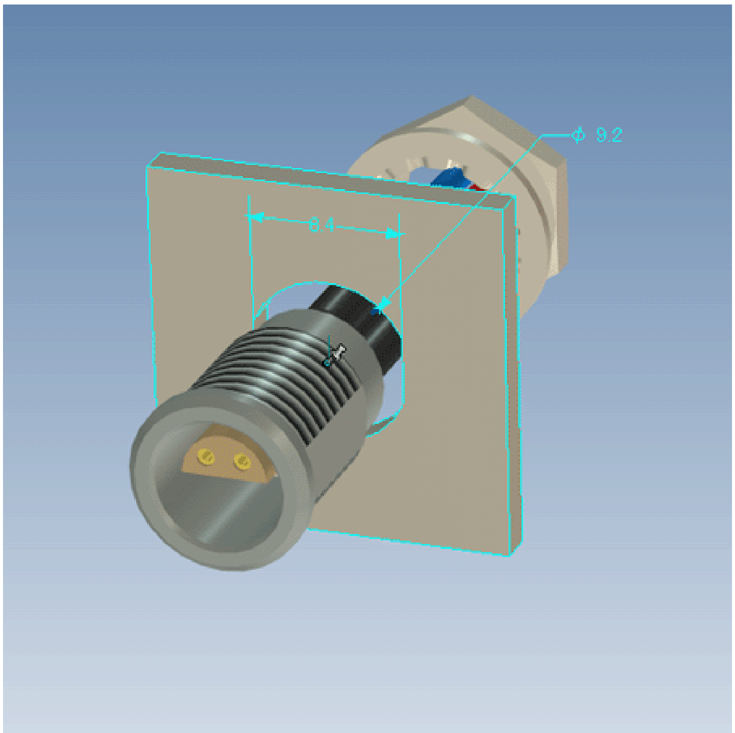
[2] Connect a dedicated power cable and an auxiliary power cable.

[3] Plug in a dedicated power cable to the power connector of the O/E converter.

Before the power cable will be connected to the O/E converter, check that the power switch, shown in [4], is OFF.

[4] Turn ON the power supply unit and turn the switch of an O/E converter.

As an order of powering on, turn on the power supply, the first. As an order of powering off, the order of power off does not matter.



To fix an auxiliary power cable to the panel, a cutout hole dimension is an oblong hole 9.2 mm in diameter, and 8.4 mm in width, as shown on the left figure.

In addition, use panel with 5mm thick or less.

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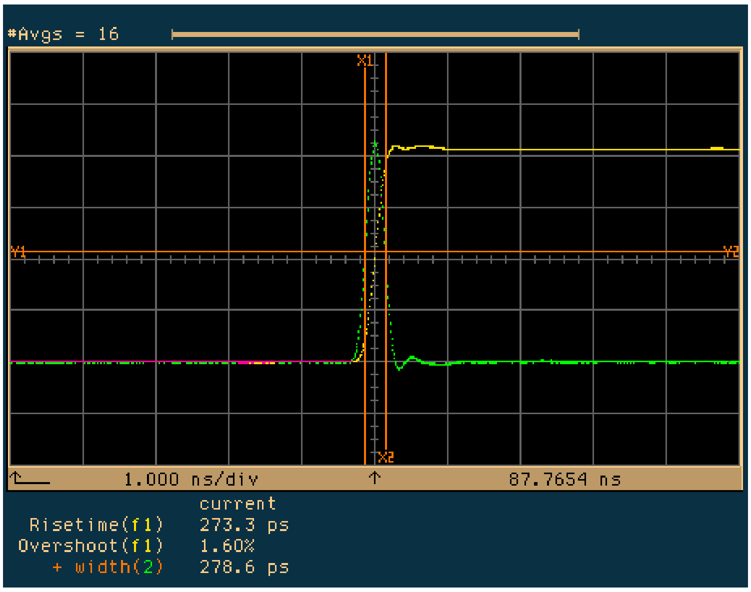
Pre-shipment test and waveform data

Actual measurement data file, that have been performed individually one at a time, is included in the product; Graviton's O/E converter. By using an example of **SPD-2_650nm**, the waveform data will be explained.



*** Impulse response (Green)**

Regarding the pre-shipment test of the O/E converter, an impulse response waveform, a step response waveform, and a frequency characteristic are measured by inputting an impulse light with duration of about 50ps to the converter.

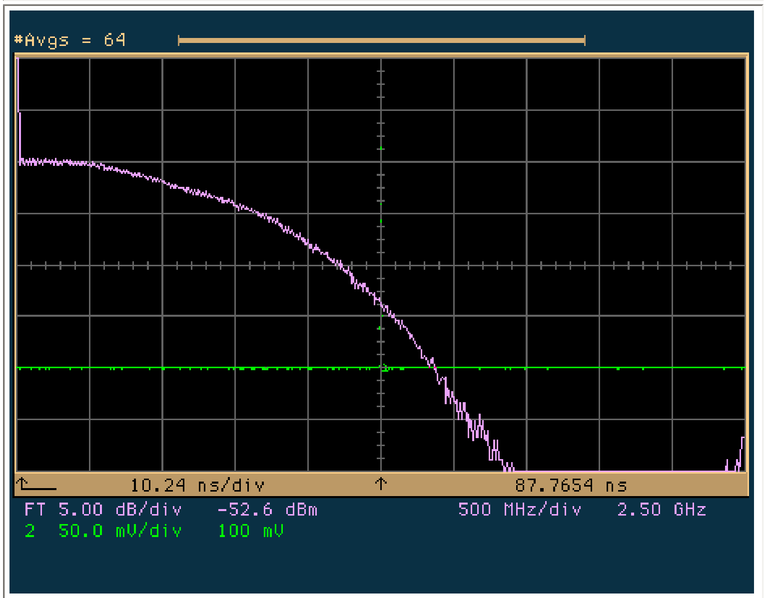
Among the waveforms shown in the figure on the left, what is drawn in green color shows the impulse response of the O/E converter.

The numerical value of "+width (2)" indicates 278.6ps, and this value is found as the impulse output half width out of an O/E converter output.

*** Step response (Yellow)**

Simulates the output waveform when the optical step pattern waveform is inputted to the O/E converter, using a feature of the oscilloscope, and applying the integration for the impulse response waveform.

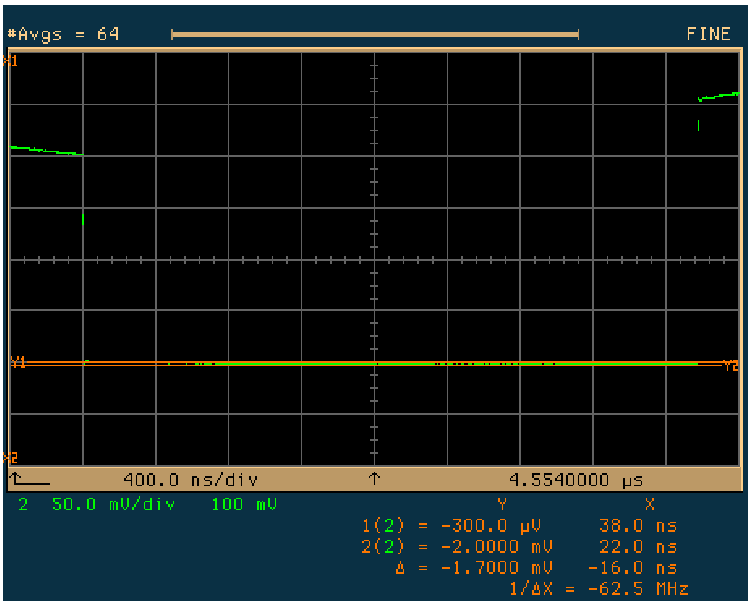
The value of "Rise time (f1)" indicates as 273.3ps, and this means that the step response speed is within 10% to 90% of the O/E converter. In addition , the value of the overshoot can be seen as 1.60 percent.



*** Frequency characteristic (Purple)**

By performing the FFT computation, which is a feature of the oscilloscope, to the impulse response waveform, the frequency characteristics of the O/E converter is measured.

The horizontal axis scale is 500MHz/div., and the vertical axis scale is the 5dB (electrical) / division. It is found that the frequency characteristic of the product is attenuated little by little from the low frequency, and reduces 3db at around 1.2GHz.



*** Light-off baseline check**

Light-off baseline output waveform is stored on attached USB memory for the product, whose reference wavelength is 650nm.

The frequency characteristic of the photodetector, used for **SPD-1**, **SPD-2**, and **SPA-2**, has a characteristic that varies by the incident wavelength in the region of 1MHz to 100MHz.

In order to compensate for this, **SPD-1** and **SPD-2** with a reference wavelength of 650 nm and an 850nm are equipped respectively, and a different frequency characteristic compensation value is used for the built-in amplifier.

In order to confirm that frequency characteristic compensation is performed correctly, the waveform of the output, immediately after input optical signal is cutoff abruptly, is measured about 3.3 us. The ideal waveform is almost flat around zero point.

Noise level, offset, a conversion gain, and power supply current

At the bottom of the shipment test data, measurement results other than waveform data are summarized in the table. The contents of the table is explained using an example of **SPA-3**.

Noise Level & DC Performance

Item	Specifications	Measured Value	Judgment
Wideband Noise Output Voltage (Up to 12.4GHz, AC Voltage)	Less than 1.50 mVrms	**1.38 mVrms**	OK
Output Offset Voltage	Within +/-0.5 mV	**+0.02 mV**	OK
Conversion Gain at 850nm (50um GI Fiber, NA = 0.2)	450 to 550 V/W	**539 V/W**	OK
Conversion Gain at 850nm (200um HPCF, NA = 0.48)	450 to 550 V/W	**540 V/W**	OK
Positive Supply Current	0.09 to 0.11 A	**0.10 A**	OK
Negative Supply Current	0.01 to 0.03 A	**0.02 A**	OK

Evaluated on ······· 2010/07/15
Evaluated by Mitsuhiro Nagatomo

*** Wideband Noise Output Voltage**
Wideband noise characteristics. The output noise voltage, measured using the oscilloscope of input impedance 50Ω and the 12.4GHz band, when a light is not inputted to O/E converter.

*** Output Offset Voltage**
Output Offset Voltage, which is a measured output DC voltage under 50-ohm resistance load, using the digital multi-meter, when a light is not inputted to an O/E converter.

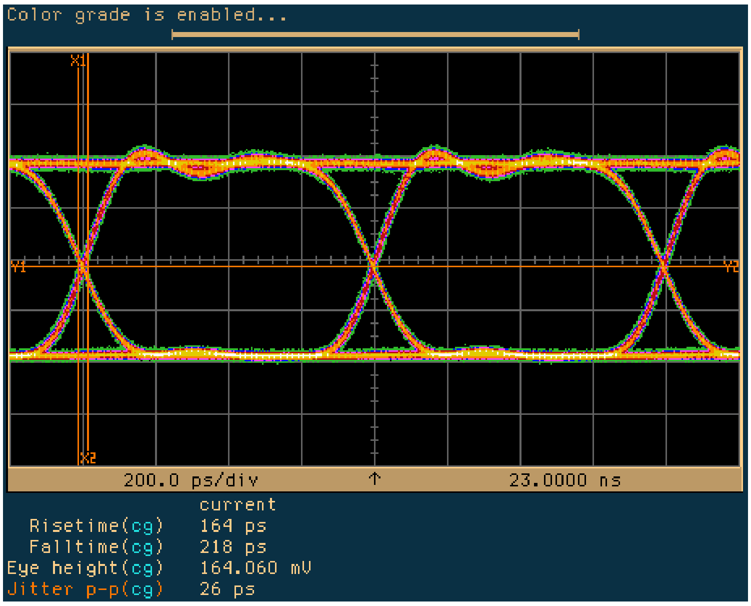
*** Conversion Gain at 850nm**
Conversion gain when the wavelength is 850 nm. The conversion gain is a value, where output voltage is divided by the input optical power when the CW light with the reference wavelength for each model is inputted into an O/E converter, and optical power is adjusted so that the output DC voltage at the time of 50-ohm load becomes to about 300 mV.

The upper column shows a value when light is inputted from GI fiber of core diameter 50um and 100um, that is whose aperture is comparatively small. A lower column shows a value when light is inputted from the optical fiber of each product, whose character is as close as possible to the limit of maximum core diameter and the maximum acceptable NA. It means that the more both measurement values are close, the input optical power loss in built-in optical system of the O/E converter is small.

*** Positive Supply Current and Negative Supply Current**
Indicates the consumption current of +15V and -15V power supply. Because **SPA-2_650nm**, only, operates by a single power supply, which is the positive side, the value of the negative side is zero.

Example of waveform measurement

An example where the optical power wave is measured using **SPD-3** (Graviton's O/E converter), after **VL-850GI** (Graviton's E/O converter) is modulated by the PRBS signal of 2^7-1, is introduced. For both oscilloscope displays, the second division line from the bottom is dark level (a position where the optical power is zero). Also, the vertical axis scale is 50mV/div.



*** 1.25-Gbps eye pattern
(Optimal modulation depth)**

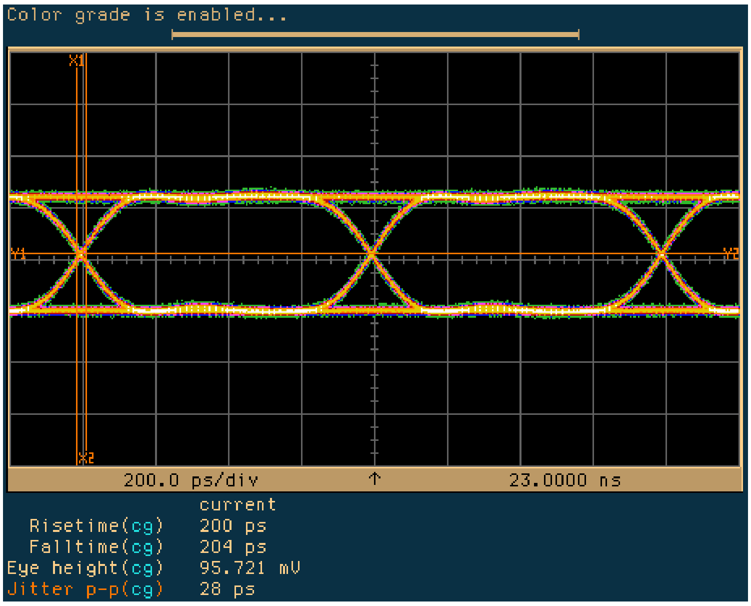
Measured example of eye pattern with a signal of 1.25Gbps PRBS, where **VL-850GI** and **SPD-3** are connected with 50 GI fiber of 5m length.

In this example, an electrical signal input level to **VL-850GI** is adjusted so that it becomes the proper degree of optical modulation by observing a waveform.

Since the center in the vertical direction of the eye pattern is located at about 100mV higher than dark level, the average optical power is read about 200uW, assuming that the conversion gain of the **SPD-3** is 500mV/mW.

Eye height is displayed as 164.060 mV, using the measurement function of the oscilloscope. In terms of optical power conversion, it turns out that the eye height is about 328uW.

In addition, Rise time and Fall time are 10% to 90% value. It is evident that light turning-off takes more time than light turning-on.



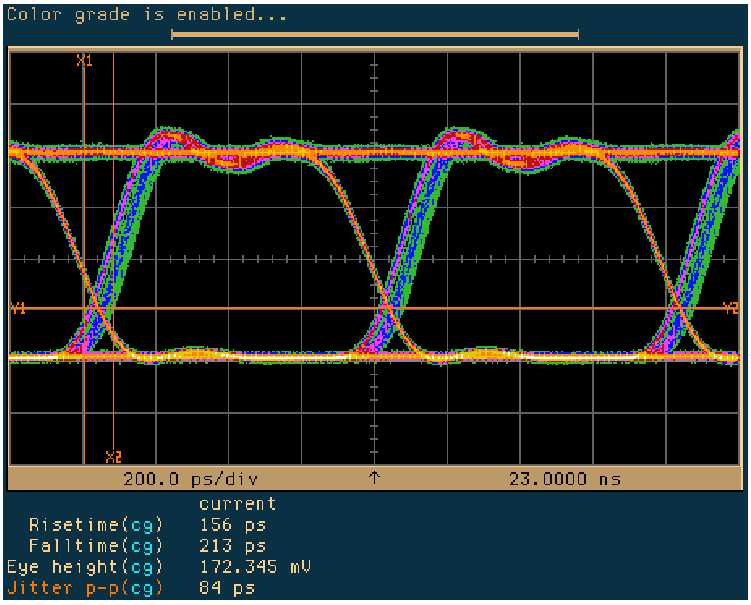
*** 1.25-Gbps eye pattern
(Small modulation depth)**

Shown in the figure on the left is an example where the modulation level to **VL-850GI** is made small about 60% of the above-mentioned level.

The modulation bottom level is read about 50mV, and the top level is read about 160mV, which is equivalent to the optical power of about 100uW and 320uW respectively.

Since modulation depth is small, both Fall time and Rise time become close and both are displayed as about 200ps. Since Rise time of **SPD-3** itself is about 180 ps, it is assumed that inherent Rise time of the **VL-850GI** is about 87ps. (Overshoot of **VL-850GI**, which is impossible to be detected by **SPD-3**, may be included.)

Eye height indicates as 95.721 mV. This is equivalent to roughly 190uW.



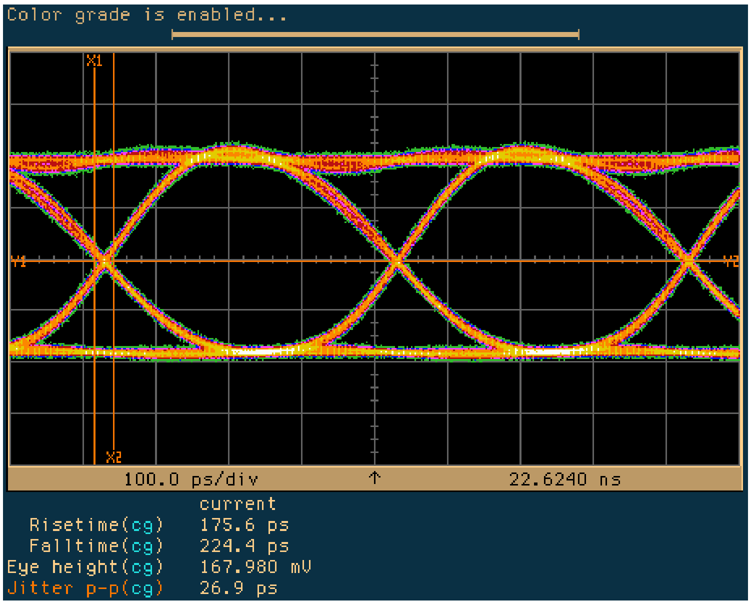
*** 1.25-Gbps eye pattern**
(Large modulation depth)

An example where intentionally the signal becomes overdriven by increasing the modulation level, given to the **VL-850GI**, is shown in the left figure.

In this example, the cross point of a rising and falling becomes lower than the peak value center, and its optical lighting duration are shorter than an inherent value, so that it turns out that the waveform becomes lean.

In addition, duration of off-time, which corresponds to the logical "0" of the PRBS pattern, changed, so that it turns out that lighting-up rise time varies and the jitter becomes larger.

How the ringing gets larger immediately after the waveform rise, is observed also.



*** 2.488-Gbps eye pattern**

Since the conversion frequency bandwidth of **SPD-3** is 2 GHz, a NRZ eye pattern up to about 2.67Gbps can be measured.

In the left example, the PRBS bit rate inputted to **VL-850GI** is 2.488 Gbps.

If the modulating signal level given to **VL-850GI** is adjusted properly, it can be checked how the value of a jitter is kept low.

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* Comparison of the frequency characteristics

* Comparison of the spectral sensitivity

* Frequency characteristic dependence on the wavelength

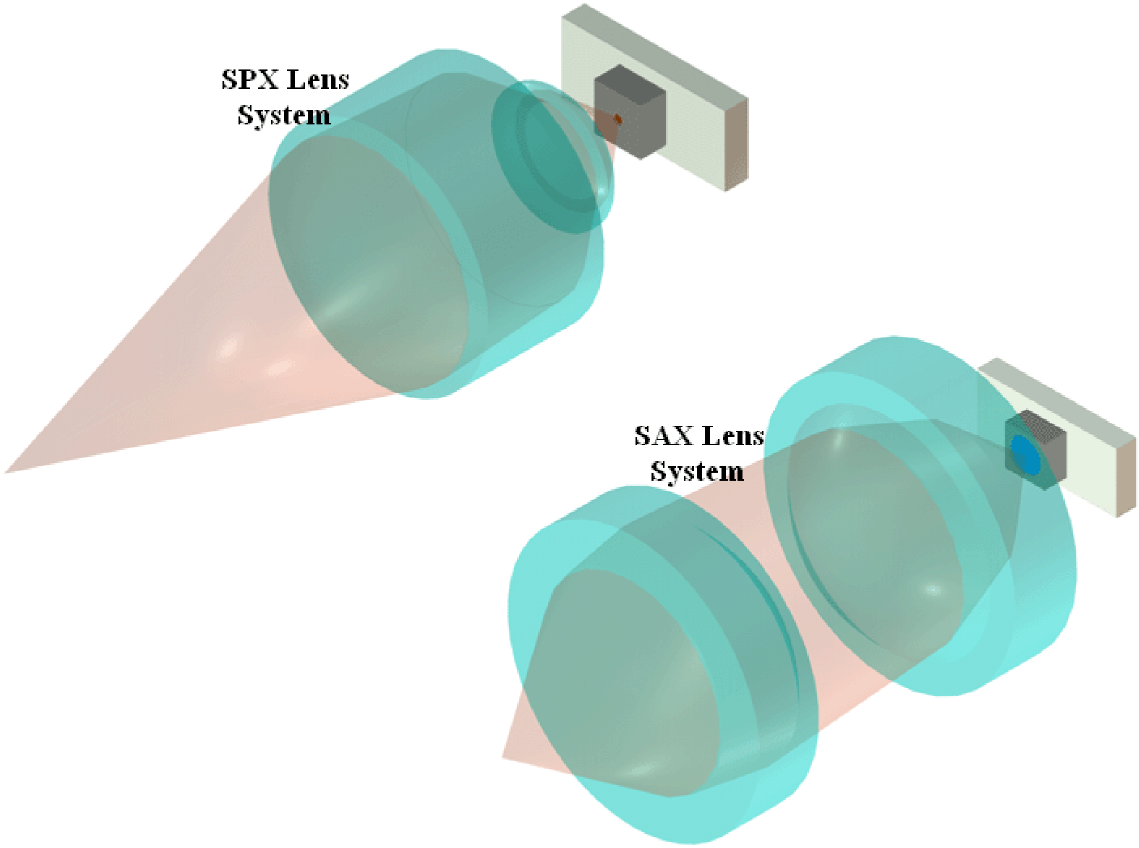
* Specifications for each model

* Options and accessories

* Calibration and Export certificates

* Contact information

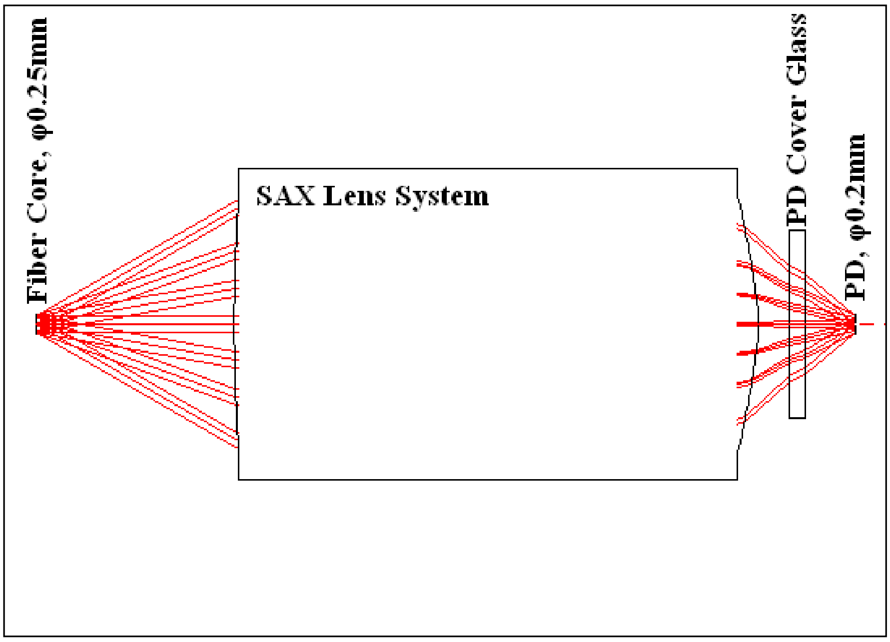
Comparison of the lens system for each model



The O/E converter other than **SPD-1**, **SPS-1**, **LPD-1**, **LPS-1** equips with lens system of proprietary design to enhance the optical coupling efficiency. The optical characteristics of beam transmission just behind the optical input connector and just in front of the photodetector are listed in the order from the model in a smaller field view of the light.

** The photodetector element with a ball lens is equipped with **SPD-1**, **SPS-1**, **LPD-1**, and **LPS-1**.

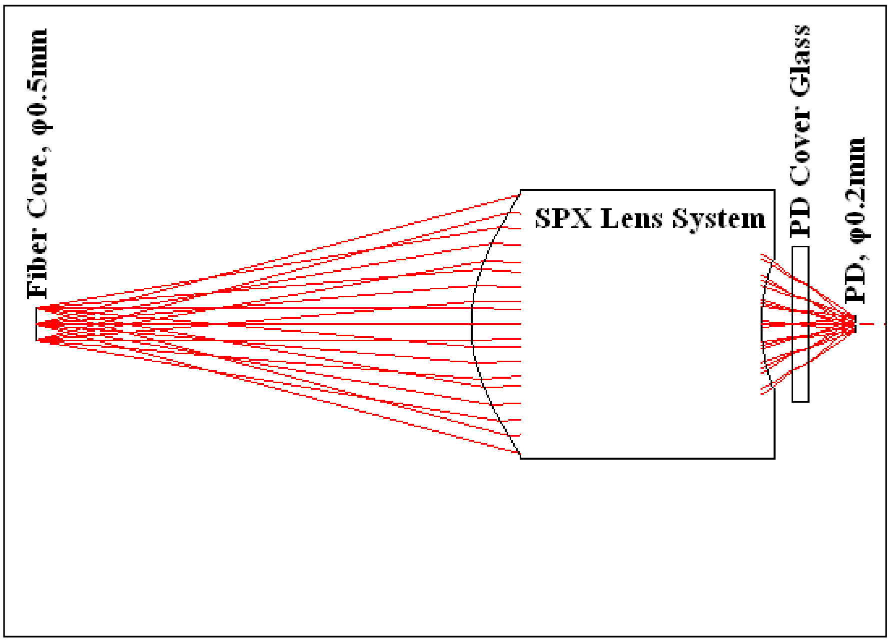
	Lens system of SPA-3 and SPA-4 **Maximum acceptable diameter = 0.25mm**



Maximum acceptable NA = 0.5

Diameter of PD = 0.2mm
Optical Magnification = 0.8

BW of SPA-3 = 2GHz
BW of SPA-4 = 3GHz



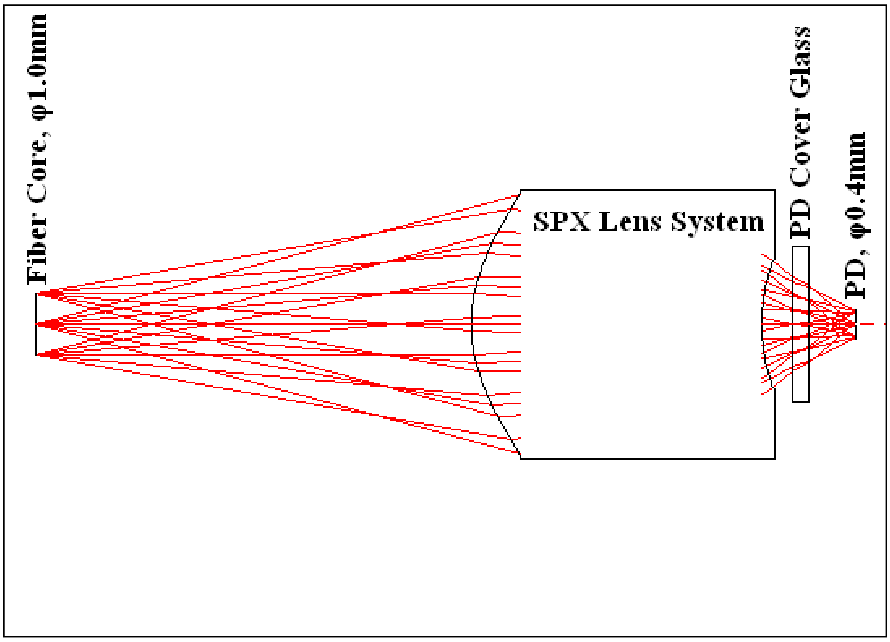
Lens system of
SPD-3,
SPD-4,
LPD-2 and
LPS-2_20KV/W

Maximum acceptable diameter = 0.5mm

Maximum acceptable NA = 0.25

Diameter of PD = 0.2mm
Optical Magnification = 0.4

BW of SPD-3 = 2GHz
BW of SPD-4 = 3GHz
BW of LPD-2 = 1.5GHz



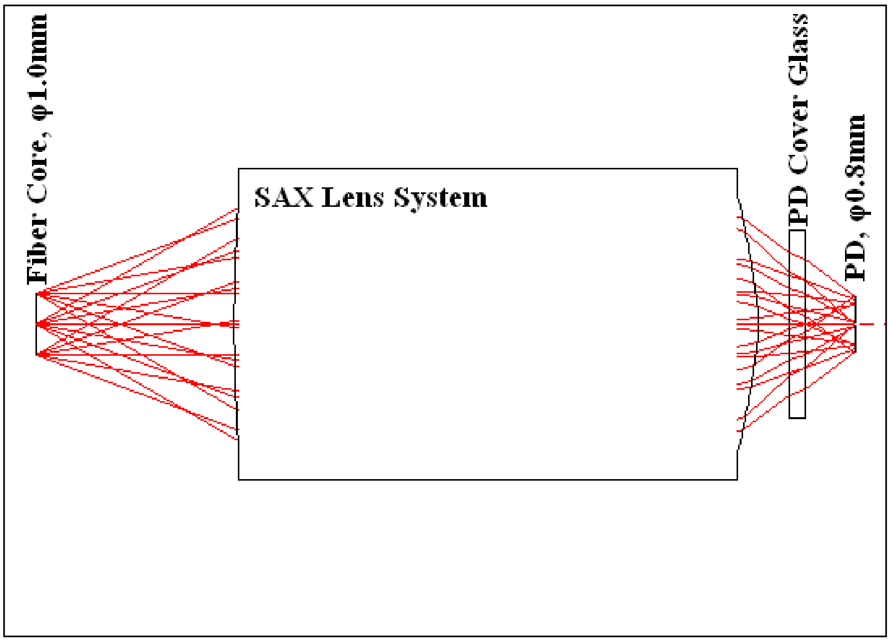
Lens system of
SPD-2_650nm and
SPD-2_850nm

Maximum acceptable diameter = 1.0mm

Maximum acceptable NA = 0.25

Diameter of PD = 0.4mm
Optical Magnification = 0.4

BW of SPD-2 = 1.2GHz



Lens system of SPA-2_650nm, SPS-2_10KV/W and SPS-2_100KV/W

Maximum acceptable diameter = 1.0mm

Maximum acceptable NA = 0.5

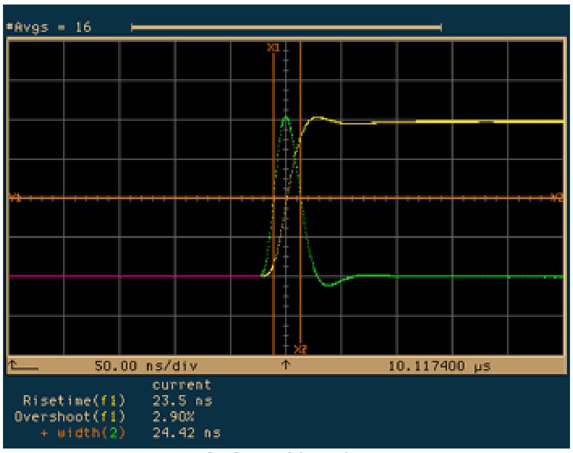
Diameter of PD = 0.8mm
Optical Magnification = 0.8

BW of SPA-2 = 1GHz

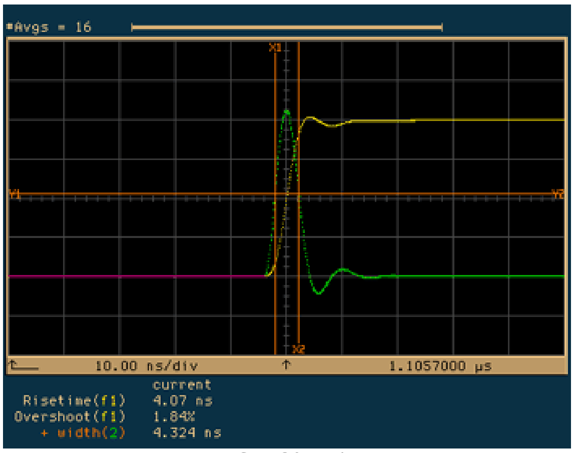
* Use a fiber with a core diameter of 100um or more.

Comparison of the step responses of each model

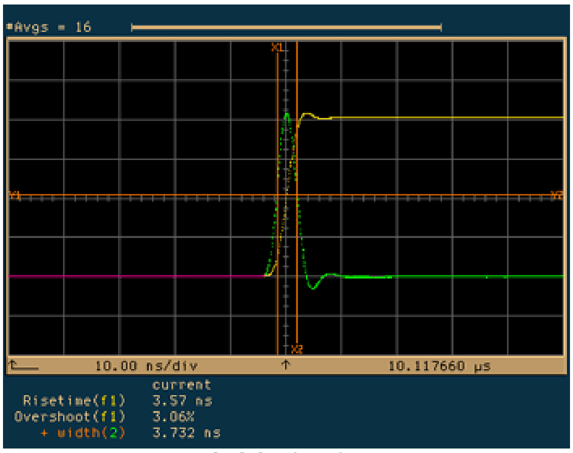
The step response characteristic of each model is introduced in order from slow as follows.



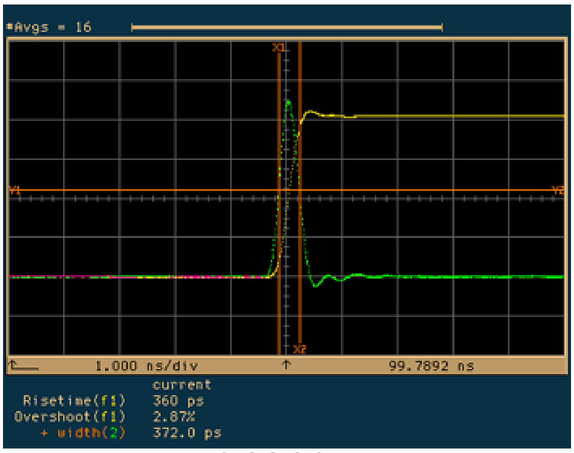
SPS-1_100KV/W
Risetime = 23.5ns, Overshoot = 2.90%



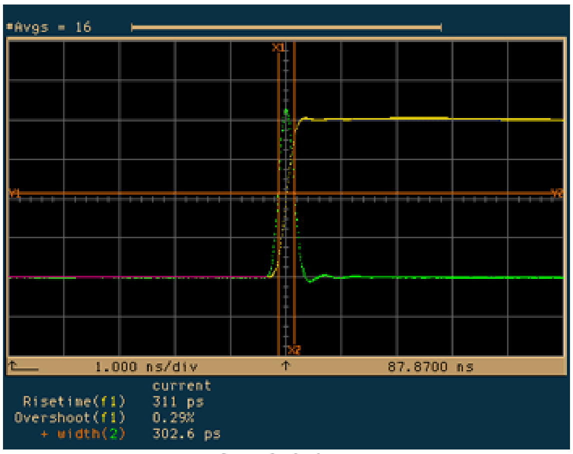
LPS-1_20KV/W
Risetime = 4.07ns, Overshoot = 1.84%



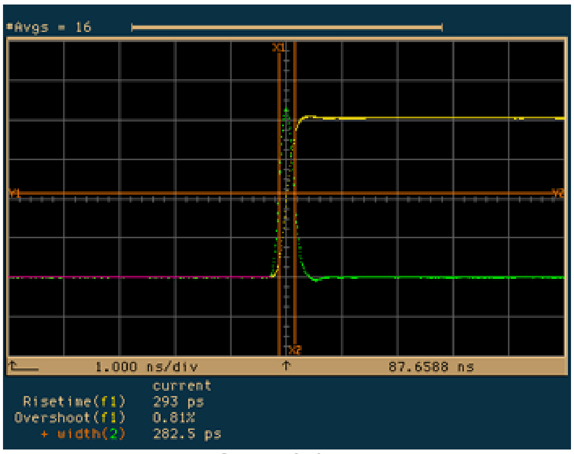
SPS-2_10KV/W
Risetime = 3.57ns, Overshoot = 3.06%



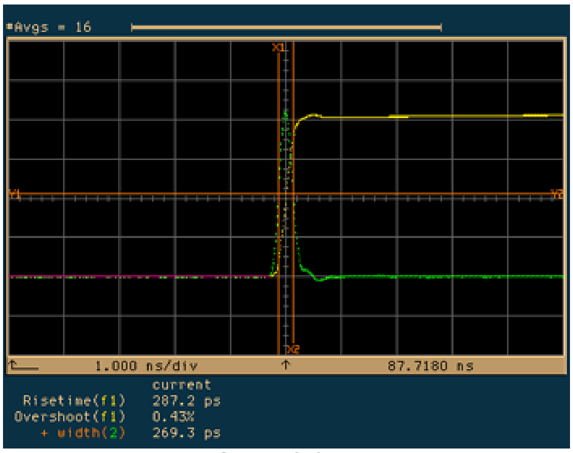
SPA-2_650nm
Risetime = 360ps, Overshoot = 2.87%



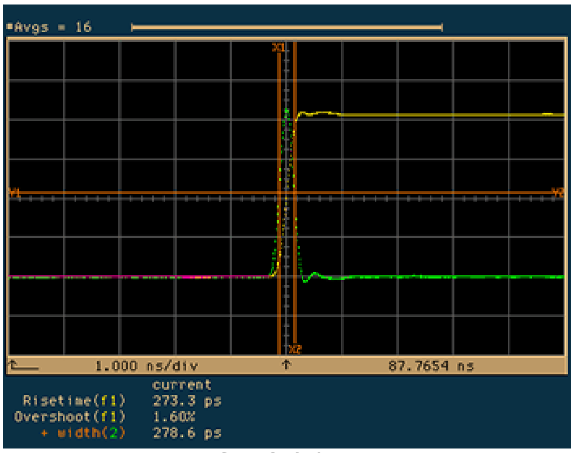
SPD-2_850nm
Risetime = 311ps, Overshoot = 0.29%



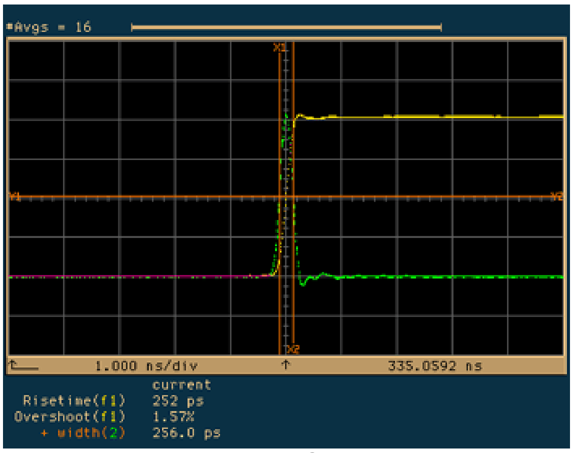
SPD-1_850nm
Risetime = 293ps, Overshoot = 0.81%



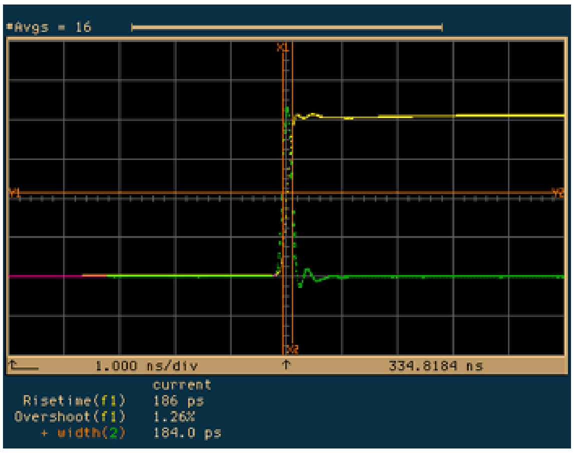
SPD-1_650nm
Risetime = 287.2ps, Overshoot = 0.43%



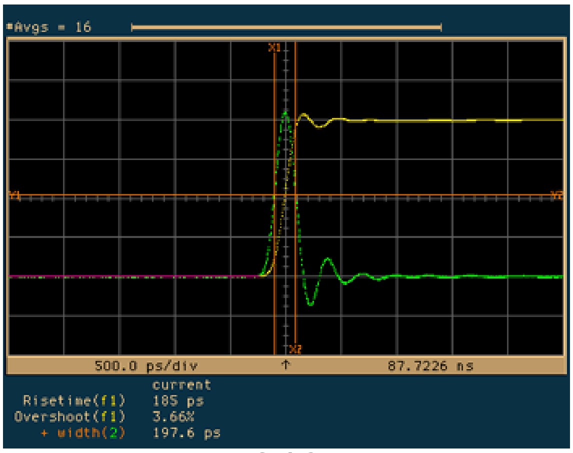
SPD-2_650nm
Risetime = 273.3ps, Overshoot = 1.60%



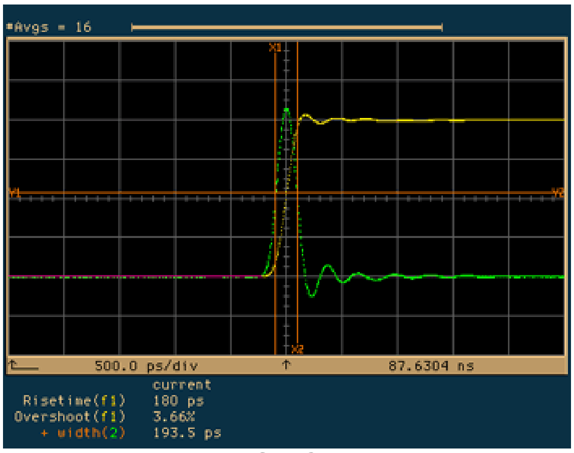
LPD-2
Risetime = 252ps, Overshoot = 1.57%



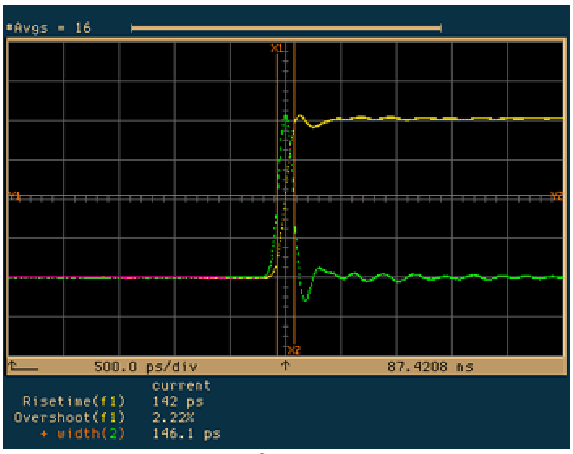
LPD-1
Risetime = 186ps, Overshoot = 1.26%



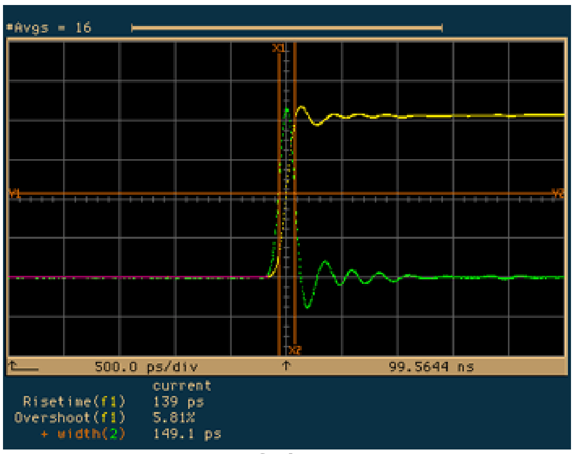
SPA-3
Risetime = 185ps, Overshoot = 3.66%



SPD-3
Risetime = 180ps, Overshoot = 3.66%



SPD-4
Risetime = 142ps, Overshoot = 2.22%



SPA-4
Risetime = 139ps, Overshoot = 5.81%

** The step response time of **SPD-1_650nm**, **SPD-1_850nm**, **SPD-2_650nm**, and **SPD-2_850nm** models is almost the same, so that the above-mentioned order of response speed may not represent the correct order due to the variation of response time of each product.

** The step response time of **SPD-3** and **SPA-3** models is almost the same, so that the above-mentioned order of response speed may not represent the correct order due to the variation of response time of each product.

** The step response time of **SPD-4** and **SPA-4** models is almost the same, so that the above-mentioned order of response speed of may not represent the correct order due to the variation of response time of each product.

-- Links to each page --

* Overview

* Precautions

* Contents of the package

* Part names and functions

* Mount and connection

* Shipment data and measurement examples

* Comparison of the lens system

* Comparison of the step responses

* Comparison of the frequency characteristics

* Comparison of the spectral sensitivity

* Frequency characteristic dependence on the wavelength

* Specifications for each model

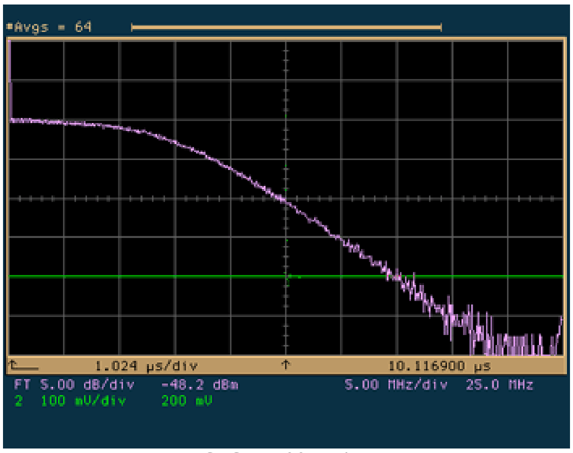
* Options and accessories

* Calibration and Export certificates

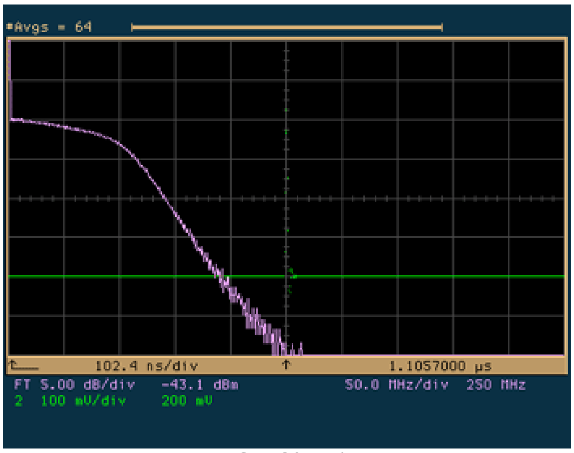
* Contact information

Comparison of the frequency characteristics for each model

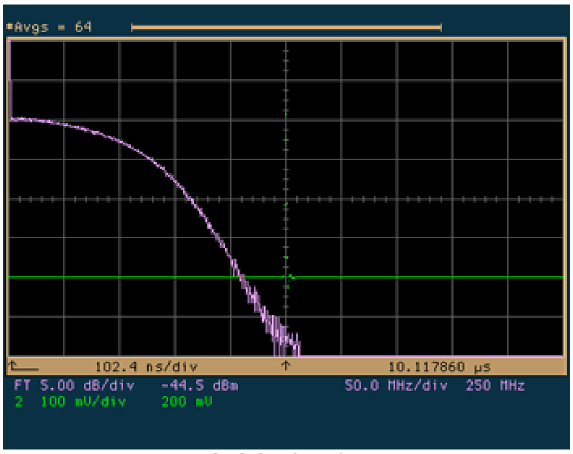
The frequency characteristic of each model is introduced in the order from slow response model.



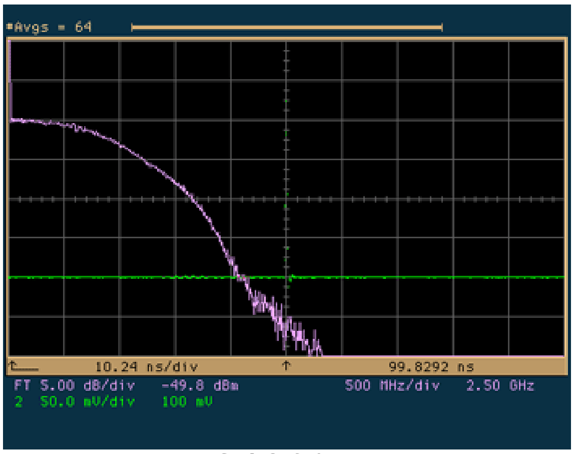
SPS-1_100KV/W
-3dB (Electrical) Frequency = Applox. 15MHz



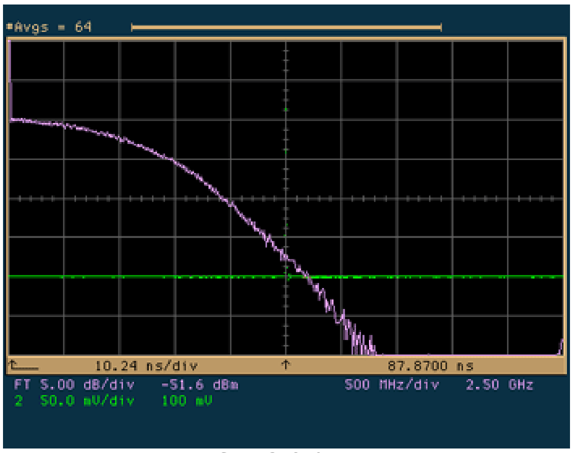
LPS-1_20KV/W
-3ｄB (Electrical) Frequency = Applox. 100MHz



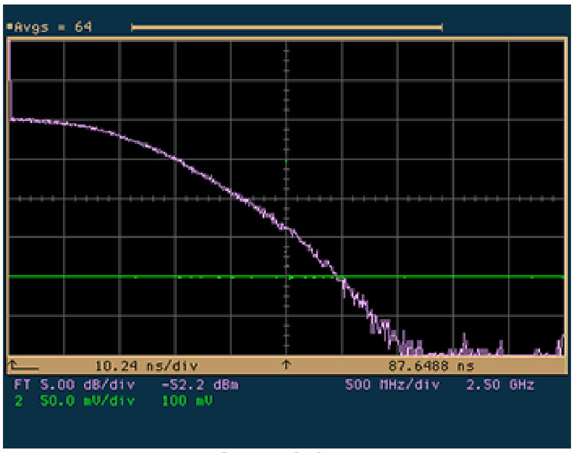
SPS-2_10KV/W
-3dB (Electrical) Frequency = Applox. 100MHz



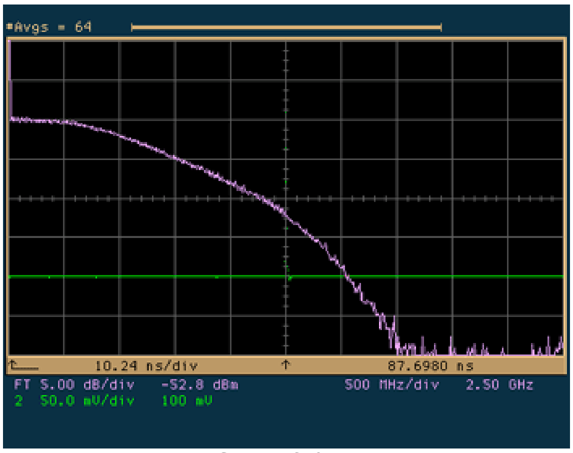
SPA-2_650nm
-3dB (Electrical) Frequency = Applox. 1.0GHz



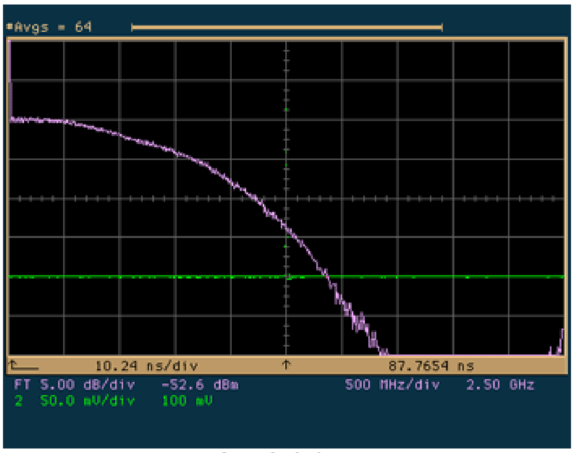
SPD-2_850nm
-3dB (Electrical) Frequency = Applox. 1.2GHz



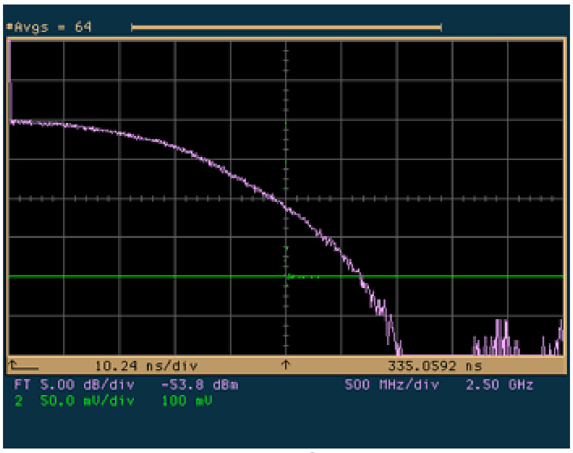
SPD-1_850nm
-3dB (Electrical) Frequency = Applox. 1.2GHz



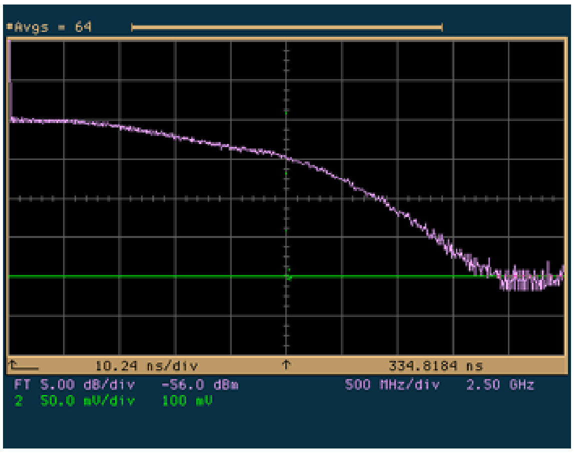
SPD-1_650nm
-3dB (Electrical) Frequency = Applox. 1.2GHz



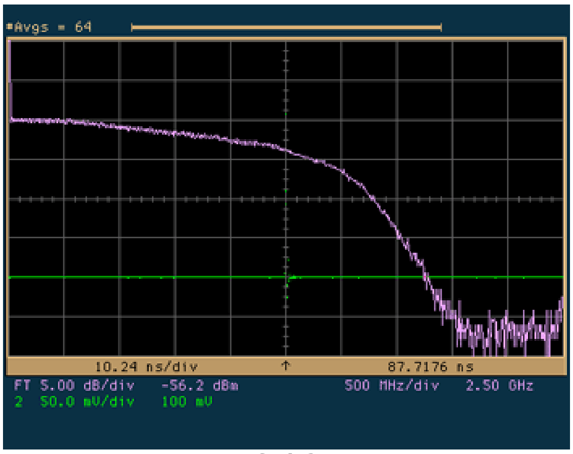
SPD-2_650nm
-3dB (Electrical) Frequency = Applox. 1.2GHz



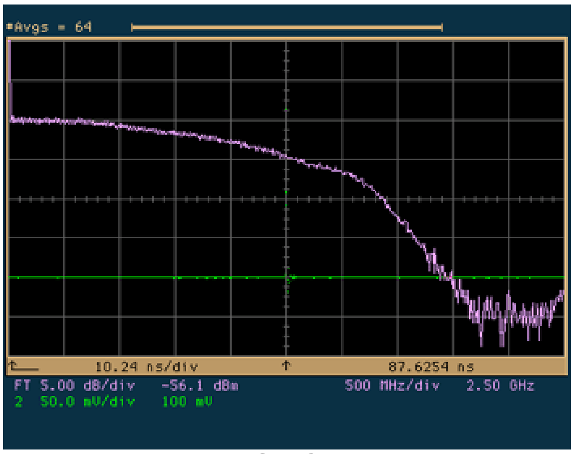
LPD-2
-3dB (Electrical) Frequency = Applox. 1.5GHz



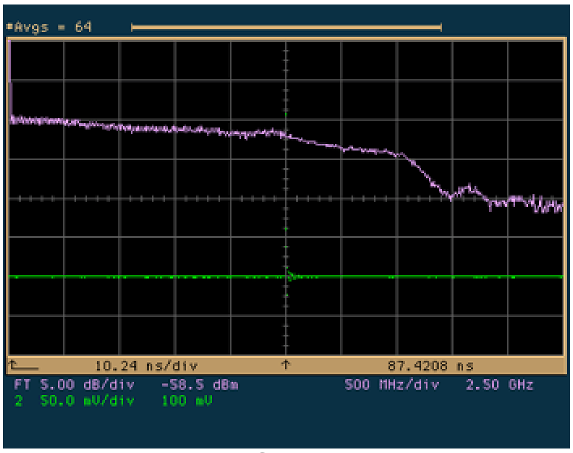
LPD-1
-3dB (Electrical) Frequency = Applox. 1.8GHz



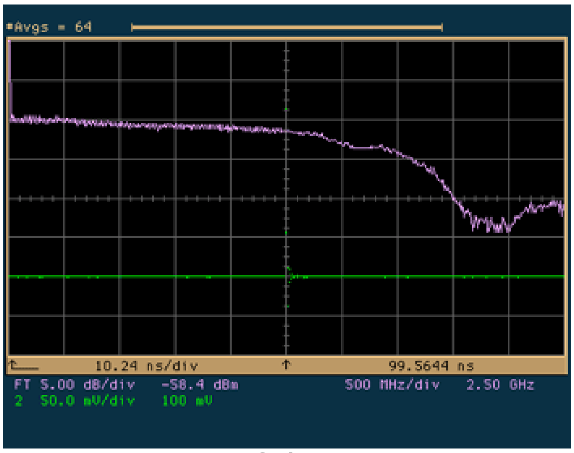
SPA-3
-3dB (Electrical) Frequency = Applox. 2.0GHz



SPD-3
-3dB (Electrical) Frequency = Applox. 2.0GHz



SPD-4
-3dB (Electrical) Frequency = Applox. 3.0GHz



SPA-4
-3dB (Electrical) Frequency = Applox. 3.0GHz

** The frequency bandwidth of **SPD-1_650nm**, **SPD-1_850nm**, **SPD-2_650nm**, and **SPD-2_850nm** models is almost the same, so that the above-mentioned order of frequency bandwidth may not represent the correct order due to its variation in each product.

** The frequency bandwidth of **SPD-3** and **SPA-3** models is almost the same, so that the above-mentioned order of frequency bandwidth may not represent the correct order due to the variation in each product.

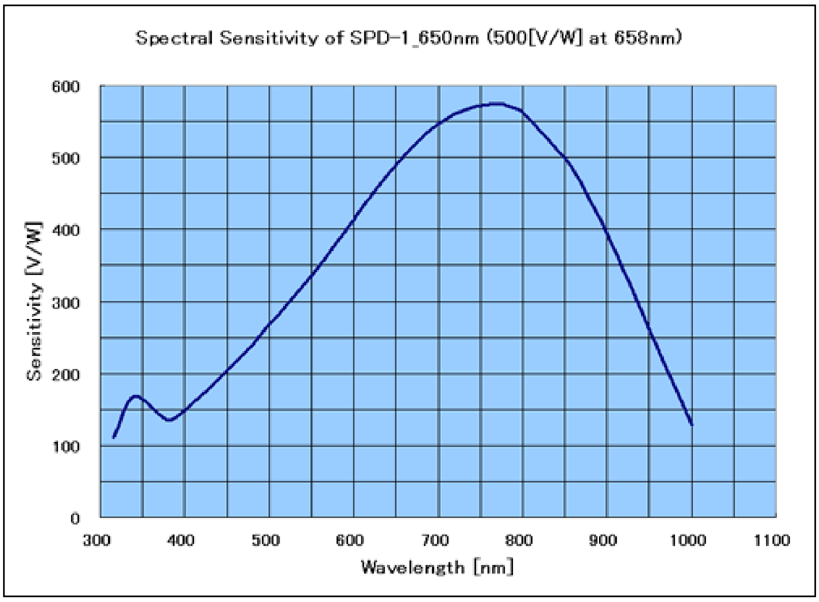
** The frequency bandwidth of **SPD-4** and **SPA-4** models is almost the same, so that the above-mentioned order of frequency bandwidth may not represent the correct order due to the variation in each product.

-- **Links to each page** --

Spectral sensitivity characteristics for each model

The graph of the spectral sensitivity characteristics for each model is shown below. Each data was calculated based on the photo-detector manufacturer's data sheet, and it is not an actual measurement result of the O/E converter.

A typical example of the sensitivity at each wavelength is shown. There is a variation of up to ± 10% for each model. Check this as a reference.



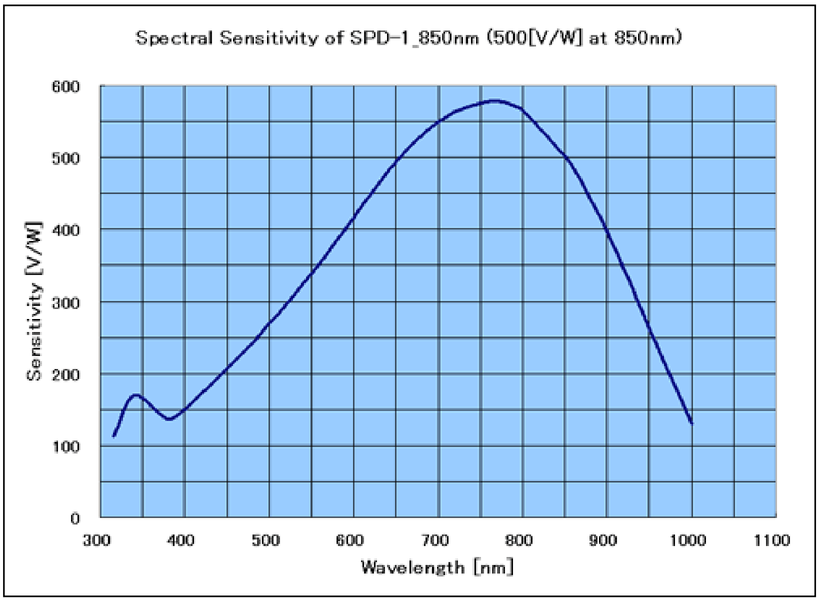
Spectral sensitivity of SPD-1_650nm

Reference wavelength = 658nm

Peak sensitivity wavelength
= Applox. 770nm

Sensitivity in dominant wavelength :

148 [V/W] at 400nm
267 [V/W] at 500nm
414 [V/W] at 600nm
545 [V/W] at 700nm
562 [V/W] at 800nm
395 [V/W] at 900nm



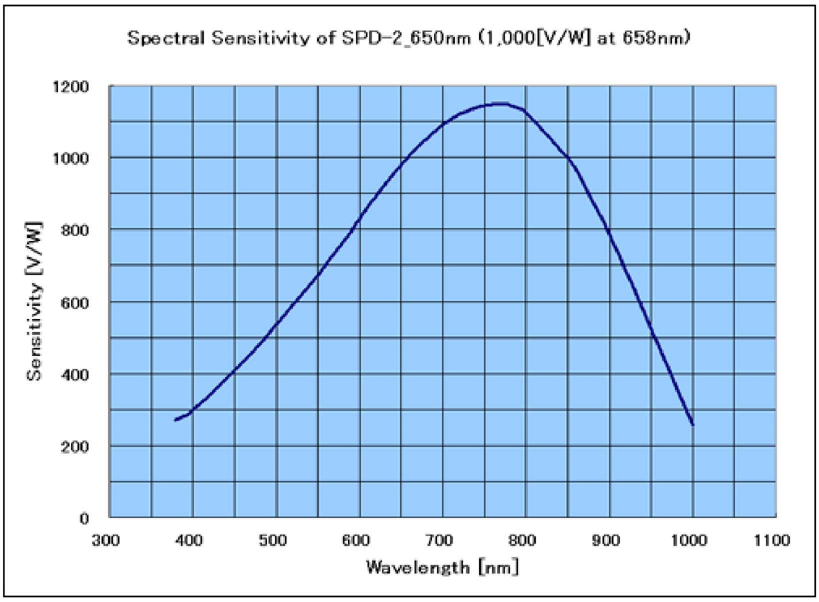
Spectral sensitivity of SPD-1_850nm

Reference wavelength = 850nm

Peak sensitivity wavelength
= Applox. 770nm

Sensitivity in dominant wavelength :

149 [V/W] at 400nm
269 [V/W] at 500nm
417 [V/W] at 600nm
549 [V/W] at 700nm
566 [V/W] at 800nm
398 [V/W] at 900nm



Spectral Sensitivity of SPD-2_650nm (1,000[V/W] at 658nm)
Sensitivity [V/W]
1200
1000
800
600
400
200
0
300
400
500
600
700
800
900
1000
1100
Wavelength [nm]

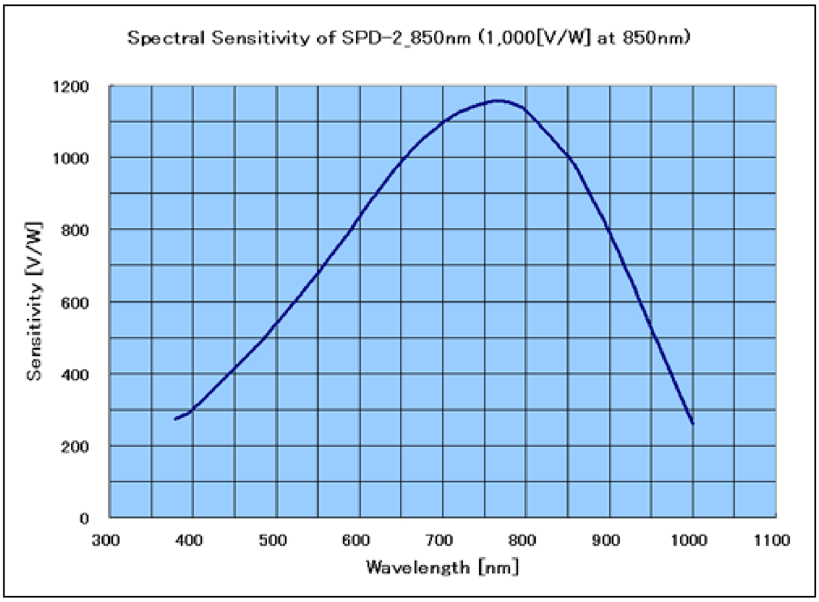
Spectral sensitivity of SPD-2_650nm

Reference wavelength = 658nm

Peak sensitivity wavelength = Applox. 770nm

Sensitivity in dominant wavelength :

296 [V/W] at 400nm
535 [V/W] at 500nm
829 [V/W] at 600nm
1,090 [V/W] at 700nm
1,125 [V/W] at 800nm
790 [V/W] at 900nm



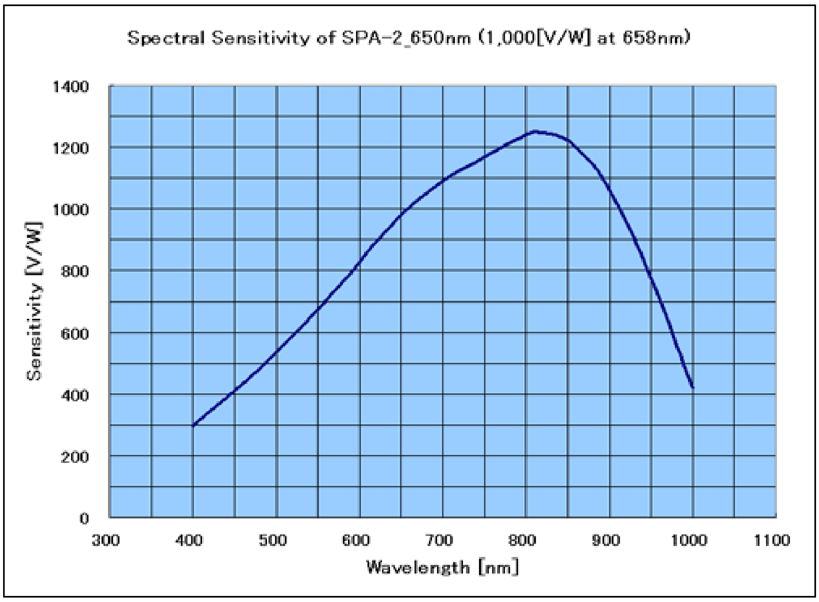
Spectral sensitivity of SPD-2_850nm

Reference wavelength = 850nm

Peak sensitivity wavelength = Applox. 770nm

Sensitivity in dominant wavelength :

298 [V/W] at 400nm
539 [V/W] at 500nm
834 [V/W] at 600nm
1,098 [V/W] at 700nm
1,133 [V/W] at 800nm
795 [V/W] at 900nm



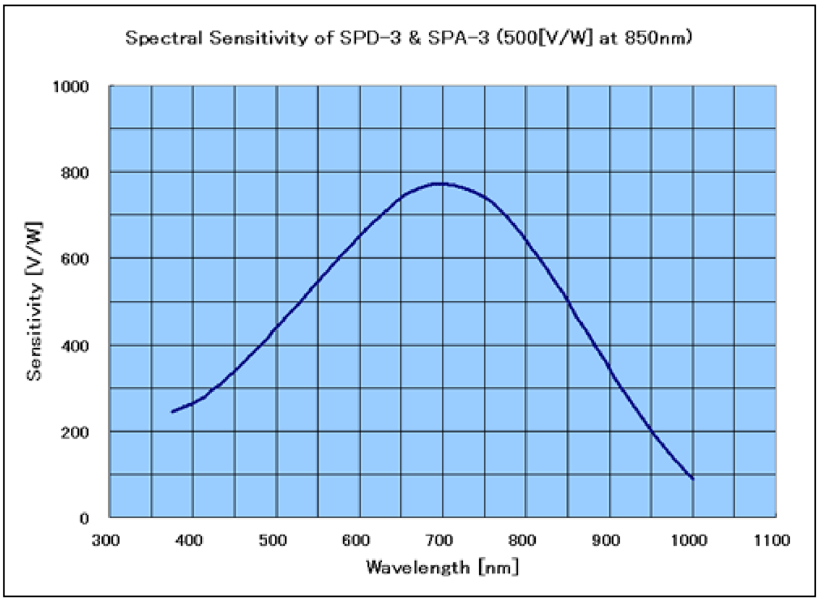
Spectral sensitivity of SPA-2_650nm

Reference wavelength = 658nm

Peak sensitivity wavelength = Applox. 820nm

Sensitivity in dominant wavelength :

296 [V/W] at 400nm
535 [V/W] at 500nm
829 [V/W] at 600nm
1,090 [V/W] at 700nm
1,240 [V/W] at 800nm
1,063 [V/W] at 900nm



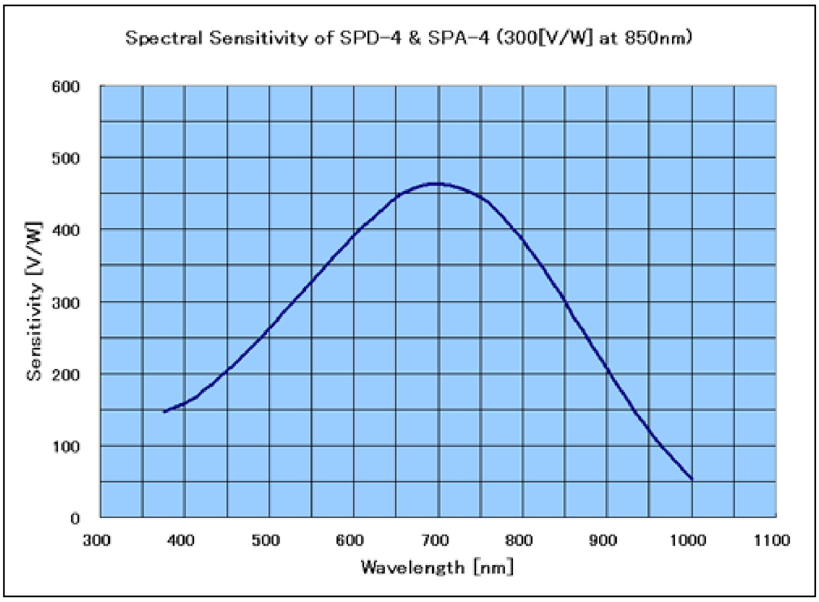
Spectral sensitivity of SPD-3 and SPA-3

Reference wavelength = 850nm

Peak sensitivity wavelength = Applox. 700nm

Sensitivity in dominant wavelength :

264 [V/W] at 400nm
438 [V/W] at 500nm
652 [V/W] at 600nm
772 [V/W] at 700nm
639 [V/W] at 800nm
341 [V/W] at 900nm



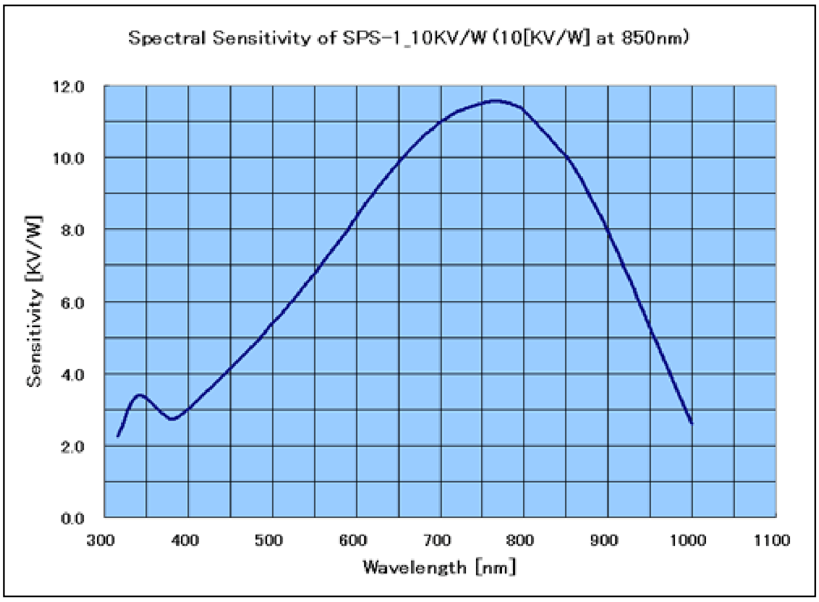
Spectral sensitivity of SPD-4 and SPA-4

Reference wavelength = 850nm

Peak sensitivity wavelength = Applox. 700nm

Sensitivity in dominant wavelength :

158 [V/W] at 400nm
263 [V/W] at 500nm
391 [V/W] at 600nm
463 [V/W] at 700nm
383 [V/W] at 800nm
205 [V/W] at 900nm



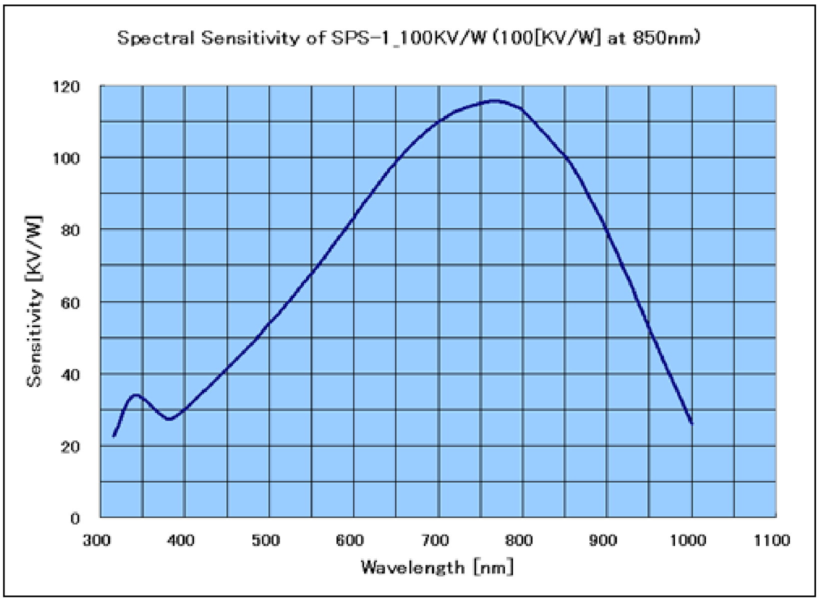
Spectral sensitivity of SPS-1_10KV/W

Reference wavelength = 850nm

Peak sensitivity wavelength = Applox. 770nm

Sensitivity in dominant wavelength :

3,000 [V/W] at 400nm
5,400 [V/W] at 500nm
8,300 [V/W] at 600nm
11,000 [V/W] at 700nm
11,300 [V/W] at 800nm
8,000 [V/W] at 900nm



Spectral Sensitivity of SPS-1_100KV/W (100[KV/W] at 850nm)
Sensitivity [KV/W]
Wavelength [nm]
0
20
40
60
80
100
120
300
400
500
600
700
800
900
1000
1100

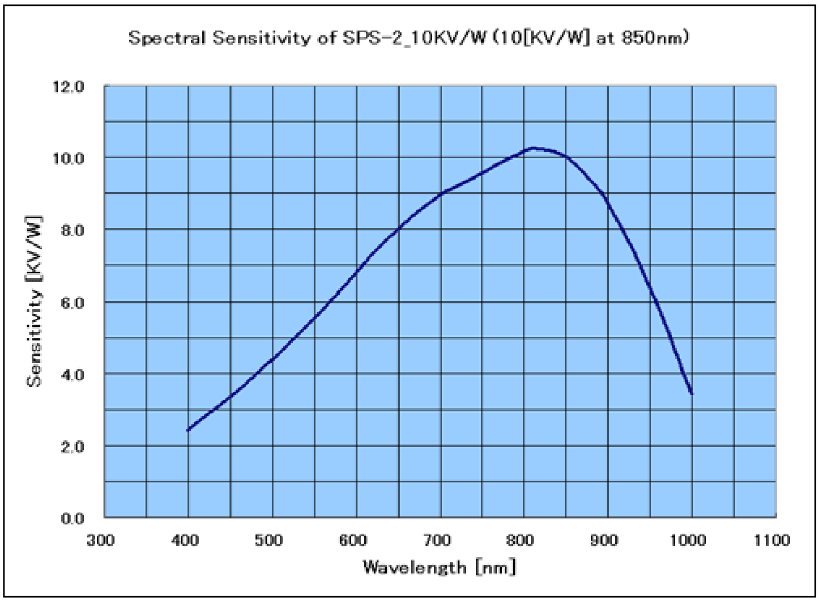
Spectral sensitivity of SPS-1_100KV/W

Reference wavelength = 850nm

Peak sensitivity wavelength = Applox. 770nm

Sensitivity in dominant wavelength :

29,800 [V/W] at 400nm
53,900 [V/W] at 500nm
83,400 [V/W] at 600nm
109,800 [V/W] at 700nm
113,300 [V/W] at 800nm
79,500 [V/W] at 900nm



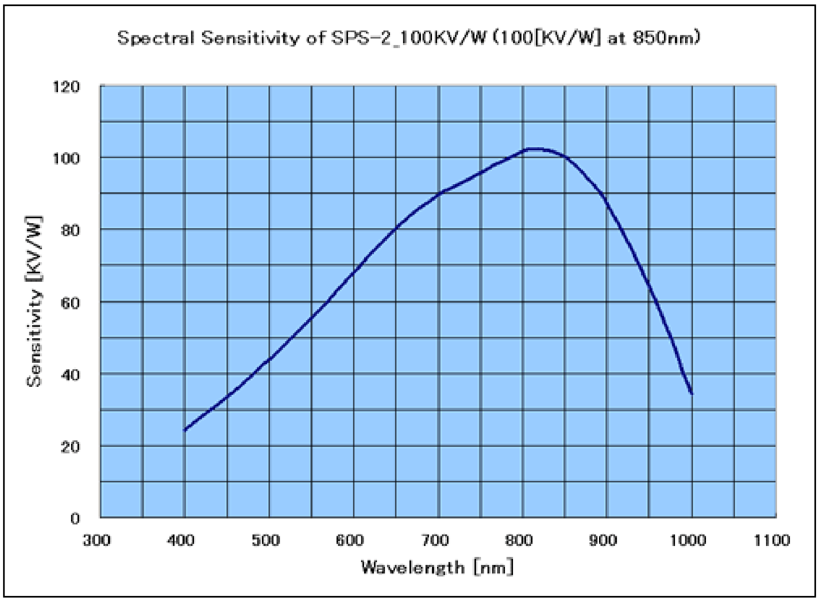
Spectral sensitivity of SPS-2_10KV/W

Reference wavelength = 850nm

Peak sensitivity wavelength = Applox. 820nm

Sensitivity in dominant wavelength :

2,400 [V/W] at 400nm
4,400 [V/W] at 500nm
6,800 [V/W] at 600nm
9,000 [V/W] at 700nm
10,200 [V/W] at 800nm
8,700 [V/W] at 900nm



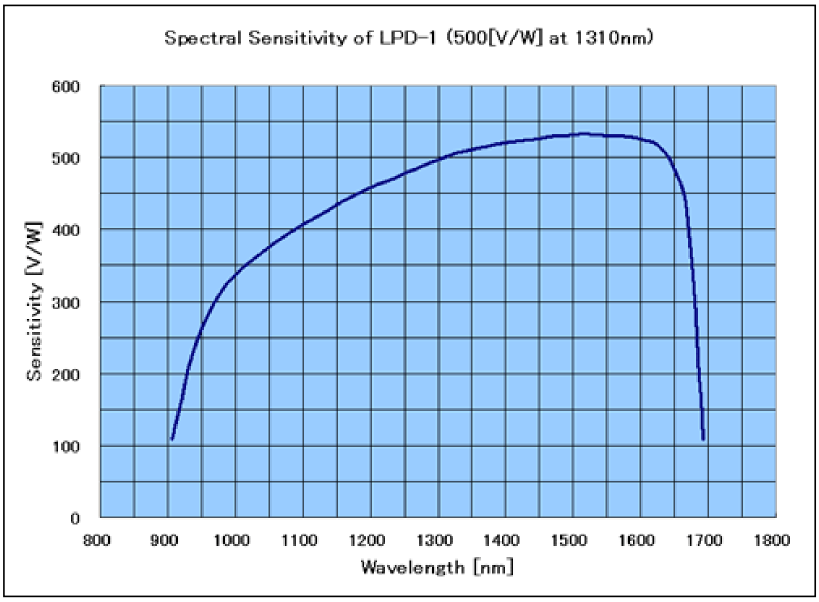
Spectral sensitivity of SPS-2_100KV/W

Reference wavelength = 850nm

Peak sensitivity wavelength = Applox. 820nm

Sensitivity in dominant wavelength :

24,300 [V/W] at 400nm
43,900 [V/W] at 500nm
68,000 [V/W] at 600nm
89,500 [V/W] at 700nm
101,800 [V/W] at 800nm
87,300 [V/W] at 900nm



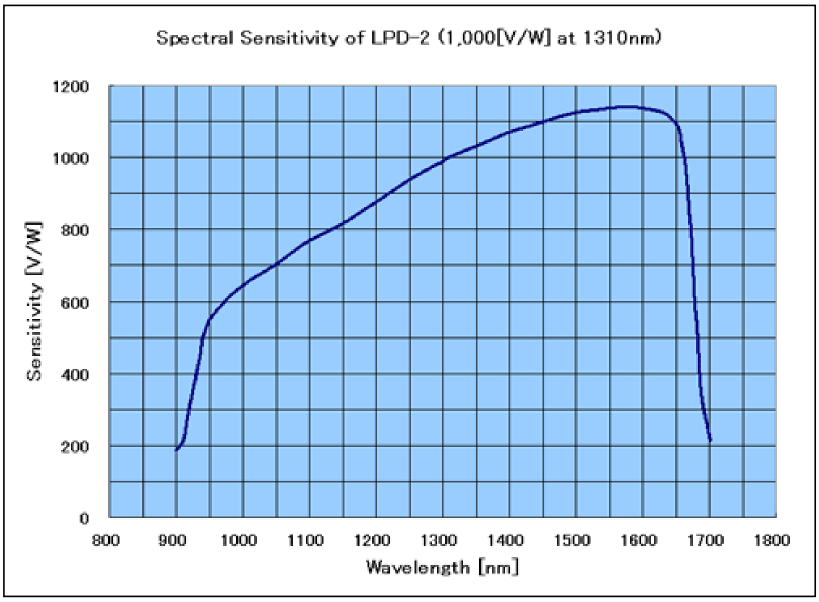
Spectral sensitivity of LPD-1

Reference wavelength = 1,310nm

Peak sensitivity wavelength
= Applox. 1,540nm

Sensitivity in dominant wavelength :

108 [V/W] at 900nm
337 [V/W] at 1,000nm
458 [V/W] at 1,200nm
520 [V/W] at 1,400nm
531 [V/W] at 1,500nm
526 [V/W] at 1,600nm



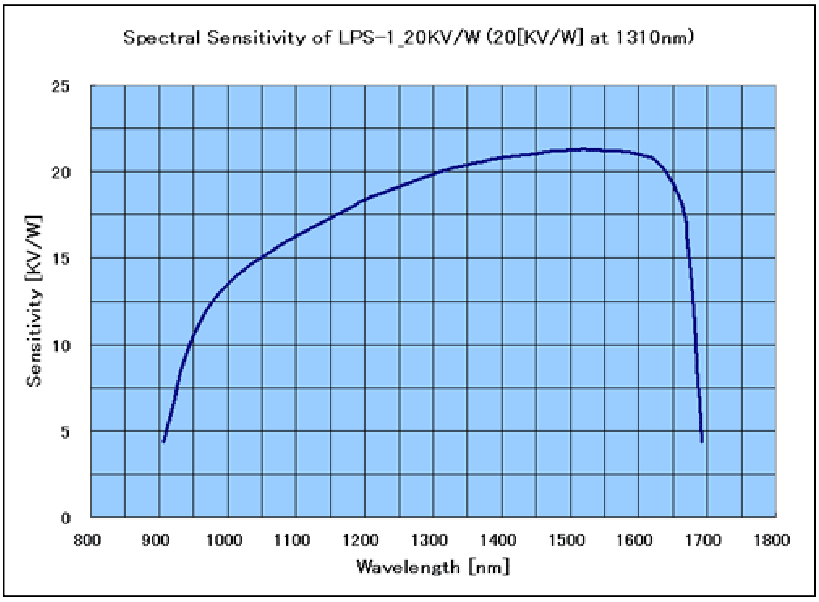
Spectral sensitivity of LPD-2

Reference wavelength = 1,310nm

Peak sensitivity wavelength
= Applox. 1,570nm

Sensitivity in dominant wavelength :

185 [V/W] at 900nm
644 [V/W] at 1,000nm
768 [V/W] at 1,100nm
878 [V/W] at 1,200nm
1,071 [V/W] at 1,400nm
1,127 [V/W] at 1,500nm
1,137 [V/W] at 1,600nm



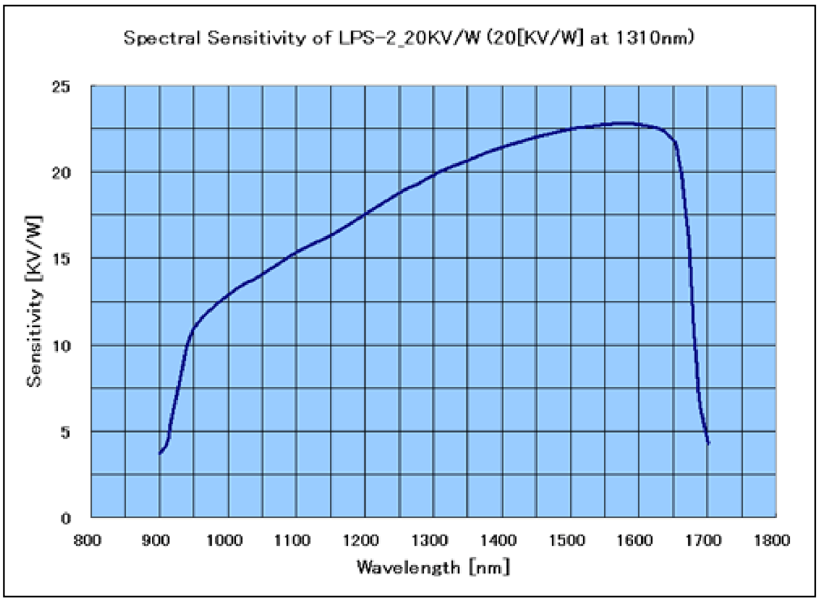
Spectral sensitivity of LPS-1_20KV/W

Reference wavelength = 1,310nm

Peak sensitivity wavelength
= Applox. 1,540nm

Sensitivity in dominant wavelength :

4,300 [V/W] at 900nm
13,500 [V/W] at 1,000nm
18,300 [V/W] at 1,200nm
20,800 [V/W] at 1,400nm
21,300 [V/W] at 1,500nm
21,000 [V/W] at 1,600nm



Spectral Sensitivity of LPS-2_20KV/W (20[KV/W] at 1310nm)
Sensitivity [KV/W]
Wavelength [nm]
0
5
10
15
20
25
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800

Spectral sensitivity of LPS-2_20KV/W

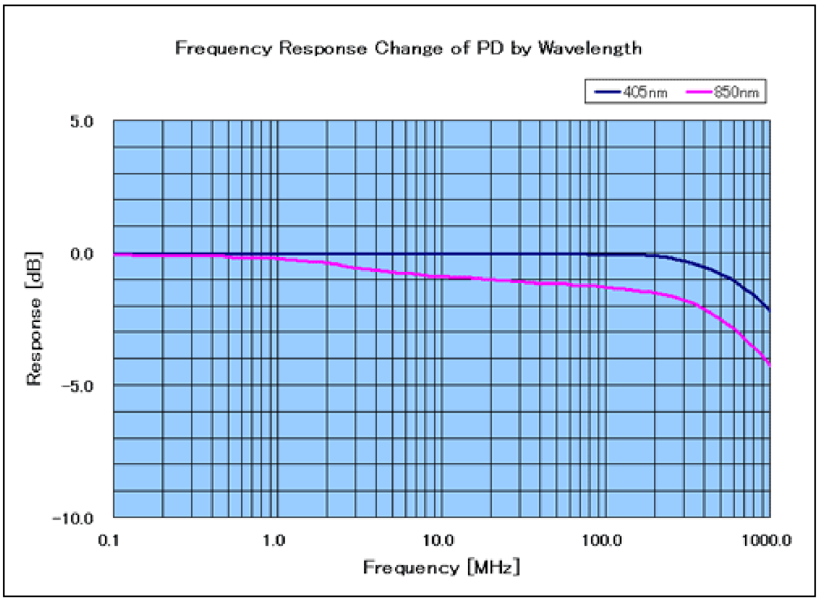
Reference wavelength = 1,310nm

Peak sensitivity wavelength
= Applox. 1,570nm

Sensitivity in dominant wavelength :

3,700 [V/W] at 900nm
12,900 [V/W] at 1,000nm
15,400 [V/W] at 1,100nm
17,600 [V/W] at 1,200nm
21,400 [V/W] at 1,400nm
22,500 [V/W] at 1,500nm
22,700 [V/W] at 1,600nm

Frequency characteristic dependence on the wavelength



The many of silicon photodetector has a frequency characteristics change, depending on the wavelength of incident light, in nature. Graph on the left is the frequency characteristic example of high-speed silicon PIN photodetector.

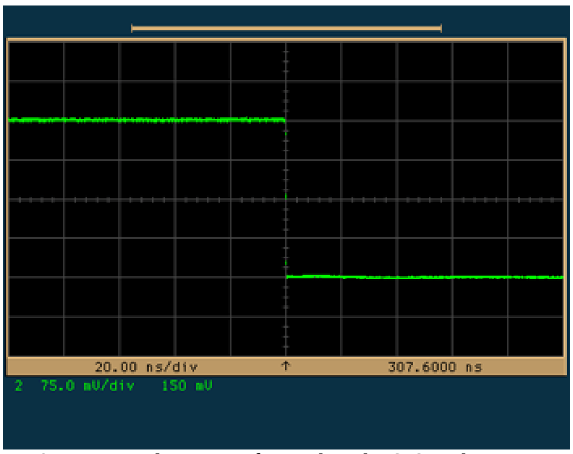
As shown in this example, it is observed that the element has a flat response up to 1GHz or more for the short wavelength, though, there is the response shelf-like decrease, starting from a relatively low frequency, for the long wavelength.

In the high-frequency range of the frequency characteristics, response is significantly reduced from where the wavelength of the beam is longer than the maximum sensitivity wavelength of the photo detector.

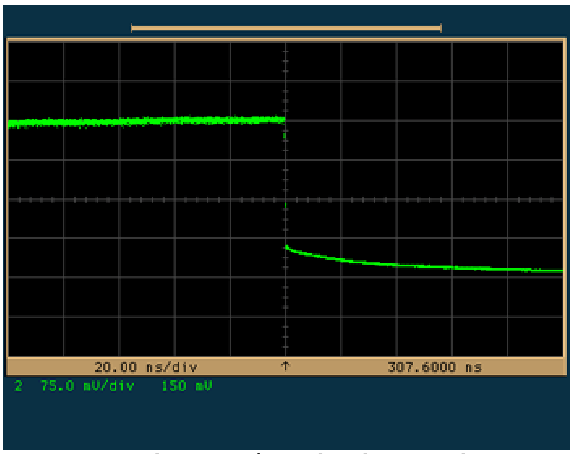
Also, the same character is seen on the photodetector currently used for **SPD-1**, **SPD-2**, and **SPA-2**.By changing the compensation constant of the circuit for each reference wavelength of the product, those models have earned a flat frequency characteristic as a whole.

Accordingly, when a light with different wavelength from the reference wavelength is inputted to **SPD-1**, **SPD-2**, **SPA-2**, the frequency characteristics of the product cannot be maintained flat, and may result in distorted. The following shows the output voltage waveform at a moment when the beam, inputted to O/E converter, is intercepted instantly.

*** Example, using SPD-1_650nm**



An output voltage waveform when the **658nm** beam is inputted to **SPD-1_650nm** and is intercepted rapidly.

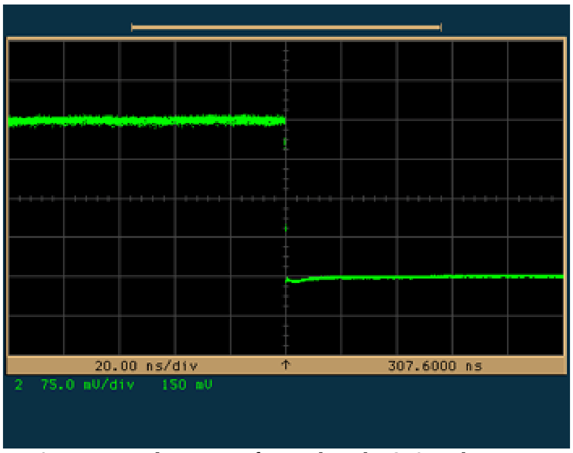


An output voltage waveform when the **850nm** beam is inputted to **SPD-1_650nm** and is intercepted rapidly.

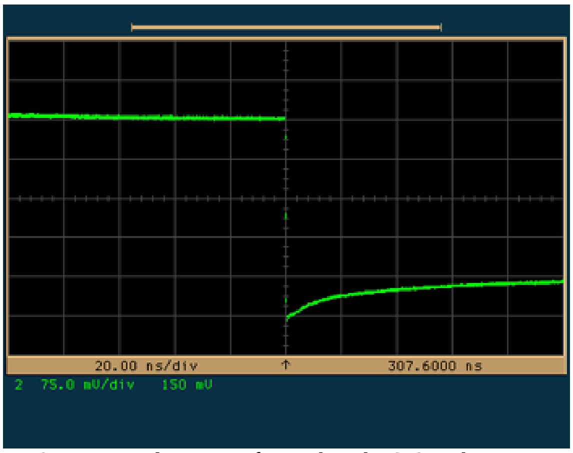
Waveform, on the left, shows the one when the wavelength of the beam and the reference wavelength of the product are close. Output voltage, immediately after the interception of the beam, is settled down instantly to dark level, and thereafter, becomes a flat waveform.

Waveform on the right shows the one when a beam wavelength is longer than the reference wavelength of the product. It is seen that the frequency characteristic compensation of **SPD-1_650nm** with the built-in amplifier, is **insufficient** for a beam of **850nm**, and the response of the frequency characteristic is decreasing in the high frequency range.

*** Example, using SPD-1_850nm**



An output voltage waveform when the **850nm** beam is inputted to **SPD-1_850nm** and is intercepted rapidly.

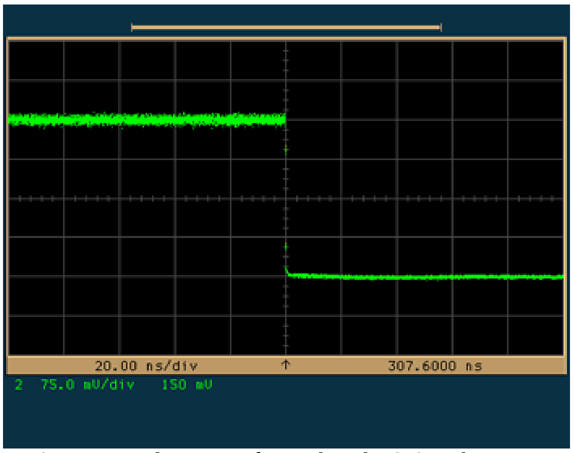


An output voltage waveform when the **658nm** beam is inputted to **SPD-1_850nm** and is intercepted rapidly.

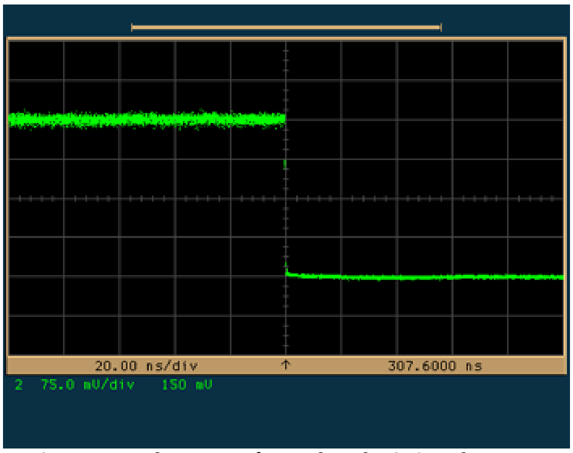
Waveform, on the left, shows the one when the wavelength of the beam and the reference wavelength of the product are close. Output voltage, immediately after the interception of the beam, is settled down to dark level, and thereafter, becomes a roughly flat waveform.

Waveform on the right shows the one when a beam wavelength is shorter than the reference wavelength of the product. It is seen that the frequency characteristic compensation of **SPD-1_850nm** with the built-in amplifier, becomes **excessive** for the beam of **658nm**, and the response of the frequency characteristic is increasing in the high frequency range.

*** Example, using SPD-3**



An output voltage waveform when the **658nm** beam is inputted to **SPD-3** and is intercepted rapidly.



An output voltage waveform when the **850nm** beam is inputted to **SPD-3** and is intercepted rapidly.

Some device among the silicon photo-detectors, whose the frequency characteristic does not depend on the wavelength, also exists. Since the model of **SPD-3**, **SPA-3**, **SPD-4**, and **SPA-4** uses such type of a photodetector, there is no response change against the wavelength of the beam for those models.

When using one unit of an O/E converter to perform measurement of different wavelengths, **SPD-3**, **SPA-3**, **SPD-4**, or **SPA-4** is recommended.

Specifications list for each model

Specifications for each O/E converter product are as shown below.

*** Converter for Visible light (Product of maximum input NA = 0.2 or 0.25)**

Model Name	SPD-1_650nm	SPD-1_850nm	SPD-2_650nm	SPD-2_850nm	SPD-3	SPD-4
Ref. Wavelength	658nm	850nm	658nm	850nm	850nm	850nm
Wavelength range	320 to 1000nm	320 to 1000nm	380 to 1000nm	380 to 1000nm	380 to 950nm	380 to 950nm
Acceptable maximum core diameter	φ0.8mm	φ0.8mm	φ1.0mm	φ1.0mm	φ0.5mm	φ0.5mm
Acceptable NA range	0.2 or less	0.2 or less	0.25 or less	0.25 or less	0.25 or less	0.25 or less
Optical input connector	FC receptacle	FC receptacle	FC receptacle	FC receptacle	FC receptacle	FC receptacle
Photodetector type	Si PIN PD	Si PIN PD	Si PIN PD	Si PIN PD	Si PIN PD	Si PIN PD
Active area of PD	φ0.4mm	φ0.4mm	φ0.4mm	φ0.4mm	φ0.2mm	φ0.2mm
Conversion gain	500V/W	500V/W	1,000V/W	1,000V/W	500V/W	300V/W
Output saturation power	-1dBm	-1dBm	-4dBm	-4dBm	-1dBm	+1dBm
Conversion bandwidth	DC to 1.2GHz	DC to 1.2GHz	DC to 1.2GHz	DC to 1.2GHz	DC to 2GHz	DC to 3GHz
Output noise level	1.3mVrms or less	1.3mVrms or less	1.9mVrms or less	1.9mVrms or less	1.5mVrms or less	1.8mVrms or less
Noise equivalent optical power	-26.0dBm or less	-26.0dBm or less	-27.3dBm or less	-27.3dBm or less	-25.2dBm or less	-22.4dBm or less
Electrical output connector	BNC plug	BNC plug	BNC plug	BNC plug	BNC plug	BNC plug
Output Impedance	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms
Output offset voltage	0.5mV or less	0.5mV or less	0.5mV or less	0.5mV or less	0.5mV or less	0.5mV or less
DC power connector	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P
Supply voltage	DC ±15V	DC ±15V	DC ±15V	DC ±15V	DC ±15V	DC ±15V
Supply current	+150mA/ -50mA	+150mA/ -50mA	+150mA/ -50mA	+150mA/ -50mA	+150mA/ -50mA	+150mA/ -50mA
Dimensions	93x44x21mm	93x44x21mm	103x44x21mm	103x44x21mm	103x44x21mm	103x44x21mm
Weight	About 110g	About 110g	About 130g	About 130g	About 130g	About 130g

** Conversion gain, output saturation power, and equivalent noise optical power are the value at the reference wavelength.
** Optical input connector, electrical output connector is that of the standard model.
** Other types of connectors are available as a customer's option.

*** Converter for visible light (Product of maximum input NA = 0.5)**

Model Name	SPA-2_650nm	SPA-3	SPA-4
Ref. Wavelength	658nm	850nm	850nm
Wavelength range	380 to 1000nm	380 to 950nm	380 to 950nm
Acceptable maximum core diameter	φ1.0mm	φ0.25mm	φ0.25mm
Acceptable NA range	0.5 or less	0.5 or less	0.5 or less
Optical input connector	FC receptacle	FC receptacle	FC receptacle
Photodetector type	Si PIN PD	Si PIN PD	Si PIN PD
Active area of PD	φ0.8mm	φ0.2mm	φ0.2mm
Conversion gain	1,000V/W	500V/W	300V/W
Output saturation power	-4dBm	-1dBm	+1dBm
Conversion bandwidth	DC to 1.2GHz	DC to 2GHz	DC to 3GHz
Output noise level	1.9mVrms or less	1.5mVrms or less	1.8mVrms or less
Noise equivalent optical power	-27.3dBm or less	-25.2dBm or less	-22.4dBm or less
Electrical output connector	BNC plug	BNC plug	BNC plug
Output impedance	50 ohms	50 ohms	50 ohms
Output offset voltage	0.5mV or less	0.5mV or less	0.5mV or less
DC power connector	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P
Supply voltage	DC +15V	DC ±15V	DC ±15V
Supply current	+150mA	+150mA/-50mA	+150mA/-50mA
Dimensions	103x44x21mm	103x44x21mm	103x44x21mm
Weight	About 130g	About 130g	About 130g

** Conversion gain, output saturation power, and equivalent noise optical power are the value at the reference wavelength.
** Optical input connector, electrical output connector is that of the standard model.
** Other types of connectors are available as a customer's option.

*** Converter for visible light (product with high sensitivity)**

Model Name	SPS-1_10KV/W	SPS-1_100KV/W	SPS-2_10KV/W	SPS-2_100KV/W
Ref. Wavelength	850nm	850nm	850nm	850nm
Wavelength range	320 to 1000nm	320 to 1000nm	380 to 1000nm	380 to 1000nm
Acceptable maximum core diameter	φ0.8mm	φ0.8mm	φ1.0mm	φ1.0mm
Acceptable NA range	0.2 or less	0.2 or less	0.5 or less	0.5 or less
Optical input connector	FC receptacle	FC receptacle	FC receptacle	FC receptacle
Photodetector type	Si PIN PD	Si PIN PD	Si PIN PD	Si PIN PD
Active area of PD	φ0.4mm	φ0.4mm	φ0.8mm	φ0.8mm
Conversion gain	10,000V/W	100,000V/W	10,000V/W	100,000V/W
Output saturation power	-8.2dBm	-18.2dBm	-8.2dBm	-18.2dBm
Conversion bandwidth	DC to 100MHz	DC to 15MHz	DC to 100MHz	DC to 15MHz
Output noise level	1.0mVrms or less	1.0mVrms or less	1.0mVrms or less	1.0mVrms or less
Noise equivalent optical power	-40dBm or less	-50dBm or less	-40dBm or less	-50dBm or less
Electrical output connector	BNC plug	BNC plug	BNC plug	BNC plug
Output impedance	50 ohms	50 ohms	50 ohms	50 ohms
Output offset voltage	0.5mV or less	0.5mV or less	0.5mV or less	0.5mV or less
DC power connector	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P
Supply voltage	DC ±15V	DC ±15V	DC ±15V	DC ±15V
Supply current	+80mA/-50mA	+80mA/-50mA	+80mA/-50mA	+80mA/-50mA
Dimensions	93x44x21mm	93x44x21mm	103x44x21mm	103x44x21mm
Weight	About 110g	About 110g	About 130g	About 130g

** Conversion gain, output saturation power, and equivalent noise optical power are the value at the reference wavelength.
** Optical input connector, electrical output connector is that of the standard model.
** Other types of connectors are available as a customer's option.

*** Converter for long wavelength**

Model Name	LPD-1	LPD-2	LPS-1_20KV/W	LPS-2_20KV/W
Ref. Wavelength	1310nm	1310nm	1310nm	1310nm
Wavelength range	900 to 1650nm	950 to 1650nm	900 to 1650nm	950 to 1650nm
Acceptable maximum core diameter	φ0.08mm	φ0.5mm	φ0.08mm	φ0.5mm
Acceptable NA range	0.2 or less	0.25 or less	0.2 or less	0.25 or less
Optical input connector	FC receptacle	FC receptacle	FC receptacle	FC receptacle
Photodetector type	InGaAs PIN PD	InGaAs PIN PD	InGaAs PIN PD	InGaAs PIN PD
Active area of PD	φ0.08mm	φ0.2mm	φ0.08mm	φ0.2mm
Conversion gain	500V/W	1,000V/W	20,000V/W	20,000V/W
Output saturation power	-1dBm	-4dBm	-11.2dBm	-11.2dBm
Conversion bandwidth	DC to 1.5GHz	DC to 1.5GHz	DC to 100MHz	DC to 100MHz
Output noise level	0.8mVrms or less	1.8mVrms or less	1.0mVrms or less	1.0mVrms or less
Noise equivalent optical power	-27.9dBm or less	-29.2dBm or less	-43dBm or less	-43dBm or less
Electrical output connector	BNC plug	BNC plug	BNC plug	BNC plug
Output impedance	50 ohms	50 ohms	50 ohms	50 ohms
Output offset voltage	0.5mV or less	0.5mV or less	0.5mV or less	0.5mV or less
DC power connector	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P	LEMO 0S-4P
Supply voltage	DC ±15V	DC ±15V	DC ±15V	DC ±15V
Supply current	+150mA/-50mA	+150mA/-50mA	+80mA/-50mA	+80mA/-50mA
Dimensions	93x44x21mm	103x44x21mm	93x44x21mm	103x44x21mm
Weight	About 110g	About 130g	About 110g	About 130g

** Conversion gain, output saturation power, and equivalent noise optical power are the value at the reference wavelength.
** Optical input connector, electrical output connector is that of the standard model.
** Other types of connectors are available as a customer's option.

Options and accessories

The standard model of Graviton's O/E converter equips FC receptacle as the optical input connector, and BNC plug as an electrical signal output connector. The following lists the connector types which are offered as a customer's option. In addition, DC power supply (by Cosel) and NA conversion adaptor (by Graviton), which can be used together with the O/E converter, are available.

*** Optical input connector option**

Model with a FC receptacle (standard)

The standard model comes with **FC** type receptacle, as shown in the left figure, for the optical input connector to the O/E converter.

Also, upon the customer's request, a product, which equips with optical connectors of **SC**, **FSMA**, **F05**, or **G-OCN** type, can be offered.(Requires an extra charge)
Please specify this option when ordering..

** The standard product with **FC-type** receptacle comes with a connector dust cap, however, the dust cap is not included in the product of other receptacle types.

** A **G-OCN** receptacle is connectable with any plug of **FC**, **SC**, **ST** and **F05** , whose ferrule diameter is 2.5 mm. However, **G-OCN** receptacle has a structure that holds the ferrule only, and is not suitable for use to keep connected for an extended period.

** Contact us for a product with **ST** receptacle connector.

Model with SC receptacle connector (option)

Model with FSMA receptacle connector (option)

Model with F05 receptacle connector (option)

Model with G-OCN receptacle connector (option)

**** Electrical signal output connector option**

Model with a BNC plug (standard)

The standard model comes with **BNC plug**, as shown in the left figure, as the electrical signal output connector of the O/E converter.

Also, upon the customer's request, a product, which equips with a **SMA jack** and a **SMA plug**, can be offered. (Requires an extra charge)
Please specify this option when ordering..

** Contact us for the product with **BNC jack**.

Model with SMA jack (option)

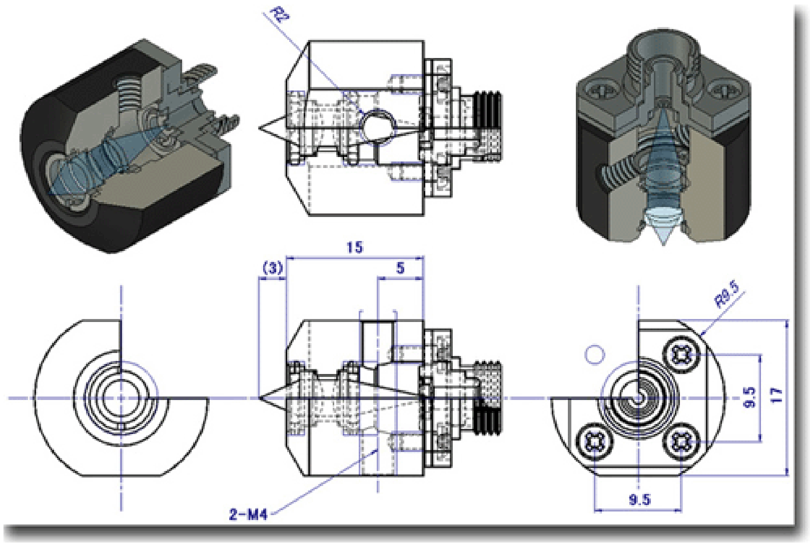
Model with SMA plug (option)

*** DC power supply**

If the electronic measuring instrument to has ± 15V output terminal of

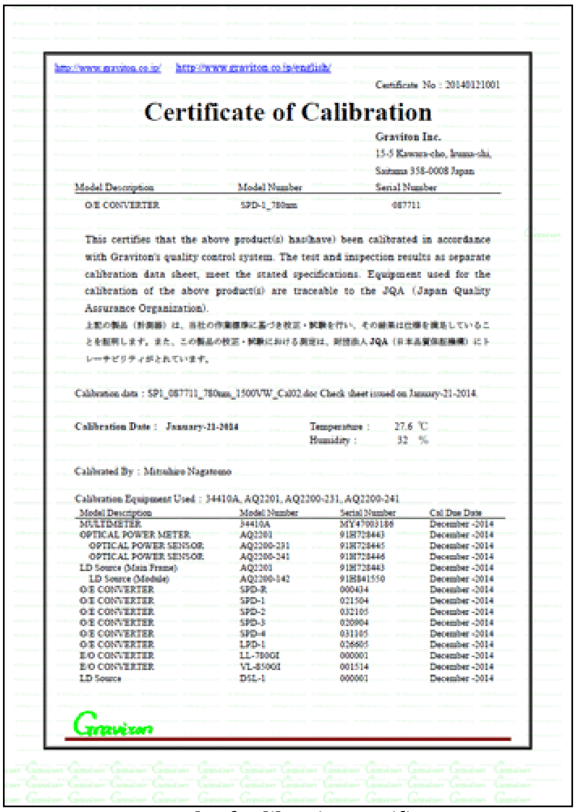
 **DC power supply, G1W-15 (by Cosel)**	LEMO 0S-4P type, DC power can be supplied to the O/E converter, using a dedicated power cable. When there is no power supply output port on the electronic measuring instrument, another stabilized power supply have to be used in order to supply power to the O/E converter. In such cases, Cosel products of DC power supply - **G1W-15** is offered and Cosel's **G1W-15** is in stock. ** This power supply is not included in the O/E converter product. Please separately purchase the power supply.

*** NA conversion adaptor, GC-3420**

 **NA conversion adaptor, GC-3420 (Product of Graviton)**	When the emitted light from a CD or a DVD pickup need to be transmitted to an O/E converter, and fiber with a large-diameter is placed over the objective lens directly, the emitted light NA is so large that sufficient quantity of light cannot be detected. If NA conversion adaptor - **GC-3420** is used, a light in the range of up to NA = 0.34 out of the emitted light, can be efficiently guided to the optical fiber of NA = 0.2. ** **GC-3420** is not included in the O/E converter product. Please separately purchase the NA conversion adaptor.

Calibration certificate and export certificate

* Calibration certificate



http://www.graviton.co.jp/ http://www.graviton.co.jp/english/

Certificate No : 20140121001

Certificate of Calibration

Graviton Inc.
15-5 Kawara-cho, Iruma-shi,
Saitama 358-0008 Japan

Model Description	Model Number	Serial Number
O/E CONVERTER	SPD-1_780nm	087711

This certifies that the above product(s) has(have) been calibrated in accordance with Graviton's quality control system. The test and inspection results as separate calibration data sheet, meet the stated specifications. Equipment used for the calibration of the above product(s) are traceable to the JQA (Japan Quality Assurance Organization).

Calibration data : SP1_087711_780nm_1500VW_Cal02.doc Check sheet issued on January-21-2014.

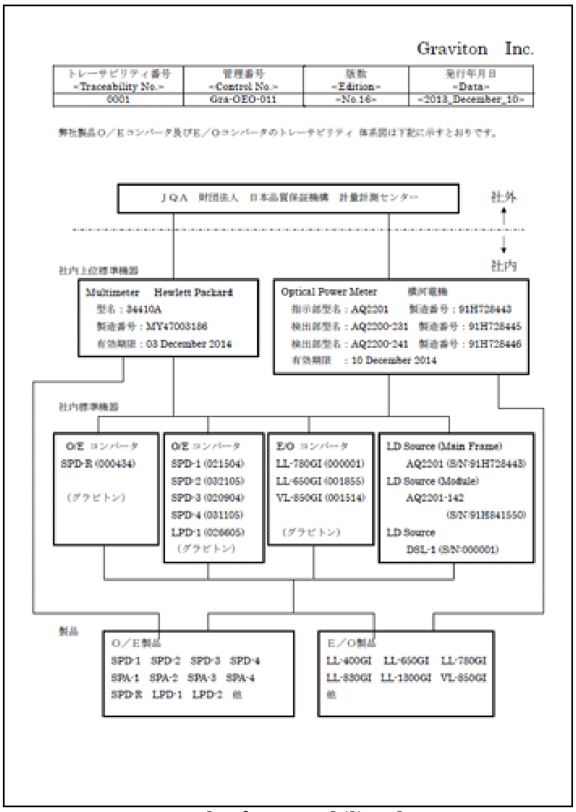
Calibration Date : January-21-2014 Temperature : 27.6 ℃ Humidity : 32 %

Calibrated By : Mitsuhiro Nagatomo

Calibration Equipment Used : 34410A, AQ2201, AQ2200-231, AQ2200-241

Model Description	Model Number	Serial Number	Cal Due Date
MULTIMETER	34410A	MY47003186	December -2014
OPTICAL POWER METER	AQ2201	91H728443	December -2014
OPTICAL POWER SENSOR	AQ2200-231	91H728445	December -2014
OPTICAL POWER SENSOR	AQ2200-241	91H728446	December -2014
LD Source (Main Frame)	AQ2201	91H728443	December -2014
LD Source (Module)	AQ2200-142	91H841550	December -2014
O/E CONVERTER	SPD-R	000434	December -2014
O/E CONVERTER	SPD-1	021504	December -2014
O/E CONVERTER	SPD-2	032105	December -2014
O/E CONVERTER	SPD-3	020904	December -2014
O/E CONVERTER	SPD-4	031105	December -2014
O/E CONVERTER	LPD-1	026605	December -2014
E/O CONVERTER	LL-780GI	000001	December -2014
E/O CONVERTER	VL-850GI	001514	December -2014
LD Source	DSL-1	000001	December -2014

Example of calibration certificate

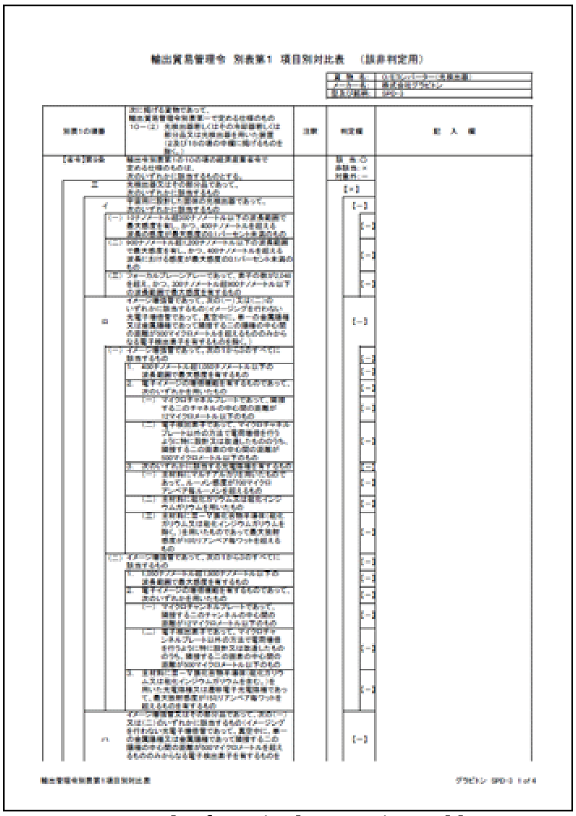


Example of a traceability chart

Calibration work and certificate issuing are available for a fee, after newly purchased product or already purchased product are taken custody for the work. For the product, where the calibration work has been performed, traceability chart and calibration certificate are issued as shown in the figure above.

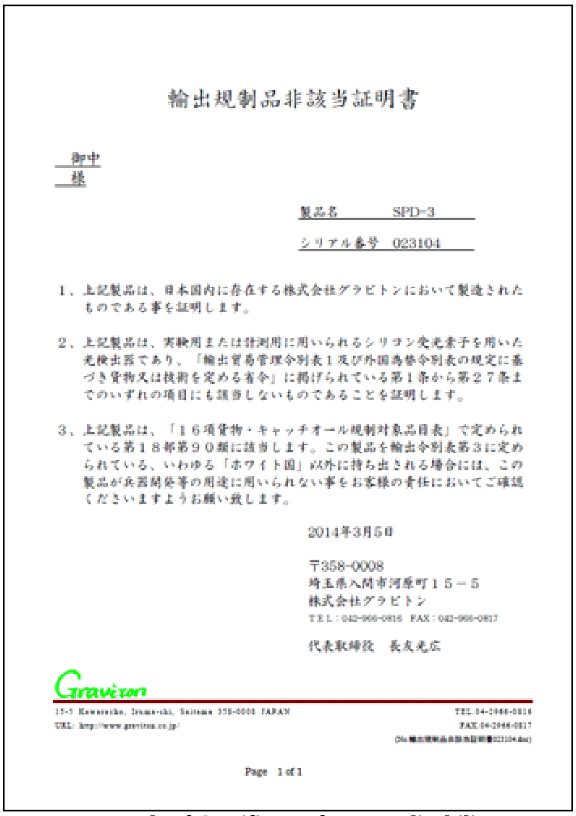
The shipment data sheet with every calibration work and repair work are recorded onto the USB memory, so that repair history and calibration history can be viewed at a later date.

*** Export certificate**



輸出貿易管理令 別表第1 項目別対比表 （該非判定用）

Example of Itemized comparison table
for the export control order



輸出規制品非該当証明書

御中
様

製品名　SPD-3

シリアル番号　023104

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2014年3月5日

〒358-0008
埼玉県入間市河原町１５－５
株式会社グラビトン

代表取締役　長友光広

Page 1 of 1

Example of Certificate of non-applicability
against any restriction subject to control order

Article 27 from Article 1, listed in the "Ordinance of the Ministry Specifying Goods and Technologies Pursuant to Provisions of the Appended Table 1 of the Export Control Order and the Appended Table of the Foreign Exchange Order" does not applies to the Graviton's O/E converters for all models for all items.

However, customer's O/E converter is carried to outside Japan, there is a case where presentation of Itemized comparison table, or a certificate of "Certificate of non-applicability against any restriction subject to control order or export trade control order" These documents can be issued from us, and contact us if needed.

In addition, it should be noted that, even if the product is not applicable for export control, "Part 18 Class 90", which is described in the "Item 16 (Catch-all control) of appended table 1 in the export trade control order of the foreign exchange and foreign trade act", will be APPLIED. When the product is carried out other than what is called a "Group A" where the O/E converter is described by Export Ordinance Appended Table 3, it is customer's responsibility to take steps to ensure that an O/E converter is not used for uses, such as weapon development.

** Graviton's O/E converters are manufactured in Japan.

** HS code of O/E converter is "8543.70-000."

The 26 countries, treated as "Group A", are listed as follows.(as of 28-August, 2019)

Argentina	Australia	Austria	Belgium
Britain	Ireland	Canada	Czechoslovakia
Denmark	Finland	France	Germany
Greece	Hungary	Italy	Luxembourg
Netherlands	New Zealand	Norway	Poland
Portugal	Bulgaria	Spain	Sweden
Switzerland	United States of America		