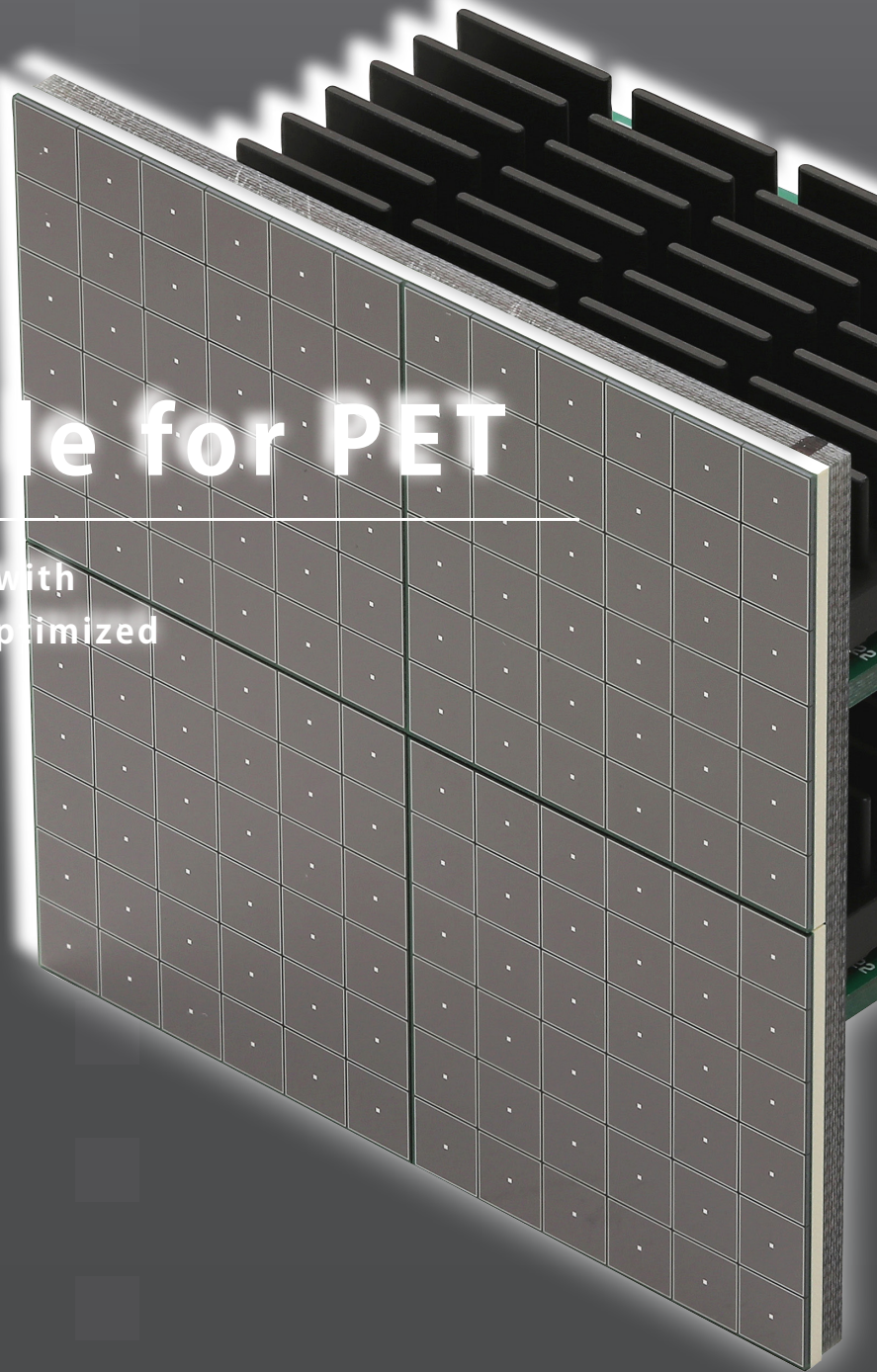
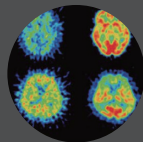
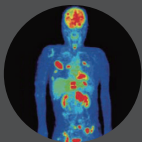


MPPC module for PET

By combining our MPPC device with circuit technologies, we offer optimized modules and circuits for PET.



HAMAMATSU
PHOTON IS OUR BUSINESS

DETECTOR

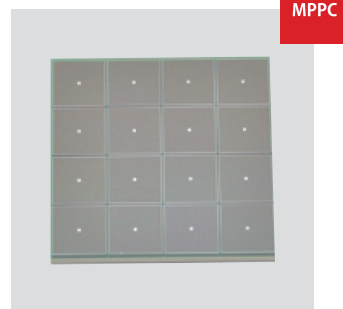
MPPC array



The MPPC is one of the devices called silicon photomultipliers (SiPM). The S14161 series is an MPPC (SiPM) array for precision measurement. It inherits the superb low afterpulse characteristics of its predecessor and further provides lower crosstalk and lower dark count. This MPPC array uses through silicon via (TSV) to minimize non-sensitive portions around the photosensitive area.

Features

- Reduced crosstalk and dark count (compared to previous products)
- Low afterpulses
- Outstanding photon counting capability (outstanding photon detection efficiency against incident photons)
- Excellent uniformity
- Low voltage operation



SCINTILLATOR

The lutecium scintillator features high light emission yields and fast decay time. Combining this scintillator with the MPPC enables the construction of excellent PET imaging systems, such as TOF-PET.

Features

- High light output
- Superior time resolution
- No deliquescence unlike CsI

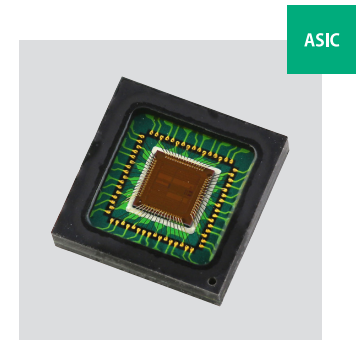


ASIC

An ASIC optimized for the MPPC and lutecium scintillator in the MPPC module was specifically designed. This ASIC along with TDC, FPGA, and other signal processing circuits necessary for TOF-PET is mounted on a compact circuit board. This is incorporated in the PET module.

Features

- Designed specifically for the PET module
- Low power consumption
- 18 ch/chip

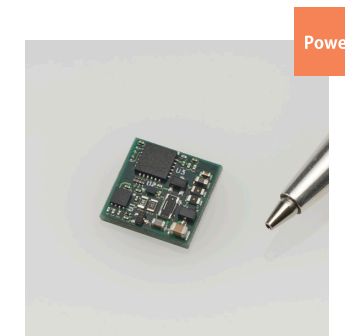


PET module

Hamamatsu PET modules consist of MPPC arrays, scintillators, and ASICs. Each part has optimum specifications for PET. Using these modules can make your PET device development more efficient. Further, Hamamatsu provides not only the light detection section but also latter-stage circuits and interface boards. Depending on your needs, you can also purchase these parts separately.

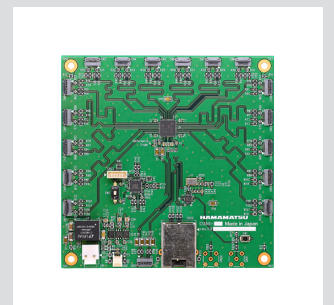
POWER SUPPLY

The power supply is for driving the MPPC. It contains a temperature compensation function to keep the MPPC operation stable. A single power supply can run multiple MPPC arrays.



PERIPHERAL CIRCUIT

The power supply unit and peripheral circuits (sold separately) are for running the PET module properly.



PET module

These modules are installed in a PET device. These integrate an MPPC, scintillator, and ASIC board.



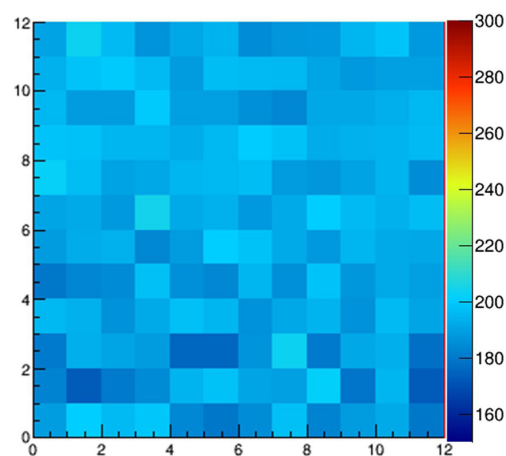
Type no.	C13500-4075YC-12
Photo	
Scintillator size/ch	4 × 4 mm (12 × 12 ch)
MPPC size/ch	4 × 4 mm, 75 μm pitch (12 × 12 ch)
Count rate	< 500 kcps
CRT (FWHM)	< 210 ps
Power consumption	2.6 W

Features 1

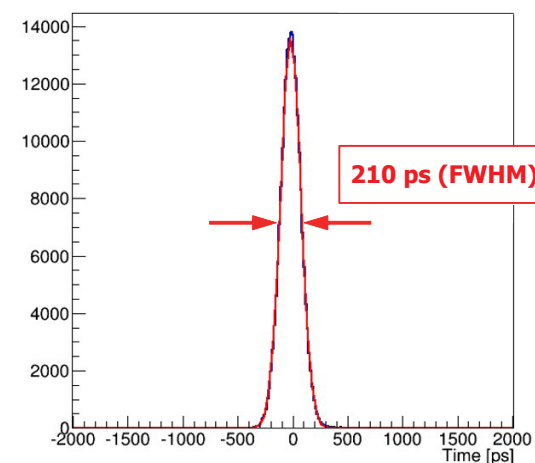
Excellent time resolution: 210 ps

- CRT (FWHM): 210 ps
- CRT variation (12 × 12 ch): ±15 ps max.

■ 2D map of CRT



■ Histogram of CRT

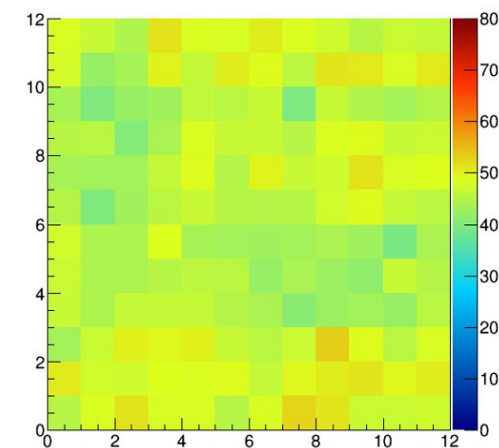


Features 2

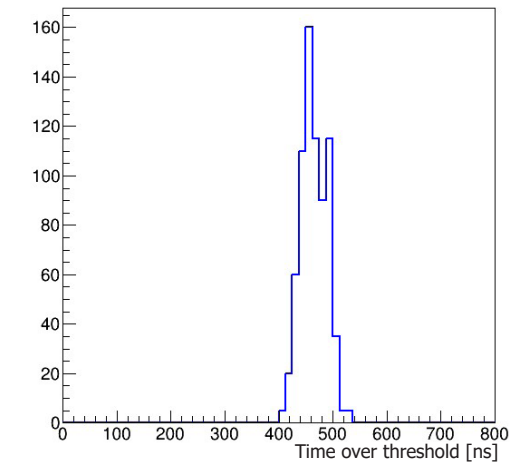
Outputs energy information of all channels

As the energy information of the PET module is processed using time over threshold, it is output as time information.

■ 2D map of energy peak (511 keV)



■ Histogram of energy peak (511 keV)



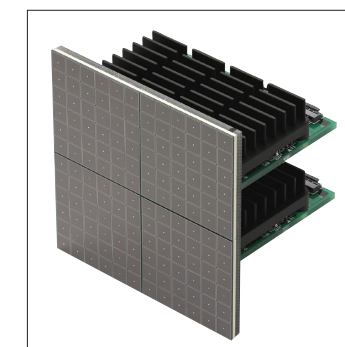
Features 3

Customizable for OEM

Customization is possible according to your needs.
Consult with your nearest Hamamatsu sales office.

Examples:

- MPPC
- Scintillator
- MR compatible
- Structure



■ Absolute maximum ratings

Parameter	Condition	C13500-4075YC-12	Unit
Supply voltage		+24	V
Operating temperature	No dew condensation	+15 to +35	°C
Storage temperature	No dew condensation	0 to +50	°C

■ Specifications (Typ. Ta=25 °C, Vs=+24 V, unless otherwise noted)

Parameter	Condition	C13500-4075YC-12	Unit
Count rate		< 500 kcps	-
CRT (FWHM)23		< 210	ps
Power consumption		2.6	W
Power supply	Using C13502-02	+24	V

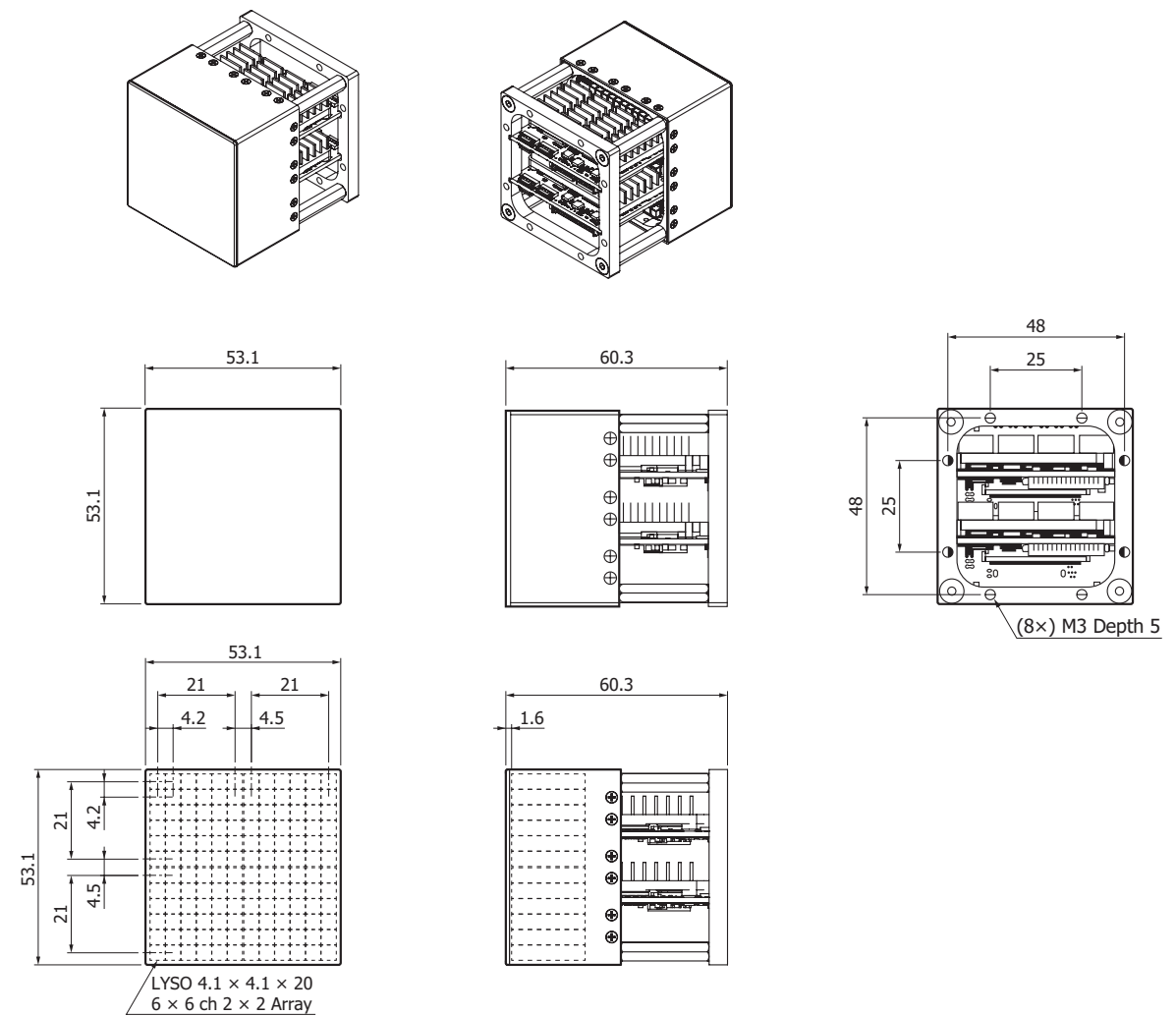
• Scintillator

Parameter	C13500-4075YC-12	Unit
Material	LYSO	-
Dimensions/ch	4.1 × 4.1 × 20	mm
Number of channels	144 (12 × 12)	ch
Element pitch	4.2	mm

• MPPC

Parameter	C13500-4075YC-12	Unit
Type	TSV (through silicon via)	-
Photosensitive area/ch	4 × 4	mm
Pixel pitch	75	μm
Number of channels	144 (12 × 12)	ch
Element pitch	4.2	mm

■ Dimensional outlines (unit: mm)

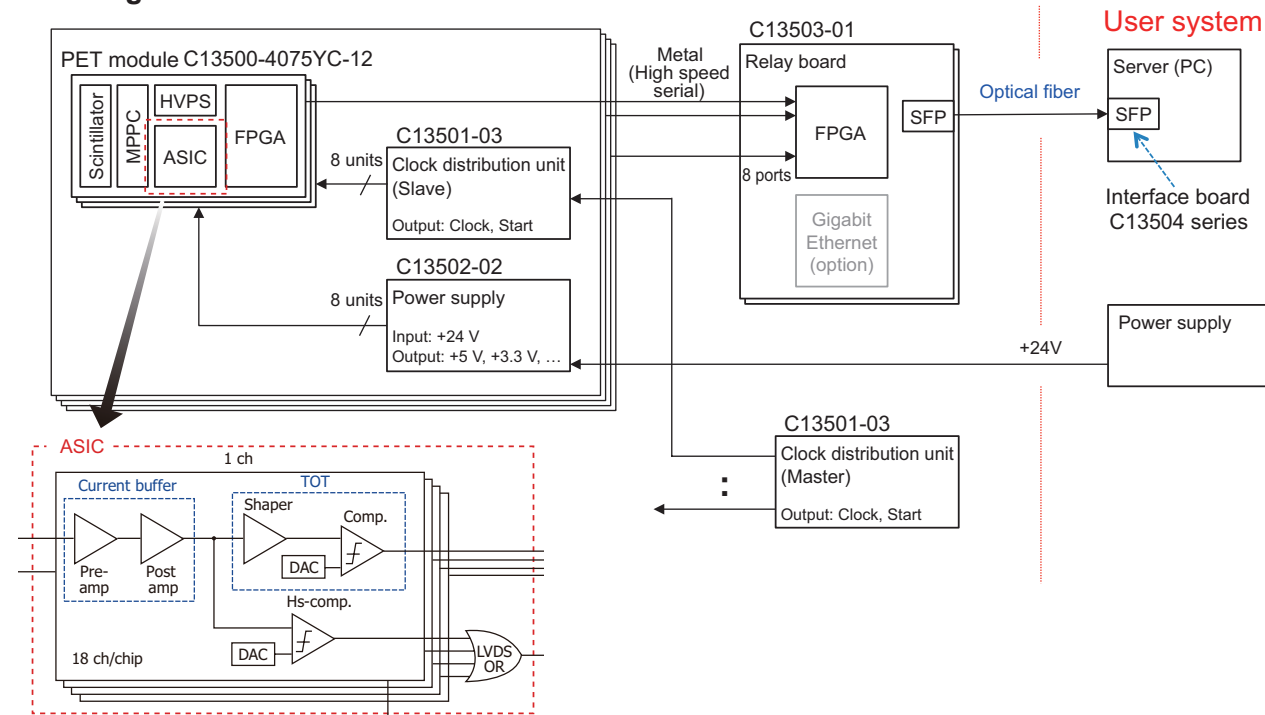


Peripheral circuit and power supply

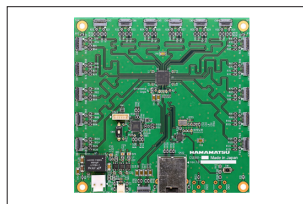
PERIPHERAL CIRCUIT

These are peripheral devices for running the PET module and peripheral circuits for generating output.

Block diagram



Clock distribution unit C13501-03

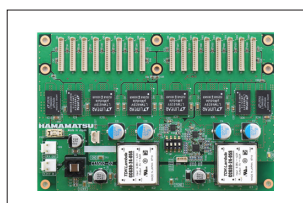


The C13501-03 provides sync signals that the PET module requires. It can distribute to eight signal processing units. It is also possible to distribute to up to 128 units by using several C13501-03s. The C13501-03 is designed on the assumption that it is connected to the PET module C13500 series.

Features

- Output signal: LVDS
- Distributes to 16 units

Power supply C13502-02

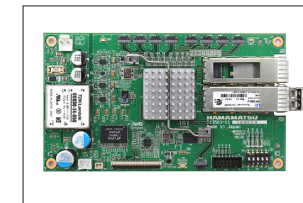


This unit is able to provide a power supply that is required for the PET module. The C13502-02 can distribute power to eight PET modules. This unit is the ideal power source to operate the PET module C13500 series.

Features

- The power supply is delivered to the PET module.
- Distributes to 16 signal processing units

Relay board C13503-01

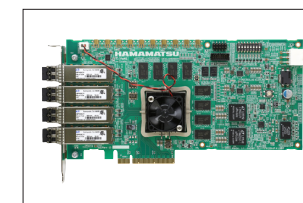


This C13503-01 gathers measurement data from PET module C13500 series and outputs data to PC via an optical fiber with high-speed data transfer.

Features

- High-speed interface
- 10 Gbps (SFP)
- 3 Gbps (Metal)
- Connects to 8 PET modules as cascade line

Interface board C13504 series

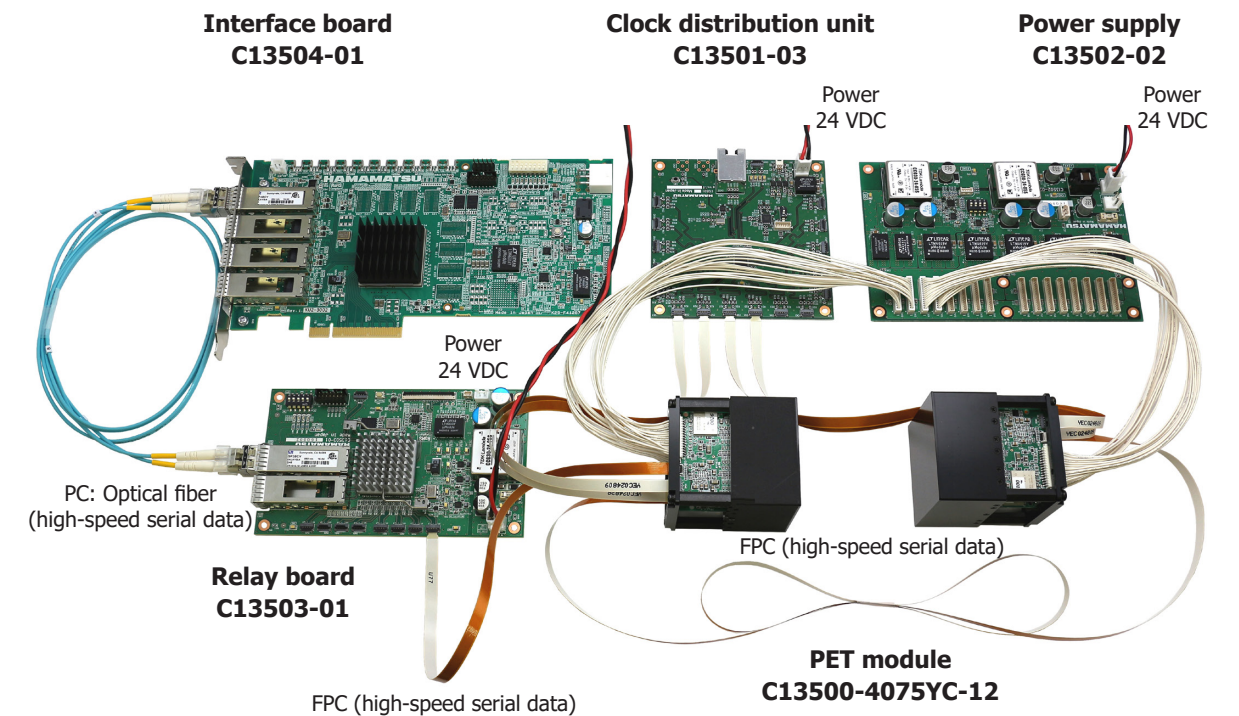


The C13504 series attach to the PCIe connector on a PC and easily collect measurement data in a PC with high-speed data transfer by connecting C13503-01.

Features

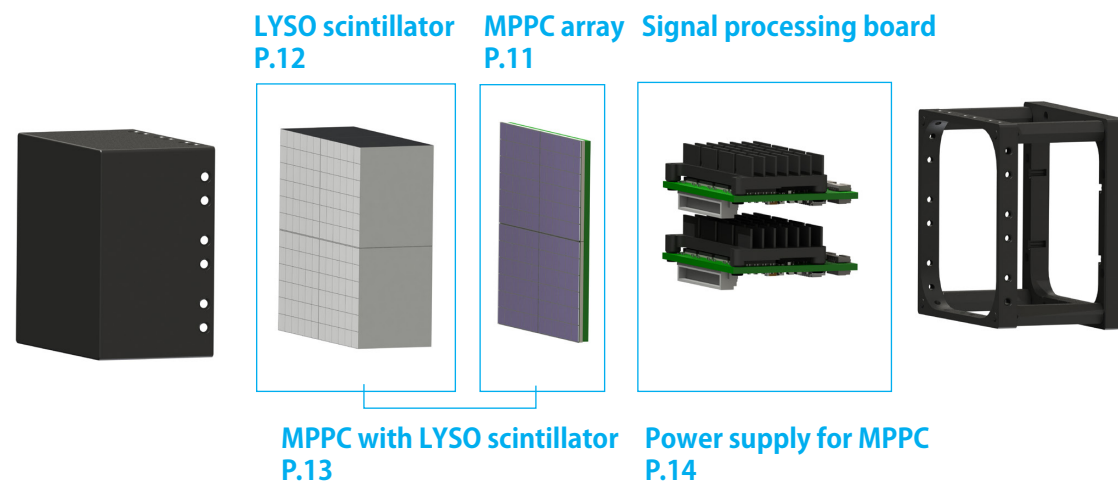
- High-speed optical interface
- C13504-01: 10 Gbps (SFP) cage × 2
- C13504-02: 10 Gbps (SFP) cage × 4
- DDR4 memory 8 GB (C13504-02)
- Windows 10 (64-bit), CentOS 6.7 (64-bit)

Connection example



Component lineup

Hamamatsu Photonics not only sells modules but also components.



MPPC array



These are MPPC arrays for PET.

Type no.	Effective photosensitive area/channel (mm)	Number of channels	Pixel pitch (μm)	Number of pixels /channel	Package	Fill factor (%)
S14161-3050HS-04	3.0 × 3.0	16 (4 × 4)	50	3531	Surface mount type	74
S14161-3050HS-08		64 (8 × 8)				
S14161-4050HS-06	4.0 × 4.0	36 (6 × 6)		6331		
S14161-6050HS-04	6.0 × 6.0	16 (4 × 4)		14331		

■ Specifications (Ta=25 °C, Vover=2.7 V)

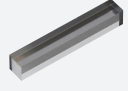

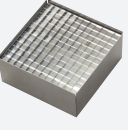

Parameter	S14161-3050HS-04/-08	S14161-4050HS-06	S14161-6050HS-04	Unit
Spectral response range	270 to 900			nm
Peak sensitivity wavelength	450			nm
Photon detection efficiency at λp^{*1}	50			%
Dark current	Typ.	0.6	1.1	μA
	Max.	1.8	3.3	
Terminal capacitance	500	900	2000	pF
Gain	2.5×10^6			-
Breakdown voltage	38			V
Recommended operating voltage	$V_{BR} + 2.7$			V
Temperature coefficient	34			mV/°C

*1: Photo detection efficiency does not include crosstalk or afterpulses.
 Note: The above characteristics were measured at the operating voltage that yields the listed gain.
 (See the data attached to each product.)

LYSO scintillator

LYSO



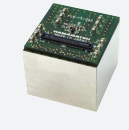
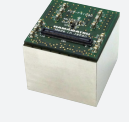
We also accept orders for individual LYSO scintillator arrays.

Type no.	Number of channels (ch)	Size/channel (mm)	Adhesive type
 J13059-3220YN	1 × 1	3.14 × 3.14 × 20	-
 J13059-3220YR-04	4 × 4	3.14 × 3.14 × 20	Reflective film
 J13059-3220YR-08	8 × 8	3.14 × 3.14 × 20	Reflective film
 J13427-1820YR-14	13 × 13 + 14 × 14	1.76 × 1.76 × 10 (2 layers)	Reflective film

MPPC with LYSO scintillator

MPPC + LYSO

These devices have LYSO scintillator arrays coupled to MPPC arrays.

Type no.	Scintillator			Built-in MPPC array	
	Number of channels (ch)	Size/channel (mm)	Channel pitch (mm)	Number of channels (ch)	Pixel pitch (μm)
 S13900-3220LR	1	3.14 × 3.14 × 20	-	1	50
 S13900-3220YR-04	4 × 4	3.14 × 3.14 × 20	3.2	4 × 4	50
 S13900-3220YR-08	8 × 8	3.14 × 3.14 × 20	3.2	8 × 8	50
 S13901-1820YR-14	13 × 13	1.76 × 1.76 × 10	1.8	8 × 8	50
	14 × 14				

Scintillator specifications

■ Specifications example (LYSO scintillator)

Parameter	Value	Unit
Density	7.2	g/cm ³
Effective atomic number	60	-
Attenuation length	1.2	cm
Decay constant	40	ns
Maximum emission	420	nm
Light yield (NaI:Tl=100%)	75	-
Refractive index	1.81	-
Energy resolution ¹³⁷ Cs	8 to 10	%
Absorbed γ-ray irradiation dose (Radiation hardness)	10 ⁸	rad (%/cm)
Hygroscopicity	No	-
Hardness	5.8	Moh
Cleavage	None	-

■ Comparison chart

Material	Density (g/cm ³)	Light yield (NaI=100%)	Decay (ns)	Application
LYSO	7.25	80	41	PET, HEP
NaI:Tl	3.67	100	230	γ-ray, X-ray
CsI	4.53	120	1050	X-ray CT
CWO (CdWO ₄)	7.68	40	5000	X-ray CT
BGO (Bi ₄ Ge ₃ O ₁₂)	7.13	12	300	PET, HEP
PWO (PbWO ₄)	8.20	1.3	10	HEP
GAGG	6.63	140	88	HEP

HAMAMATSU

www.hamamatsu.com

HAMAMATSU PHOTONICS K.K., Solid State Division

1126-1 Ichino-cho, Chuo-ku, Hamamatsu City, 435-8558 Japan, Telephone: (81)53-434-3311, Fax: (81)53-434-5184

U.S.A.: HAMAMATSU CORPORATION: 360 Foothill Road, Bridgewater, NJ 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218

Germany: HAMAMATSU PHOTONICS DEUTSCHLAND GMBH: Arzbergerstr. 10, 82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-265-8 E-mail: info@hamamatsu.de

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

United Kingdom: HAMAMATSU PHOTONICS UK LIMITED: 2 Howard Court 10 Tewin Road, Welwyn Garden City, Hertfordshire, AL7 1BW, UK, Telephone: (44)1707-294888, Fax: (44)1707-325777 E-mail: info@hamamatsu.co.uk

North Europe: HAMAMATSU PHOTONICS NORDEN AB: Torshammsgatan 35, 16440 Kista, Sweden, Telephone: (46)8-509-031-00, Fax: (46)8-509-031-01 E-mail: info@hamamatsu.se

Italy: HAMAMATSU PHOTONICS ITALIA S.R.L.: Strada della Moia, 1 int. 6 20044 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41 E-mail: info@hamamatsu.it

China: HAMAMATSU PHOTONICS (CHINA) CO., LTD.: 1201, Tower B, Jiaming Center, 27 Dongsanhuan Bellu, Chaoyang District, 100020 Beijing, P.R. China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: hpc@hamamatsu.com.cn

Taiwan: HAMAMATSU PHOTONICS TAIWAN CO., LTD.: 13F-1, No.101, Section 2, Gongdao 5th Road, East Dist., Hsinchu City, 300046, Taiwan(R.O.C) Telephone: (886)3-659-0080, Fax: (886)3-659-0081 E-mail: info@hamamatsu.com.tw