CCD area image sensor
S8980, S8981-02

Front-illuminated FFT-CCDs for X-ray imaging



S8980 is an FFT-CCD image sensor ideal for intra-oral X-ray imaging in dental diagnosis. S8980 has 1.5 mega (1500 × 1000) pixels each of which is 20 × 20 µm. The fiber optic plate (FOP) used as an input window is as thin as 1.5 mm but highly resistant to X-ray irradiation, making S8980 very reliable even over a long-term operation. The scintillator coated on the FOP is optimized to have high X-ray sensitivity and high resolution (20 Lp/mm).
S8981-02 is an easy-to-use X-ray imaging module using S8980, with added functions such as a cable assembly and X-ray trigger circuit. S8981-02 is advanced type for S8981 and adapted both AC and DC X-ray sources.

Features

- Sensor has X-ray monitoring photodiode
- Compactness
  5.1 mm thickness excluding I/O connector part
- High dynamic range: 12 bit
- Long-term stability
  For use under 100,000 shots
  (60 kVp, 30 mR X-ray irradiation)
- Resolution: 20 Lp/mm
- 1500 (H) × 1000 (V) pixel format
- Pixel size: 20 × 20 µm
- Coupled with FOS for X-ray imaging
- 100 % fill factor
- Low dark signal
- Low readout noise
- MPP operation
- AC/DC X-ray source adapted

Applications

- General X-ray imaging
- Non-destructive inspection
- Intra-oral X-ray imaging in dental diagnosis

■ Selection guide

Type No.	Cooling	Number of total pixels	Number of active pixels	Active area [mm (H) × mm (V)]
S8980 S8981-02	Non-cooled	1508 × 1002	1500 × 1000	30 × 20

■ General ratings

Parameter	S8980	S8981-02
CCD structure	Full frame transfer	
Fill factor	100 %	
Number of active pixels	1500 (H) × 1000 (V)	
Pixel size	20 (H) × 20 (V) µm	
Active area	30 (H) × 20 (V) mm	
Vertical clock phase	2 phase	
Horizontal clock phase	2 phase	
Output circuit	Emitter follower without load resistance	
Dimensional outline	35.5 (H) × 23.2 (V) mm	38.7 (H) × 26.3 (V) mm
Reliability	100,000 shots at 60 kVp, 30 m Roentgen	
Window	Scintillator on 1.5 mm FOP	
Other	MPP mode (low dark current operation), module (S8981-02)	

SOLID STATE DIVISION

■ Absolute maximum ratings (Ta=25 °C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Storage temperature	Tstg	-20	-	+70	°C
Operating temperature	Topr	0	-	+40	°C
OD voltage	V_{OD}	-0.5	-	+20	V
RD voltage	V_{RD}	-0.5	-	+18	V
SG voltage	V_{SG}	-15	-	+15	V
OG voltage	V_{OG}	-15	-	+15	V
RG voltage	V_{RG}	-15	-	+15	V
TG voltage	V_{TG}	-15	-	+15	V
Vertical clock voltage	V_{P1V}, V_{P2V}	-15	-	+15	V
Horizontal clock voltage	V_{P1H}, V_{P2H}	-15	-	+15	V
Vcc voltage	Vcc	0	-	+7	V

■ Operating conditions (MPP mode, Ta=25 °C)

Parameter		Symbol	Min.	Typ.	Max.	Unit
Output transistor drain voltage		V_{OD}	12	15	-	V
Reset drain voltage		V_{RD}	12	13	14	V
Output gate voltage		V_{OG}	-0.5	2	5	V
Substrate voltage		Vss	-	0	-	V
Vertical shift register clock voltage	High	V_{P1VH}, V_{P2VH}	0	3	6	V
	Low	V_{P1VL}, V_{P2VL}	-9	-8	-7	V
Horizontal shift register clock voltage	High	V_{P1HH}, V_{P2HH}	0	3	6	V
	Low	V_{P1HL}, V_{P2HL}	-9	-8	-7	V
Summing gate voltage	High	V_{SGH}	0	3	6	V
	Low	V_{SGL}	-9	-8	-7	V
Reset gate voltage	High	V_{RGH}	0	3	6	V
	Low	V_{RGL}	-9	-8	-7	V
Transfer gate voltage	High	V_{TGH}	0	3	6	V
	Low	V_{TGL}	-9	-8	-7	V
+5 V power supply voltage		Vcc	4.75	5	5.25	V

■ Electrical characteristics (Ta=25 °C)

Parameter		Symbol	Remark	Min.	Typ.	Max.	Unit
Signal output frequency		fc	*1	-	1	5	MHz
Vertical shift register capacitance		C_{P1v}, C_{P2v}		-	60,000	-	pF
Horizontal shift register capacitance	S8980	C_{P1H}, C_{P2H}		-	350	-	pF
	S8981-02			-	550	-	
Summing gate capacitance	S8980	C_{SG}		-	20	-	pF
	S8981-02			-	220	-	
Reset gate capacitance	S8980	C_{RG}		-	20	-	pF
	S8981-02			-	220	-	
Transfer gate capacitance	S8980	C_{TG}		-	250	-	pF
	S8981-02			-	450	-	
Charge transfer efficiency		CTE	*2	0.99995	0.99998	-	-
DC output level		Vout	*3	5	8	11	V
Output impedance		Zo	*3	-	500	-	Ω
Power dissipation		P	*3 *4	-	75	-	mW
+5 V power supply current	S8980	Icc		-	1	-	mA
	S8981-02			-	2	-	

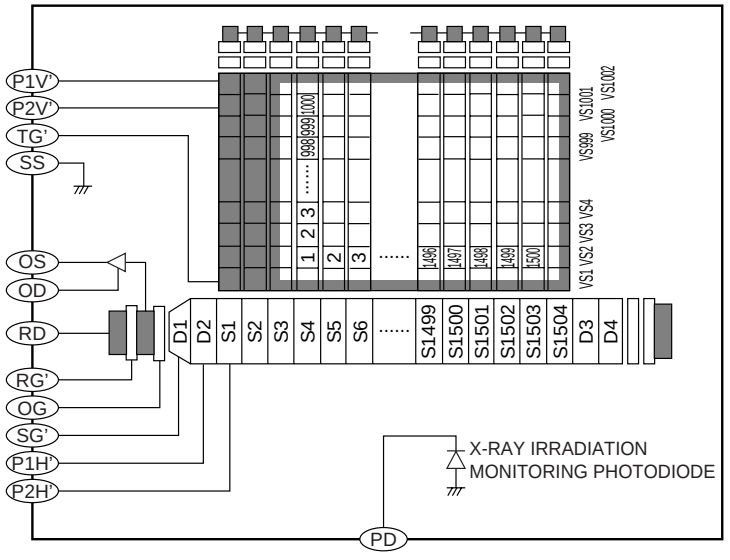
*1: S8980 only. In case of S8981-02, maximum frequency is strongly depend on peripheral circuit and cable length.
*2: Measured at half of the full well capacity. CTE is defined per pixel.
*3: V_{OD}=15 V
*4: Power dissipation of the on-chip amplifier.

■ Electrical and optical characteristics (Ta=25 °C, unless otherwise noted, V_{OD}=15 V)

Parameter			Symbol	Remark	Min.	Typ.	Max.	Unit
Full well capacity		Vertical	Fw		100	200	-	ke^-
		Horizontal			-	300	-	
		Summing			-	600	-	
CCD node sensitivity			Sv	*5	1.0	1.4	-	$\mu V/e^-$
Dark current (MPP mode)			DS	*6	-	250	2,500	e^-/pixel/s
Readout noise			Nr	*7	-	60	-	e^-rms
Dynamic range			DR	*8	-	3333	-	-
X-ray response non-uniformity			XRNU	*9, *10	-	±10	±30	%
Blemish *11	Point defects *12	White spots	-		-	-	20	-
		Black spots			-	-	20	
	Cluster defects			*13	-	-	3	
	Column defects			*14	-	-	1	
X-ray resolution			ΔR	*9	15	20	-	Lp/mm

*5: V_{OD}=15 V, R_L(load resistance of emitter follower)=1 kΩ.
*6: Dark signal doubles for every 5 to 7 °C.
*7: -40 °C, operating frequency is 1 MHz.
*8: Dynamic range = Full well capacity / Readout noise
*9: X-ray irradiation of 60 kVp, measured at half of the full well capacity.
*10: XRNU (%) = Noise / Signal × 100
Noise: Fixed pattern noise (peak to peak)
In the range that excludes 5 pixels from edges to the center at every position.
*11: Refer to “Characteristics and use of FFT-CCD area image sensor” of technical information.
*12: White spots > 10 times of Max. Dark signal (2,500 e^-/pixel/s).
Black spots > 50 % reduction in response relative to adjacent pixels, measured at half of the full well capacity.
*13: continuous 2 to 9 point defects.
*14: continuous > 10 point defects.

■ Device structure



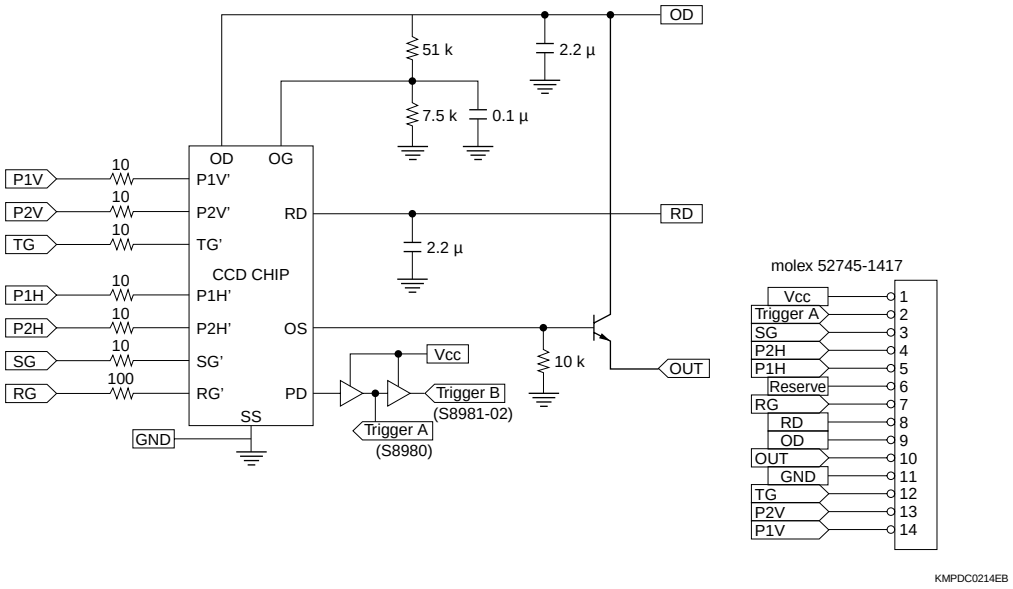
KMPDC0163EA

■ Pixel format

← Left Horizontal Direction → Right						
Blank	Optical black	Isolation	Effective	Isolation	Optical black	Blank
2	2	1	1500	1	0	2

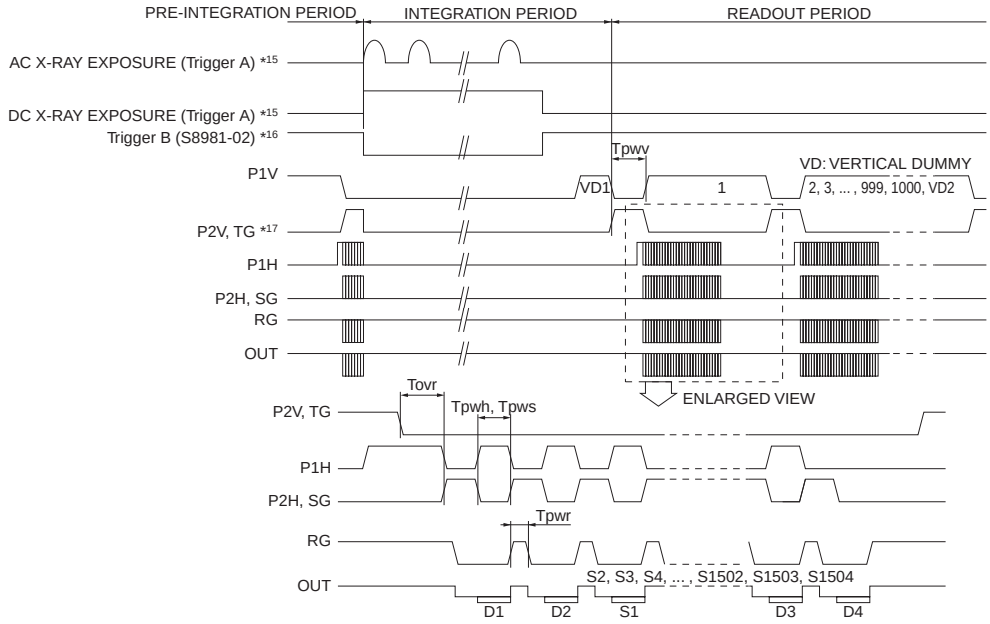
Top ← Vertical direction → Bottom		
Isolation	Effective	Isolation
1	1000	1

■ On-board circuit



KMPDC0214EB

■ Timing chart



*15: Trigger A (S8980) is the same as AC/DC X-ray exposure form.
*16: Low active trigger pulse
*17: TG terminal can be short-circuited to P2V terminal.

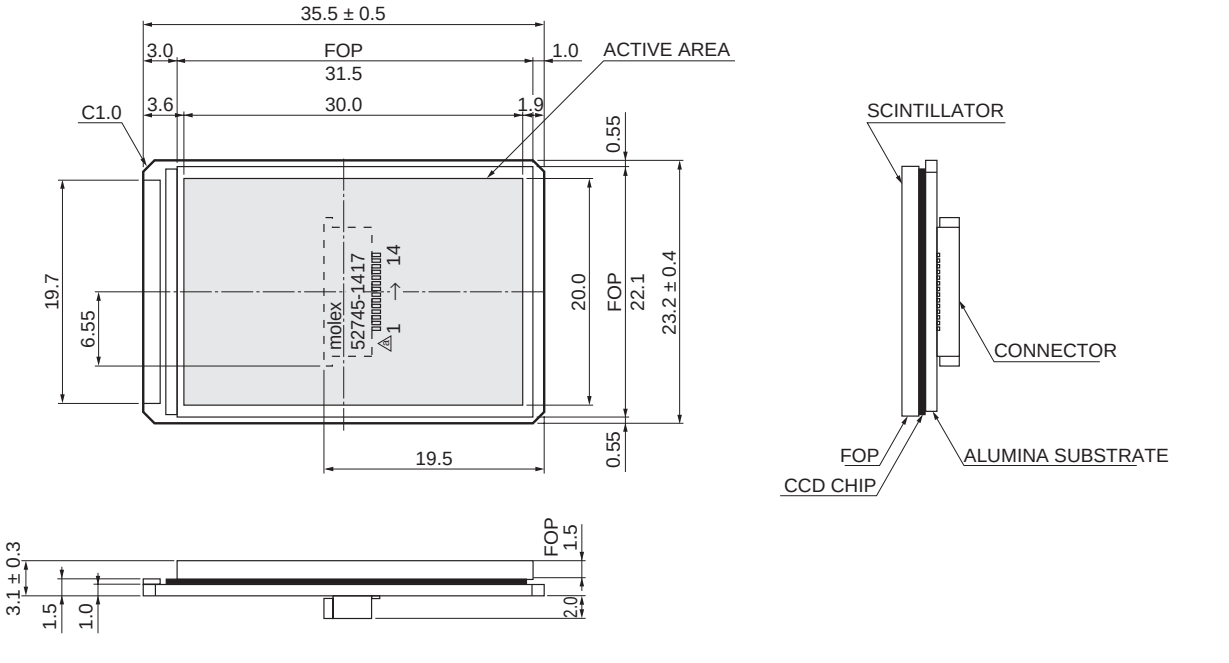
KMPDC0215EA

Parameter		Symbol	Remark	Min.	Typ.	Max.	Unit
P1V, P2V, TG	Pulse width	tpwv	*18	30	60	-	µs
	Rise and fall time	tprv, tpfv		200	-	-	ns
P1H, P2H	Pulse width	tpwh		100	500	-	ns
	Rise and fall time	tprh, tpfh	*18	5	-	-	ns
	Duty ratio			-	50	-	%
SG	Pulse width	tpws		100	500	-	ns
	Rise and fall time	tprs, tpfs		3	-	-	ns
	Duty ratio			-	50	-	%
RG	Pulse width	tpwr		10	50	-	ns
	Rise and fall time	tprr, tpfr		3	-	-	ns
TG-P1H	Overlap time	tovr		18	36	-	µs

*18: Symmetrical pulses should be overlapped at 50 % of maximum amplitude.

■ Dimensional outlines (unit: mm)

S8980



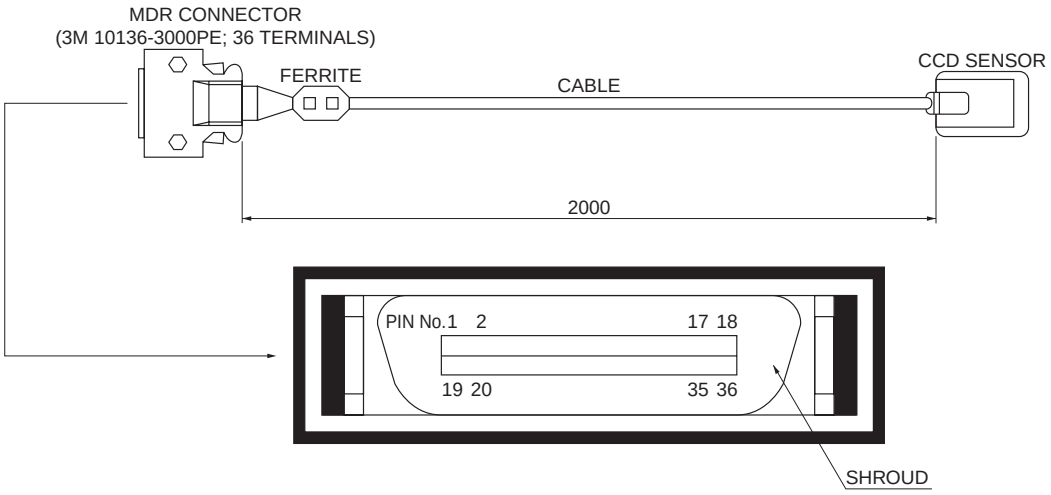
KMPDA0169EB

■ Pin connections (Connector on CCD package)

Pin No.	Symbol	Description	Remark
1	Vcc	Analog power +5 V	
2	Trigger A	Trigger A output	
3	SG	Summing gate	
4	P2H	CCD horizontal register clock-2	
5	P1H	CCD horizontal register clock-1	
6	Reserve		Should be opened
7	RG	Reset gate	
8	RD	Reset drain	
9	OD	Output transistor drain	
10	OUT	Signal output	
11	GND	Ground	
12	TG	Transfer gate	
13	P2V	CCD vertical register clock-2	
14	P1V	CCD vertical register clock-1	

S8981-02

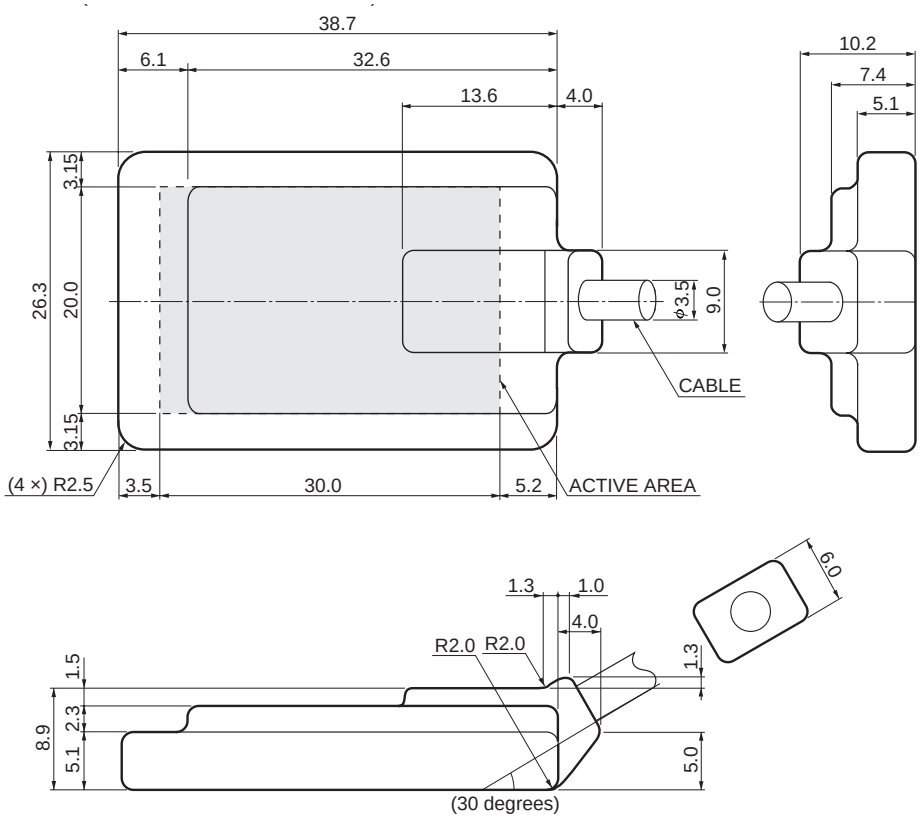
● Entire view



KMPDA0189EA

* The shield of cable and the shroud of MDR connector are electrically connected each other.
They are short-circuited, so there is no electrical contact to any other positions.

● CCD sensor



KMPDA0190EA

■ Pin connections

Pin No.	Symbol	Description	Remark
1	GND	Ground	
2	Vcc	+5 V power supply	
3	SG	Summing gate	Same timing as P2H
4	Trigger B	Trigger B output	
5	RG	Reset gate	
6	NC		
7	Reserve		Should be opened
8	NC		
9	RD	Reset drain	
10	NC		
11	OD	Output transistor drain	
12	NC		
13	OUT	Sensor output	
14	NC		
15	GND	Ground	
16	NC		
17	P1V	CCD vertical register clock-1	
18	Reserve		Should be opened
19	Reserve		Should be opened
20	P2H	CCD horizontal register clock-2	
21	NC		
22	P1H	CCD horizontal register clock-1	
23	NC		
24	GND	Ground	
25	NC		
26	RD	Reset drain	
27	NC		
28	OD	Output transistor drain	
29	NC		
30	GND	Ground	
31	NC		
32	OUT	Sensor output	
33	NC		
34	P2V	CCD vertical register clock-2	
35	NC		
36	TG	Transfer gate	Same timing as P2V

■ Precautions for use (Electrostatic countermeasures)

*Handle these sensors with bare hands or wearing cotton gloves. In addition, wear anti-static clothing or use a wrist band with an earth ring, in order to prevent electrostatic damage due to electrical charges from friction.

*Avoid directly placing these sensors on a work-desk or work-bench that may carry an electrostatic charge.

*Provide ground lines or ground connection with the work-floor, work-desk and work-bench to allow static electricity to discharge.

*Ground the tools used to handle these sensors, such as tweezers and soldering irons.

It is not always necessary to provide all the electrostatic measures stated above. Implement these measures according to the amount of damage that occurs.

HAMAMATSU Information furnished by HAMAMATSU is believed to be reliable. However, no responsibility is assumed for possible inaccuracies or omissions. Specifications are subject to change without notice. No patent rights are granted to any of the circuits described herein. ©2006 Hamamatsu Photonics K.K.

HAMAMATSU PHOTONICS K.K., Solid State Division
1126-1 Ichino-cho, Higashi-ku, Hamamatsu City, 435-8558 Japan, Telephone: (81) 53-434-3311, Fax: (81) 53-434-5184, www.hamamatsu.com
U.S.A.: Hamamatsu Corporation: 360 Foothill Road, P.O.Box 6910, Bridgewater, N.J. 08807-0910, U.S.A., Telephone: (1) 908-231-0960, Fax: (1) 908-231-1218
Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany, Telephone: (49) 08152-3750, Fax: (49) 08152-2658
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
United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, United Kingdom, Telephone: (44) 1707-294888, Fax: (44) 1707-325777
North Europe: Hamamatsu Photonics Norden AB: Smidesvägen 12, SE-171 41 Solna, Sweden, Telephone: (46) 8-509-031-00, Fax: (46) 8-509-031-01
Italy: Hamamatsu Photonics Italia S.R.L.: Strada della Moia, 1/E, 20020 Arese, (Milano), Italy, Telephone: (39) 02-935-81-733, Fax: (39) 02-935-81-741

Cat. No. KMPD1084E02
Sept. 2006 DN