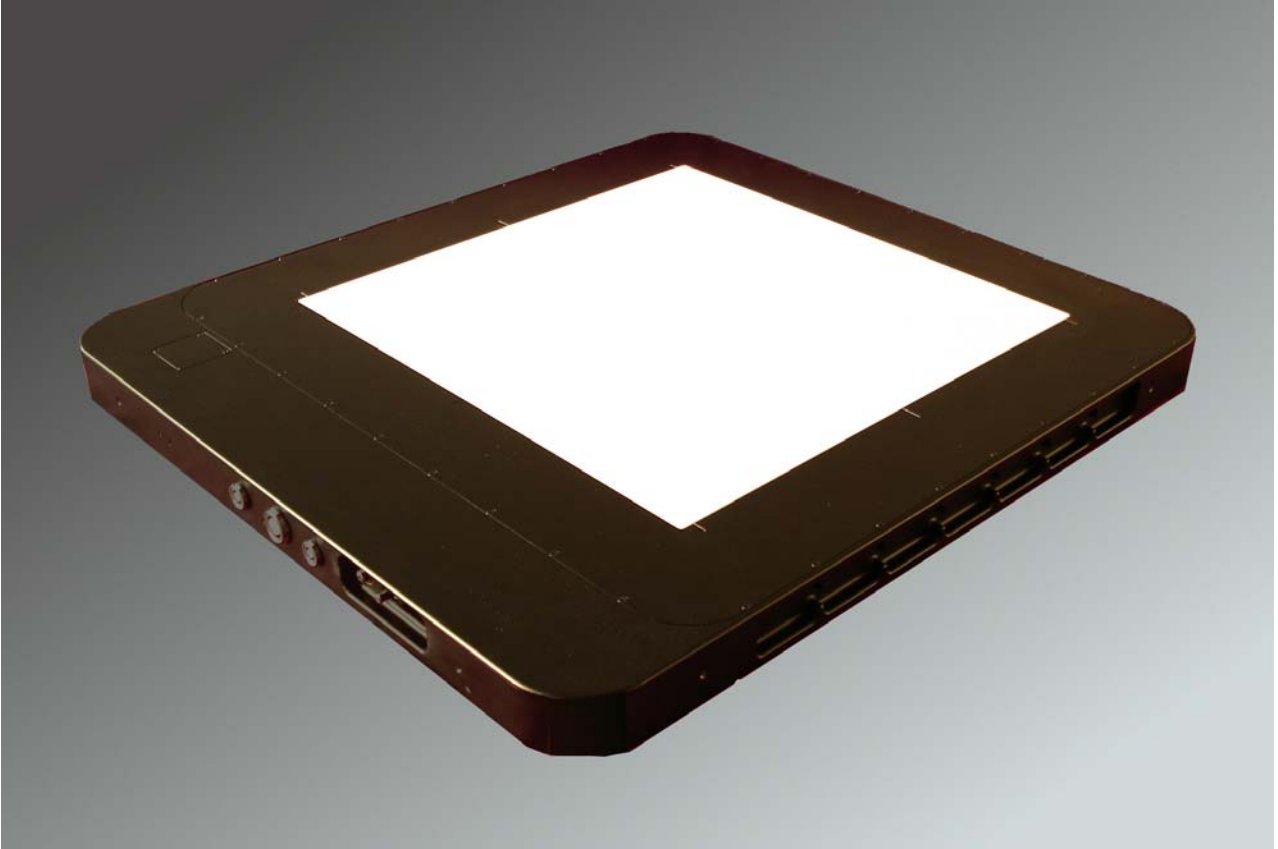


# XRD 1621 AN/CN

## Digital X-Ray Detector

DIGITAL IMAGING

REFERENCE MANUAL



## FOR YOUR SAFETY

### Warning

- Read the manual and all accompanying papers carefully before operating the **XRD 1621** system to avoid any damage and personal injury.
- The system is intended for use by qualified personnel who are familiar with the operation of electrical equipment (considering safety precautions to avoid possible injuries)
- The system should only be installed by qualified personnel who are familiar with the installation of electrical equipment (considering safety precautions to avoid possible injuries and damage to the system)
- The X-Ray Detector is intended to operate from a power source that will not apply more than 240 Volts rms between the supply conductors or between either supply conductor and ground. Other system components have to be grounded through the protection earth conductors in the power cords:
  - Computer with frame grabber
  - Monitor
- The required potential equalization has to be managed through the labelled connectors at the detector and the **XRD-EP** power supply.
- To avoid electrical shock, plug the power cords into a properly wired receptacle before performing all other connections. For best performance avoid receptacles which are not properly grounded
- Exercise extreme care to select a low noise, ripple free ground connection for the whole system. Ground terminals of wall receptacles are not suitable to ground the detector housing due to high noise and ripple input into the system.
- If the protective-ground connection is lost, all accessible conductive parts can render an electric shock, including the parts which appear to be isolated.
- Use only the original power cords. Inspect power cords and connectors regularly. Cord and connector repairs should only be serviced by qualified personnel.
- Be sure to operate the X-Ray Detector with the specified power supply. Use of an incorrect voltage will cause system failure and create a hazard.
- If any abnormal phenomena are evident such as smoke, strange sounds or fumes, unplug the Power Supply and contact your dealer, distributor or PerkinElmer Optoelectronics subsidiaries (page 35) immediately. Further use may be dangerous.
- Removing the housing of the X-Ray Detector or of the Power-Supply may cause electrical shock and/or irreparable damage of highly sensitive components.
- Do not place any objects in the X-Ray Detector or in the power supply. In case of an accident, unplug the power supply immediately and contact your dealer, distributor or PerkinElmer Optoelectronics subsidiaries (page 35). Using the X-Ray Detector or the power supply any longer may cause fire, electrical shock or other damage.
- Install the X-Ray Detector horizontally on a flat, stable surface. It is required to use screws for fixation, if the detector is placed vertically or in any tilted position. The X-Ray Detector may cause an injury if it falls or is dropped.
- Do not place the X-Ray Detector or other components on or near other devices.
- Do not use the X-Ray Detector or the power supply near water or other liquids  
Water contact to the X-Ray Detector the power supply and may cause fire, electrical shock as well as damage the device(s).



### Caution

- Do not operate the system in or around flammable gases or liquids.
- Temperature changes  
Fire, electric shock, and/or damage may occur if the X-Ray Detector is used in dusty, humid, or smoky areas or areas subjected to sudden temperature changes.
- Environmental Conditions  
Environmental conditions that are not in compliance with Section 3 of this manual may reduce the lifetime and/or irreparably damage the X-Ray Detector.

- Disconnect the cables prior to moving the **XRD 1621**.  
Prior to moving the X-Ray Detector, unplug all cables and turn off the power supply.. Disconnect the cables by use in the plug and not the cable itself as stressing the cable may cause fire or electrical shock. It is recommended that two people are used to move the **XRD 1621**.
- Do not touch the plug with wet hands  
Pulling or inserting the plug with wet hands may cause electrical shock.
- Do not touch the **XRD 1621** or the power supply **XRD-EP** and the patient at the same time.
- Do not use more than 25 Vac and/or 60Vdc at SIP/SOP.

### EMC Safety

- Medical Devices are in need of special precautions concerning EMC and should be installed and operated as written in the accompanying documentation.
- High electro magnetic fields near the X-Ray Detector or the data cables may result in erroneous readings.
- Mobile RF-communication devices near the X-Ray Detector or the data cables may result in erroneous readings.
- Only original components should be used, and no modifications and/or alterations to the product or any portion thereof should be performed without obtaining the prior written authorization of PerkinElmer.



### ESD Safety

- Shut down the power supply before connecting or disconnecting any cables.
- Only original components should be used, and no modifications and/or alterations to the product or any portion thereof should be performed without obtaining the prior written authorization of PerkinElmer.
- The system must be grounded through the grounding conductors of the power cords and in addition a protective potential equalization is required for the X-Ray Detector **XRD 1621**, and the power supply **XRD-EP**.
- Proper Electrostatic Discharge protection must be used prior to handling electrical connections to the X-Ray Detector

### Cleaning

- Only cloth lightly moistened with a mild detergent solvent and afterwards a soft dry cloth should be used.
- For safety reasons, turn off and unplug the power supply and unplug before cleaning.
- Never use any of the following strong solvents as damage to the X-Ray Detector and accessories may occur.
  - Thinner
  - Benzine
  - Abrasive cleaner
  - Wax
  - Acid or Alkaline solvent
  - Spray-type cleaner

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## 1 Scope

This document describes design elements and respective interfaces for the **XRD 1621** detector family. Where applicable mechanical, electronic, and software interfaces will be addressed.

## 2 Regulatory Requirements

The assembly of the X-Ray Detector **XRD 1621** is designed to be compliant with the requirements detailed in the table below.

All regulatory certificates are valid only if the original accessories as listed in Table 7 are used. All regulatory certificates are rendered invalid if any modifications and/or alterations to the Product are made, or any portion thereof, without obtaining the prior written authorization of PerkinElmer.

Standard	Description
<b>INTERNATIONAL</b>	
IEC 60950	Safety of information technology equipment including electrical business equipment and associated equipment, with a rated voltage not exceeding 600V.
UL 60601-1	General Requirements for Safety and Electromagnetic Compatibility for Medical Electrical Equipment (US)
<b>EUROPEAN</b>	
EN 60950 A497	Safety of information technology equipment including electrical business equipment and associated equipment, with a rated voltage not exceeding 600V
EN 60601-1	General Requirements for Safety and Electromagnetic Compatibility for Medical Electrical Equipment
EN 60601-1-2:2001	Medical electrical equipment, Part 1-2: General requirements for safety - Collateral standard: Electromagnetic compatibility

Table 1 Regulatory Requirements

## 3 Environmental Considerations

Environments outside the specification reduce the lifetime and may irreparably damage the Product.

	Transportation / Storage* <sup>1</sup>		Operation
Ambient temperature	0° to +50°C	0° to +45°C (CsJ)* <sup>2</sup>	+15° to +35°C
Relative humidity* <sup>3</sup>	5% to 90%	10% to 80% (CsJ)	30% to 70%
Atmospheric pressure	700 to 1250 hPas		800 to 1250 hPas
Vibration	2g (10 Hz to 150 Hz)		0.5g (10Hz to 150Hz)
Shock	20g (duration 11 ms)		2g (duration 11ms)

**Note:** \*<sup>1</sup> In original transport container  
\*<sup>2</sup> Temp. Gradient: max 4.5 K/hour  
\*<sup>3</sup> No condensation

Table 2 Environmental Considerations

## 4 Description of the XRD 1621

### 4.1 Principle of the XRD 1621

The detector **XRD 1621** works as a complete X-Ray detector, the sensor and its electronics are housed in one package. In order to increase the durability of the device in MeV source applications, the electronics are placed on the perimeter of the active sensor, out of the direct path of the beam. No lead shielding is provided for the electronics, and thus the customer is required to block the radiation by lead shielding to avoid damage of the electronics, and to adjust the field of view (FOV) to the active area. Any portion of the housing outside of the Field of View has to be protected such that the overall applied dose does not harm the electronic components. The removable aluminium plate in the housing protects the sensor against mechanical impacts only and is not designed to shield the electronics from X-Rays. The PROM used for the FPGA downloading has an additional window and is placed on the front of the housing. The cover is designed to allow an exchange of the PROM.

The flat panel sensor of the **XRD 1621** is fabricated using thin film technology based on amorphous silicon technology. Electronically, the sensors are much like conventional photodiode arrays. Each pixel in the array consists of a light-sensing photodiode and a switching Thin Film Transistor (TFT) in the same electronic circuit. Amorphous silicon photodiodes are sensitive to visible light, with a response curve roughly comparable to human vision. The sensitivity of amorphous silicon photodiodes peaks in green wavelengths, well matched to scintillators such as CsI or  $Gd_2O_2S:Tb$  (commercially available as LANEX<sup>®</sup> or DRZ<sup>®</sup> scintillators). The response has the excellent linearity of a charge-integrating biased photodiode.

These sensors are of special interest primarily for the size. The **XRD 1621** sensor is based on a single panel. This means that no optical reduction is needed when recording large images, as from conventional X-ray cameras. The panel provides a very large improvement in the capture of optical photons from the scintillator when compared to a fibre optic taper or reducing lens.

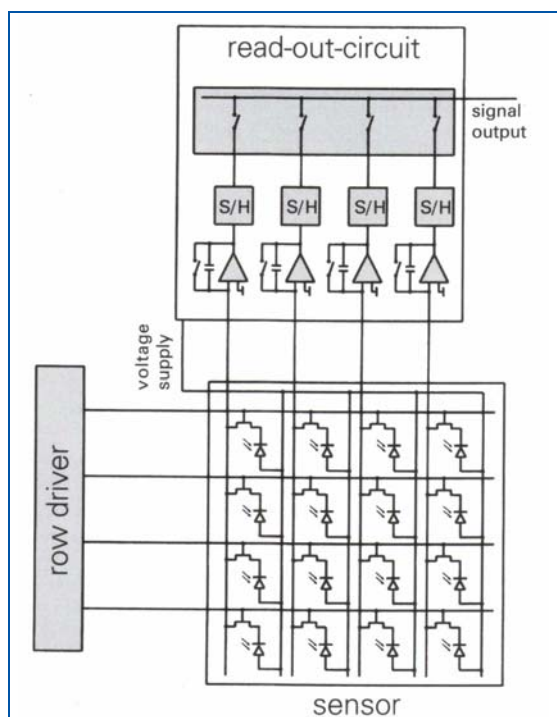


Figure 1 Principle electronic arrangement of XRD 1621

The incident X-rays are converted by the scintillator material to visible light which generates electron hole pairs in the biased photodiode. The charge carriers are stored in the capacity of the photodiode. By pulsing the gates of a TFT line within the matrix, the charges of all columns are transferred in parallel to the signal outputs. All signals of the columns are amplified in custom readout multiplexers for further processing (see Fig 1).



### 4.2 Electronic control and readout

Charge amplifiers for readout of the sensor, and row drivers for addressing the rows are placed on chip on board (COB) modules contacting the pads at the edges of the sensor. The COBs for control and readout are connected to A/D conversion PCB boards. The analogue part of the electronics is placed beside the sensor and includes sophisticated FPGA control of the detector. Numerous features are realized to minimize noise, as well as shaping and timing of the control pulses and isolation of digital and analogue sections. The digital control is reprogrammable through a PROM to enable future upgrades or modifications.

### 4.3 Structure of the XRD 1621

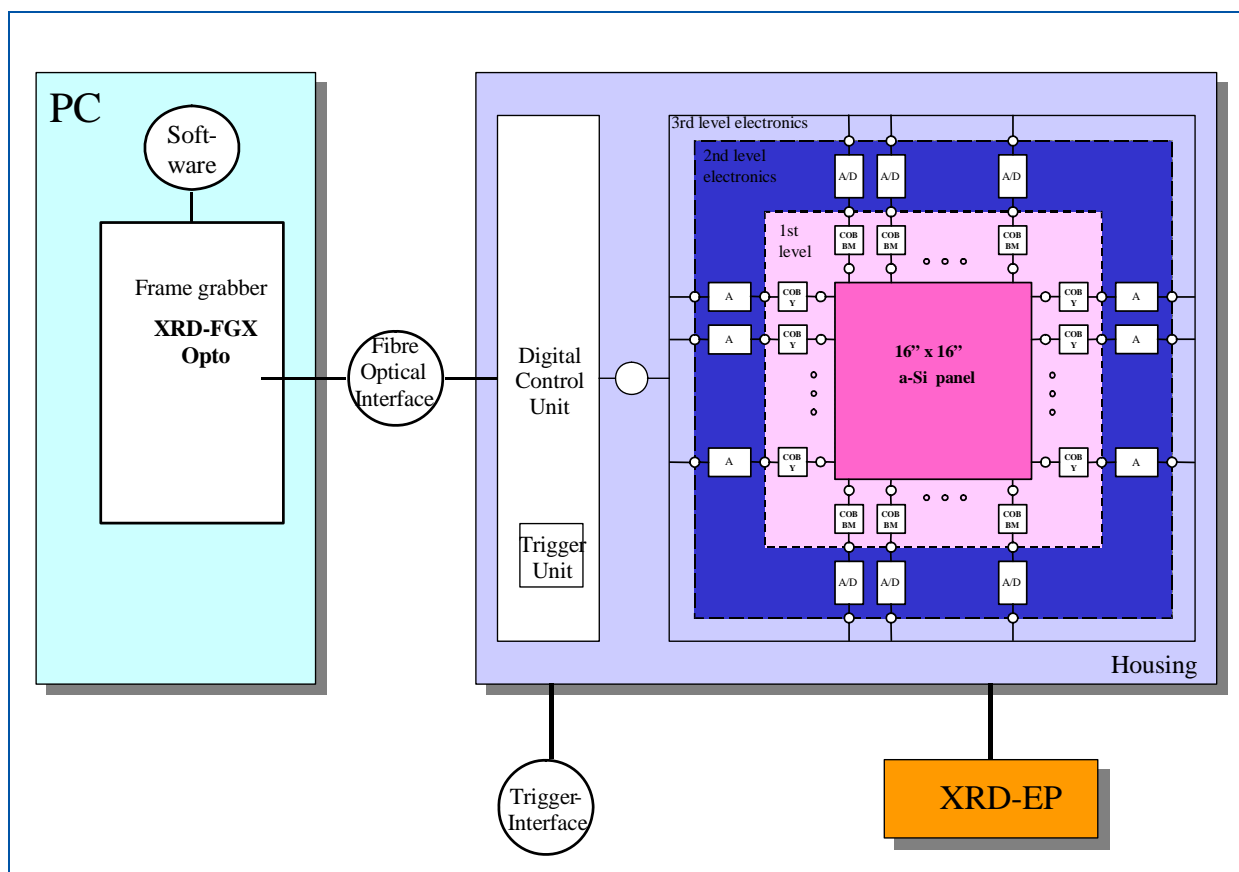


Figure 2 Structure of the XRD 1621

## 4.4 Detector Overview

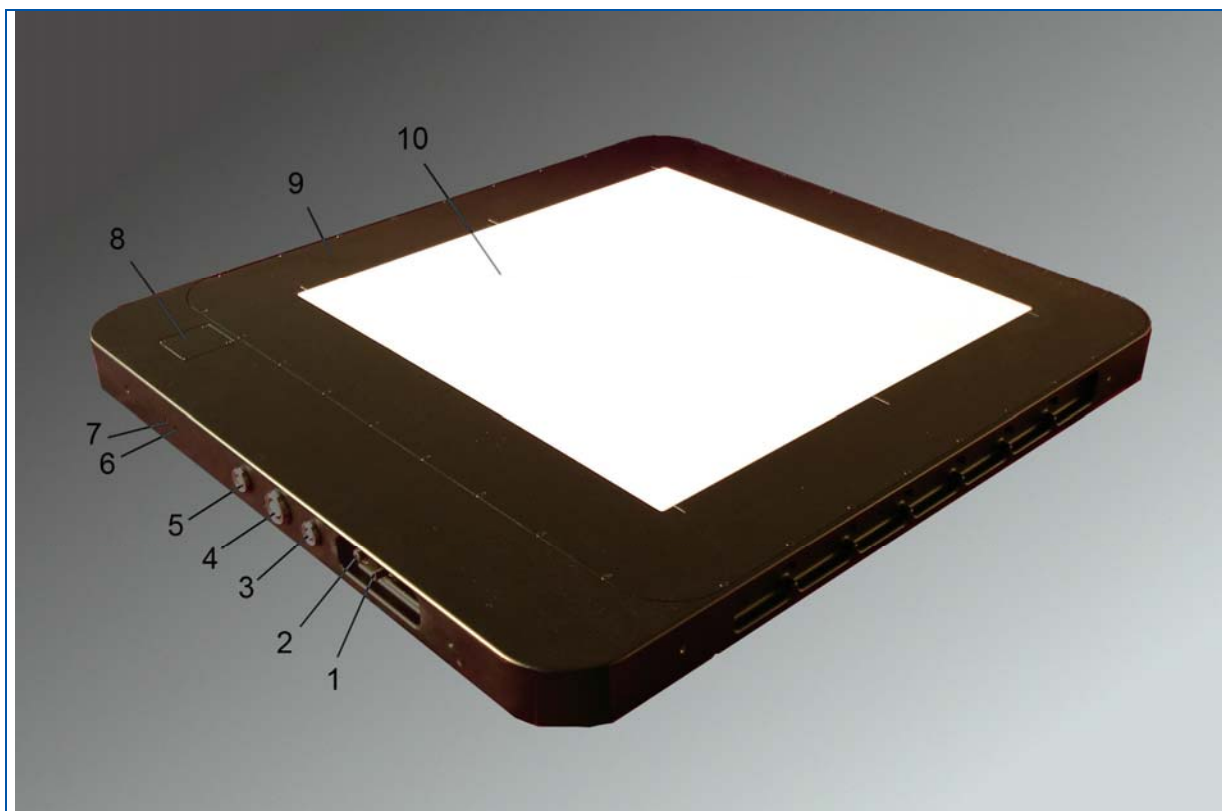


Figure 3 Detector Overview

1	Potential Equalization	
2	Ground Connector	
3	Trigger Input (page 14)	
4	Power Input (page 14)	
5	XRD Fibre Optical Interface Bus	
6	Detector Mode and Frame Rate (page 16)	
	Green	Free Running
	Yellow	Trigger Mode
7	Power On and Detector Status	
	Green	Power ON
	Orange	Self Inspection
6 + 7	All Lights On during Self Inspection (Power-ON)	
8	PROM Holder	
9	Electronics (This Area needs to be shielded)	
10	Active Area	

Table 3 Detector Overview

## 5 XRD 1621 Specification

### 5.1 Technical data of the XRD 1621

#### 5.1.1 Mechanical specification

<u>Size:</u>	672 mm x 599 mm x 44 mm
<u>Weight:</u>	approximately 25 kg.
<u>Connectors:</u>	Fibre Optical connector; 10-pole power supply connector; 7-pole trigger connector; M4 screw for grounding; Plug for Potential Equalization.
<u>Construction:</u>	
Sensor:	
PCB sandwich:	carbon fibre core (thickness 3 mm);
Detector:	single glass substrate;
Contacts:	heat sealing contacts (including bias voltages);
Scintillator:	Kasei DRZ-STD, DRZ-PLUS optional: CsI (TI) needles directly deposited on the aSi photodiodes Al metallised Carbon fibre plate or a molybdenum plate protects the scintillator, (active thickness of the protection is about 0.9 mm.)
Vertical:	9.35 mm (distance between sensor top and housing plate top);
Horizontal:	from upper left of housing: 377.5 mm, 299.5 mm to sensor centre.
<i>Electronics :</i>	Chip on Board Modules (COB) for charge amplifiers and row drivers; Pre-controlling of COB's for charge amplifiers and row drivers; PCB signal generation, FPGA control and Interface generation, Main PCB for interconnecting all PCB components;
<i>Housing:</i>	aluminum profiles. 8 screw holes on the side of the imager
<i>Top plate:</i>	aluminum plate for protection of sensor/scintillator (Thickness 0.75 mm). optional: Carbon fibre plate (Thickness 0.75 mm).
<b>Shielding</b>	<b>No lead shielding</b> - The FOV (Field of view) of the detector is restricted to the maximum of 40,96 x 40,96 cm <sup>2</sup> active area, otherwise electronics X-ray destruction might occur at any X-ray energy

Table 4 Mechanical specification

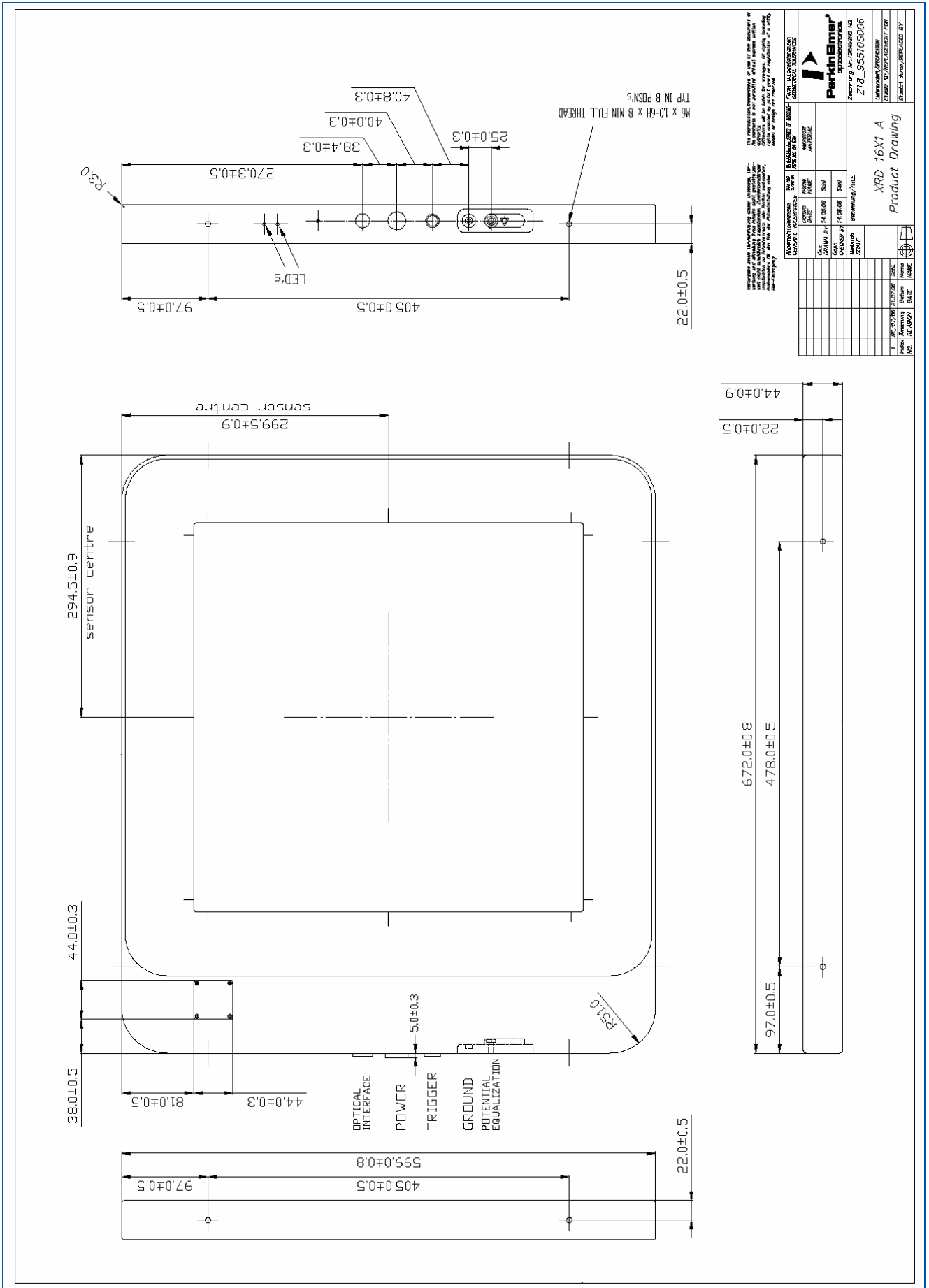


Figure 4 Mechanical drawing of the XRD 1621 A

### 5.1.2 Readout Specification

<b>Sensor:</b>		
Total pixel number		2048 x 2048
Active pixel number		2024 x 2024
Pitch		200 $\mu$ m
Total area		409.6 x 409.6 mm <sup>2</sup>
Diode capacity		2.1 pF
<b>For CsI Option (75 kVp, 20mm Al filtration, 7mm Al HVL):</b>		
MTF (0.5 lp/mm)		80% (typical 86%)
MTF (2.0 lp/mm)		30% (typical 45%)
DQE (0.5 lp/mm)		56% (typical 65%)
DQE (2.0 lp/mm)		28% (typical 37%)
<b>Electronics:</b>		
Charge amplifier		32 x 128 channel ASIC
ADC	XRD 1621 xN:	32 (16bit, 1 MSps)
	XRD 1621 xN ES:	32 (16bit, 2 MSps)
Gain (e-/ADU):		0.25 pF, 0.5 pF, 1 pF, 2 pF, 4 pF, 8 pF
Integration time (minimum)	XRD 1621 xN:	133.2 ms @ 200 $\mu$ m 66.5 ms @ 400 $\mu$ m (2x2 Binning)
	XRD 1621 xN ES:	66.6 ms @ 200 $\mu$ m 33.2 ms @ 400 $\mu$ m (2x2 Binning)
Non-Linearity:		< 1 % (10 % to 90 % FSR))
<b>Detector:</b>		
Dynamic range		> 77 dB
Response Non-Uniformity		< $\pm$ 2 % (10 % to 90 % of FSR)
Image lag (standard) (CsI-option)		< 8 % (1 <sup>st</sup> frame) < 10 % (1 <sup>st</sup> frame)
Maximum frame rate	XRD 1621 xN	7.5 fps @ 200 $\mu$ m 15 fps @ 400 $\mu$ m (2x2 Binning)
	XRD 1621 xN ES:	15 fps @ 200 $\mu$ m 30 fps @ 400 $\mu$ m (2x2 Binning)
Scintillator	Optional	Kasei DRZ-STD, DRZ-PLUS CsI (TI) (direct deposition on aSi photodiodes)
Radiation energy		40 keV – 15 MeV (XRD 1621 AN (ES)) 20 keV – 15 MeV (XRD 1621 CN (ES))

\*Returned detectors to PerkinElmer Optoelectronics Inc. shall have activation less than 0.2 $\mu$ Sv/h

**Table 5** Readout Specification accomplished at Timing 0, 200 $\mu$ m and 1pF with all corrections applied.

### 5.1.3 Connectors of the XRD 1621

One edge of the housing contains the connectors for the XRD Interface Bus, the power supply **XRD-EP**, the housing ground and the trigger input.

- Trigger input: ODU Series G8B1 (Male)
- Power supply: ODU Series G83B (Male)

PIN	Colour	Connection
1	Black	TRIGIN_+
2	Brown	TRIG_IN_-
3	Red	TRIGOUT_+
4	Orange	TRIGOUT_-
5	Yellow	FGND
6	Blue	5PF
7	Magenta	

Table 6 PIN assignment of Trigger signal (LVDS Signals)

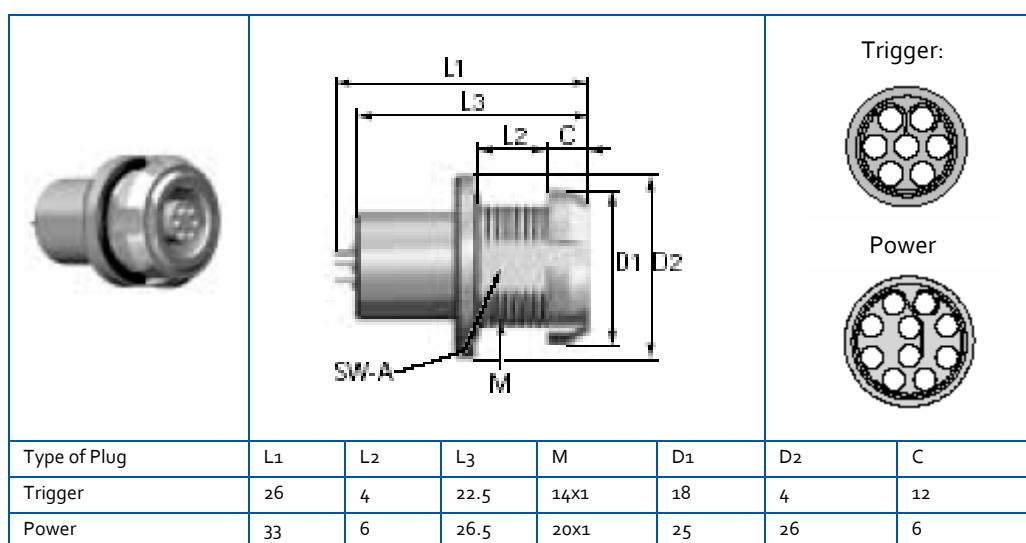


Figure 5 Drawing of the connectors for Power and Trigger (front view)

#### 5.1.4 Accessories

On safety reasons the **XRD 1621** should only be used with the **XRD-EP** power supply and its original cables and connectors. The use of other cables and connectors or components which have any modifications and/or alterations to the product by customer, or any portion thereof, may influence the ESD and EMC behaviour of the detector system.

PerkinElmer Art. No.	Description
95510215H	PCI-X Frame Grabber XRD-FGX Opto
95510570	XRD-FGX Optical PC Connection Cable 7.6m/25ft
95510571	XRD-FGX Optical Extension Cable 7.6m/25ft
95510572	XRD-FGX Optical Extension Cable 30.5m/100ft
95510590	XRD-DETEKTOR TRIGGERKABEL 25FT / 7,6M
95510254H	Power Supply XRD-EP
95510300H	Power Supply XRD-EP (wall mounted)
95510581H	XRD-EPS DC Cable 25FT / 7.6M
95510582H	XRD-EPS DC Cable 50 FT / 15,25M
95510583H	XRD-EPS DC Cable 100 FT / 30.5 M
95510584H	XRD-EPS DC Cable 25FT / 7.6M
95510331	XRD-EP AC Cable EP – Germany
95510332	XRD-EP AC Cable EP – US*
95510333	XRD-EP AC Cable EP – JP
95510334	XRD-EP AC Cable EP – UK
95510336	XRD-EP AC Cable EP – IEC
95510544H	XRD-EP AC Cable EP – CN

\*mains plug has to be Hospital Grade; 125 Vac / 13 A

Table 7 Accessories for the XRD 1621

## 5.1.5 Detector Modes and Timings

### 5.1.5.1 Detector Mode

Three different acquisition modes are available. They are called "Free Running", "External Trigger" and "Internal Timer". These Modes are described in more details in the "How to Run the Detector"

- ▶ The free running mode means that the detector sends out frames continuously according to the selected frame time. This is the default mode.
- ▶ The external triggered mode means that the detector sends a frame after triggering by an external pulse and ignores all other incoming trigger pulses until the selected frame time has elapsed. After that the detector can be triggered by a new pulse.
- ▶ The internal triggered mode means that each frame time can be selected between the fastest timing and 5 seconds, and the frame grabber triggers the detector by this frame time. This mode is a combination of the free running and the external trigger modes.
- ▶ DDD mode: The detector is running in a "silent" mode, like free running mode but without transferring image data. If the user application (Software, Frame Grabber or external Source) sends a triggers signal to the detector, the detector accomplishes the current frame. The next frame is processed also with the fastest integration time and a delay time appears which is the best time suited for exposure in case of pulsed or shuttered radiation. After this delay the detector performs the image scan and transfers the desired data. After this the detector returns to the silent mode until the next trigger pulse is sent.

### 5.1.5.2 Timings

Eight different frame times are available and the detector starts automatically in the first timing (Timing 0) which is the fastest readout time. This means that the detector needs a minimum of 133.2 ms @ 200µs (ES: 66.6 ms) for one frame. Each pixel is read out every 133.2 ms and during this time the pixel also collects radiation. For details of the readout scheme see the chapter Sorting.

### 5.1.6 Information

For any further information for the detector including warranty conditions please contact the party from where the product was purchased for after-sales service. If information is not available, please contact PerkinElmer Optoelectronics (page 35).



## 5.2 Underperforming Pixel Specification

This section defines the characteristics of underperforming pixels and their distribution. PerkinElmer performs a final quality test on all detectors to ensure the required specifications are met. An underperforming pixel map is created as part of the final quality test and defines the location of the underperforming pixels. This pixel map is delivered with each detector.

### 5.2.1 General Definition

- All underperforming pixels are defined at the 200 micron pixel size.
- All tests are accomplished in the Timing 0 (133.2 ms; ES:  $T_0=66.6$  ms), 200 $\mu$ m and at 1pF capacity, unless otherwise indicated.
- Offset and Gain Correction Files are always implemented under the same detector conditions.

### 5.2.2 Definition of Cluster

- Underperforming Lines are more than 10 consecutive underperforming pixels
- Full cumulative underperforming lines are 2048 underperforming pixels which are parts of underperforming lines
- Adjacent underperforming lines are pairs of neighbored lines
- Cluster pixels are counted if they are connected by their sides (4-neighborhood)

### 5.2.3 Definition of Panel Region

- Central: The central region is defined as the inner 1024 by 1024 pixels. If an underperforming occurs at the boundary of this area then it is permissible to shift the area by up to 10 pixels but not to reduce it.
- Rim: The rim is defined as the 6 pixels (AN3: 12 pixels) around the edge of the detector. No specifications are given for this region since the behaviour of the sensor can not be guaranteed in this area.
- General: This is the total sensor area minus rim.

### 5.2.4 Definition of Underperforming Pixel Measurement

Offset:	offset image
Gain:	gain image
m:	number of images in a sequence
j:	image j in a sequence
n:	number of pixels in one image (2048x2048)
i:	pixel i in a image
$x(i,j)$	pixel value
$X$ :	median value
$\sigma$ :	standard deviation

### 5.2.4.1 Signal sensitivity

Tests performed on bright offset corrected image at different X-ray energies at first free running timing (133.2 ms).

- ▶ **Underperforming Bright pixel:** value is greater than 150% of the median bright
- ▶ **No Gain pixel:** dark pixel with no light response
- ▶ **Underperforming Dark pixel:** value is below 45% of the median bright

### 5.2.4.2 Bright Noise:

A sequence of 100 bright images in the first free running timing (To) is acquired. The bright image has a nominal value of roughly 30000 units. The pixel sigma for each pixel across the 100 images and the median pixel sigma are calculated. A underperforming bright noise pixel is a pixel whose sigma is more than 6 times the median pixel sigma.

$$\sigma(i) = \sqrt{\frac{1}{m-1} \sum_{j=1}^m (\bar{x}(i) - x(i, j))^2} \quad \text{(pixel sigma)}$$

$$\Rightarrow \text{sort}_i(\sigma(i))$$

$$\Rightarrow \bar{\sigma} = \sigma_{50\%}(i) \quad \text{(median pixel sigma)}$$

For (i=1, n, i++) if  $(\sigma(i) > 6 * \bar{\sigma}) \Rightarrow$  pixel is underperforming

### 5.2.4.3 Dark Noise

A sequence of 100 dark images is acquired in two free running timings (To) and 1 s). The pixel sigma for each pixel across the 100 images and the median pixel sigma are calculated. An underperforming dark noise pixel is a pixel whose sigma is more than 6 times the median pixel sigma.

$$\sigma(i) = \sqrt{\frac{1}{m-1} \sum_{j=1}^m (\bar{x}(i) - x(i, j))^2} \quad \text{(pixel sigma)}$$

$$\Rightarrow \text{sort}_i(\sigma(i))$$

$$\Rightarrow \bar{\sigma} = \sigma_{50\%}(i) \quad \text{(median pixel sigma)}$$

For (i=1, n, i++) if  $(\sigma(i) > 6 * \bar{\sigma}) \Rightarrow$  pixel is underperforming

### 5.2.4.4 Uniformity

Analysis performed on Offset correction image acquired at To and Multiple Gain correction images acquired also at To. Gain Images having a nominal value of 30000 and 3000 digits and the flood image a nominal value of 10000 digits acquired at To.

half\_og: offset and gain corrected bright image at a nominal value at 10.000  
ADU

$\bar{x}_{9,9}$  Median value of 9x9 neighbours

#### ▶ Global uniformity:

A pixel is marked as underperforming if its value exceeds a deviation of more than +/- 2% for fixed Integration time of To, corrected with gain-and offset- images acquired at To both.

For (i=1, n, i++) if  $((x(i) > 1.02\bar{x}) \parallel (x(i) < 0.98\bar{x})) \Rightarrow$  pixel i is underperforming

#### ▶ Local uniformity

A pixel is marked as underperforming if its value exceeds a deviation of more than +/- 1 % of the median value of its 9x9 neighbours in the corrected image for fixed Integration time of To, corrected with gain-and offset- images acquired at To ms both.

For (i=1, n, i++) if  $((x(i) > 1.01\bar{x}_{9,9}) \parallel (x(i) < 0.99\bar{x}_{9,9})) \Rightarrow$  pixel i is underperforming

### 5.2.4.5 LAG

The detector is set to an integration time of 2 s (triggered mode). A sequence of offset corrected frames is acquired where one image is irradiated during the gap after the readout time of the detector of up to 30,000 units. The following two dark images (first frame after exposure and second frame after exposure) are analyzed in correspondence of the irradiated frame. A pixel is marked as underperforming if its value exceeds the following limit: 8% in 1st Frame, 4% in 2nd frame; and for the Csl option: 10% in 1st Frame, 5% in 2nd frame.

```

image_oc(1):    offset corrected bright image at 30.000 ADU
image_oc(2):    offset corrected first dark image
image_oc(3):    offset corrected second dark image
result(1) = image_oc(2) / image_oc(1)
result(2) = image_oc(3) / image_oc(1)
for (i=1, n, i++) if (result(1,i) > 0,1 || result(2,i) > 0,05) => pixel i is
                                                    underperforming
    
```

## 5.2.5 Number of Underperforming Pixel

### 5.2.5.1 Imaging Grade

Ttype	Limit per region		Max # pixels
	Central	General	
<b>Lines:</b>			
2 Adjacent underperforming lines	4	8	
3-4 Adjacent underperforming lines	1	2	
Cumulative underperforming lines	8	20	40960
<b>Clusters:</b>			
Mega cluster (maximum 36 pixels)	2	7	350
Large cluster (maximum 17 pixels, no 4x4)	15	40	680
Medium cluster (4-9 pixels, no 3x3)	125	400	3600
<b>Density:</b>			
Pixel density (number of pixels in a 51x51 block)	10%	10%	260
<b>Total number of underperforming pixels</b>		2%	83800

Table 8 Definition of Imaging Grade

### 5.2.5.2 CT-Grade

Defect type	Limit per region		Max # pixels
	Central	General	
<b>Lines:</b>			
2 Adjacent underperforming lines	0	1	
Cumulative underperforming lines	5	11	22528
<b>Clusters:</b>			
Mega cluster (maximum 36 pixels)	0	1	36
Large cluster (maximum 17 pixels, no 4x4)	5	20	340
Medium cluster (4-9, no 3x3)	50	200	1800
<b>Density:</b>			
Pixel density (number of pixels in a 51x51 block)	10%	10%	260
<b>Total number of underperforming pixels</b>		1 %	40000

Table 9 Definition of CT Grade

### 5.3 Power supply XRD-EP

The enhanced power supply **XRD-EP** is a stand-alone unit to support the XRD 1621 series. The power supply belongs to the protection class I and supports 100 V to 240 V at 47 Hz to 66 Hz. An LED Display indicates the status of the device. In case of “overload” the power supply must be switched off and can be switched on after a few minutes.

For any further information for the detector including warranty conditions please contact the party from where the product was purchased for after-sales service. If information is not available, please contact PerkinElmer Optoelectronics (page 32).

Light	Status
Overload	The Power Supply is overloaded. The power Supply has to be switched OFF.
Mains	The power Supply is connected to mains.
DC-Output	The DC-Output is ON.

Table 10 Status Lights of the XRD-EP



Figure 6 Image of the Power Supply XRD-EP


Specifications	XRD-EP
Physical Dimension (L,W,H)	291 mm x 100 mm x 180 mm
Weight	6,56 kg
Input	100 Volts – 240 Volts AC 47 Hz – 66 Hz 3,3 Ampere max; 200 Watts
Output	5,5 Volts / 5 Ampere DC 12,5 Volts / 5 Ampere DC -12,5 Volts / 5 Ampere DC
Internal Fuse	4 Ampere / 250 Volts
Protection Class	 protection class I

Table 11 Electrical and Mechanical Specification of the XRD-EP

	Transportation / Storage	Operation
Ambient temperature	-10° to +70°C	+0° to +70°C Derating > 50°C: 2.5%/K
Relative humidity	5% to 90%	5% to 90%

Note: No condensation

**Table 12 Environmental Considerations for the Power Supplies**

PIN	Output
1	+ 12,5 V (UA2)
2	NC
3	0 V Sensor (UA1)
4	+5,5 V Sensor (UA1)
5	+12,5 V Sensor (UA2)
6	-12,5 V Sensor (UA3)
7	NC
8	-12,5 V (UA1)
9	0 V
10	+5,5 V (UA1)
11	0 V Sensor (UA2, UA3)
12	0 V

**Table 13 PIN assignment of power supply XRD-EP**

### 5.4 Frame Grabber Board

The **XRD 1621** can be directly operated by the PCI-X Frame Grabber **XRD-FGX Opto** or the PCIe Frame Grabber **XRD-FGE Opto** over the **XRD Fibre Optical Interface Bus**. Both Frame Grabbers utilizes direct image acquisition into the PC's main memory and detector control functions. Main memory is used as a flexible frame buffer of virtual size. The XISL (X-Ray Imaging Software Library) integrates the frame grabber drivers for Microsoft Windows® XP and Windows® 2000 and is used to set internal DLL parameters to drive and read-out the **XRD 1621** detectors (Table 18).

#### 5.4.1 The XRD-FGX Opto PCI-X interface board

The **XRD-FGX Opto** is a 3/4 size board designed for standard PCI-X bus. It contains a sophisticated bus-master DMA controller for data transfer into memory, using scatter-gather DMA for linear storage even of image sequences. The XRD-FGX provides an FPGA and 256 MB RAM to perform on-board corrections including Multiple Gain Correction at 10 signal levels. The robust glass fibre optical interface provides galvanic isolation between detector and frame grabber and IP68 proofed plugs at the detector side and on both sides of the extension cable. Up to four frame grabbers, each using its own detector can be connected to one PC. The XRD FGX provides the advantage of synchronization between the detector and x-ray source or manipulator by using an external trigger signal or by using the internal trigger function of the frame grabber (Table 17).

Specifications	XRD-FG
Physical Dimension	195 mm x 107 mm
PCI-X Compliant	PCI-X 2.0
PCI-Bus	133 MHz / 64 Bit
Memory	256 MB
Operation System	Windows™ 2000, XP Professional,

**Table 14 Frame Grabber Specification**

	Transportation / Storage	Operation
Ambient temperature	-10° to +60°C	+0° to +40°C ( 2 m/s forced air cooling)
Relative humidity	5% to 90%	5% to 80%

**Note:** No condensation

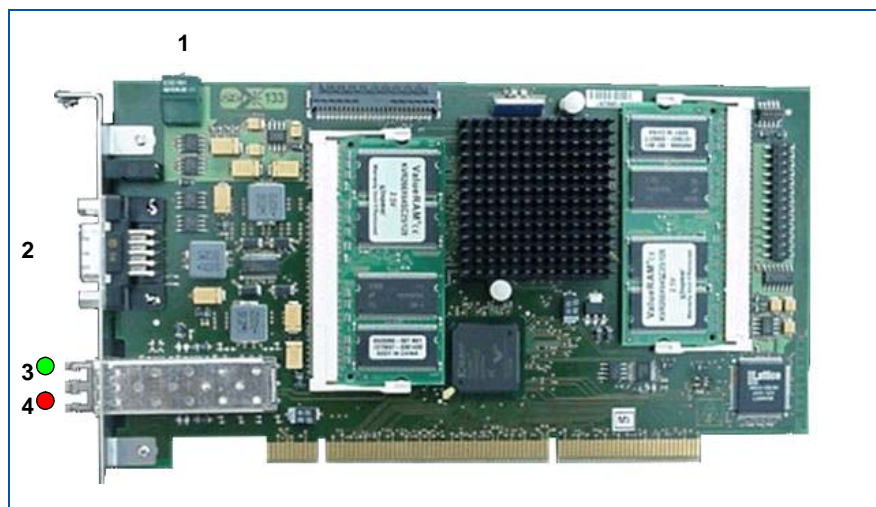
**Table 15 Environmental Considerations for the Frame Grabber**

Optical Interface Specification	
Bending radius:	
Dynamic	105 mm
Static:	70 mm
Traction:	
Temporary:	2000 N
Long-term::	800 N
Lateral Pressure Resistance:	
Temporary:	2500 N/dm
Long-term:	1000 N/dm
Cable Weight	approx. 55kg/km
Temperature:	
Transport and Storage	- 25°C to + 70°C
Laying:	- 5°C to + 50°C
Operation:	- 5°C to + 50°C

Table 16 Optical Interface Specification

### 5.4.2 Connectors of the Frame Grabber

The connectors of the **XRD-FGX Opto** PCI-X interface board link the **XRD 1621** detector to the personal computer. The fibre optical connector on the module can be used to plug in the Interface cable. The module allows data acquisition via the fibre optical interface, detector mode control via the serial configuration bus and generation of external triggering.



- 1 – HEX Switch
- 2 – D-Sub connector (details below)
- 3 – Optical Transceiver Out (IP68)
- 4 – Optical Transceiver In (IP68)

Figure 7 Image of the XRD-FGX Opto Frame Grabber

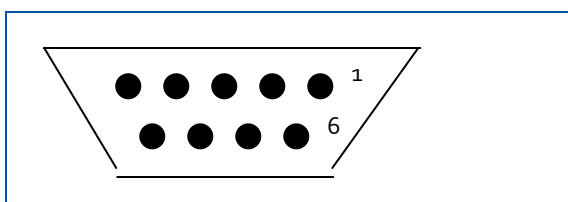


Figure 8 D-Sub connector front view:

PIN	DESCRIPTION	
1	GP_OUT0+	frame enable
2	GP_OUT1+	frame sync
3	GP_IN0+	trigger in
4	GP_IN1+	na
5	GND	
6	GP_OUT0-	frame enable
7	GP_OUT1-	frame sync
8	GP_IN0-	trigger in
9	GP_IN1-	na

Table 17 FG-X D-Sub connector description

### 5.4.3 Installation of the Frame Grabber

To install the frame grabber the computer should be shut down, and the power supply unplugged. Failure to do so may cause severe damage to both the motherboard and frame grabber. In most cases the mainboard has an onboard LED which shows the power OFF mode or the soft-off mode (Power is still on). Hold the grabber by the edges and do not to touch the chips, leads or connectors. Please place the frame grabber on a grounded antistatic pad whenever the grabbers are separated from the system.

An exclusive IRQ port should be used, please consult the mainboard manual provided by the PC manufacture for more information. If more than one frame grabber has to be used in the system the switch on the left side of the grabber must be set to a unique number for every board. Please read the readme.txt on the installation CD for the latest information before installing the frame grabber driver and the application software.

#### 5.4.3.1 Hardware Installation

- 1) Shut down the computer
- 2) Unplug the power supply and remove the computer system cover
- 3) Turn the switch of the grabber to a unique number for every board
- 4) Carefully align the frame grabber's connectors and press firmly
- 5) Secure the card(s) on the slot with the screw
- 6) Replace the computer system's cover
- 7) Restart the computer system
- 8) Log on to Windows using the administrator account

#### 5.4.3.2 Installation of the XRD-FGX Opto on Windows®XP, Windows®2000

- 1) After LOG ON the Hardware Wizard notice the new frame grabber as an multimedia device
- 2) Plug in the XIS Installation CD-ROM
- 3) Follow the hardware wizard to install the **XRD-FGX Opto** as a new device
- 4) After installation of the **XRD-FGX Opto** and XISL drivers by the Wizard start the XIS setup from the appearing menu or if the Setup does not start automatically start the START.EXE in the root directory of the CD
- 5) The XIS SETUP program will lead you through the installation process
- 6) Restart the computer system
- 7) The XIS is now ready to start
- 8) If the initialization of the frame grabber and the detector is successful if a corresponding message appears in the status bar.

## 5.5 X-Ray Imaging Software Library (XISL)

The X-Ray Imaging Software Library (XISL) allows implementation and use of all required detector functions into specific image processing software programs. The list below describes a selection of important routines. The routines can be easily integrated in any modular programmed software. Their specific use is described in the on-line help of the XIS program and the XIS Reference Book.

Command Module	Explanation
Acquisition_Init	Routine for general initialization of an XRD and Frame Grabber.
Acquisition_EnumSensors	Enumerates all connected sensors
Acquisition_GetNextSensor	Iterates through all recognized sensors.
Acquisition_Define_DestBuffers	Definition of the required destination buffers for image capturing.
Acquisition_Acquire_Image_Ex	General routine to acquire images from the detector.
Acquisition_Abort	Stops image acquisition.
Acquisition_Close	Frees all resources allocated for image acquisition.
Acquisition_Acquire_OffsetImage	Allows acquisition of an Offset image for a specific or for all available frame times.
Acquisition_Acquire_GainImage	Allows acquisition of a specific Gain image for a chosen frame time.
Acquisition_DoOffsetCorrection	Routine corrects an image automatically with the actual Offset image.
Acquisition_DoOffsetGainCorrection_Ex	Routine corrects an image automatically with the actual Gain image.
Acquisition_DoPixelCorrection	Routine for an automatic pixel-wise mean correction with the loaded PxlMask map.
Acquisition_LoadPixelMap	Load the map of defective pixels for Median correction.
Acquisition_CreateGainMap	Create a List of Median values for the Multiple Gain-Correction
Acquisition_IsAcquiringData	Checks if sensor is about to acquire images.
Acquisition_GetIntTime	Routine to detect the actual frame time automatically.
Acquisition_SetReady	Informs the XISL that image drawing is ready. If not ready a warning message is generated by XISL.
Acquisition_GetReady	Informs the user if image drawing is ready.
Acquisition_GetErrorCode	If any of the XISL function returns with an error, extended information can be obtained.
Acquisition_GetConfiguration	Retrieves the current configuration setting of the XISL.
Acquisition_SetCameraMode	Allows setting of detector frame time. (not available for all detectors)
Acquisition_SetCameraGain	Allows setting of detector sensitivity.
Acquisition_SetFrameSyncMode	This function sets the synchronization mode of the frame grabber and detector
Acquisition_GetWinHandle	Returns the currently set acquisition window handle (mostly main window).
Acquisition_GetActFrames	Current acquisition frame.
Acquisition_GetAcqType	Returns the currently used acquisition mode (single image, sequence, continuous, average and so on).
Acquisition_SetCorrData_Ex	This function switches the correction buffers during a running acquisition.
Acquisition_GetCorrData_Ex	This function retrieves the correction buffers during a running acquisition



Acquisition_SetCameraBinningMode	set binning Mode
Acquisition_GetCameraBinningMode	Retrieve actual binning Mode.
Acquisition_ResetFrameCnt	Reset detector Frame counter (not for all detectors)
Acquisition_GetHwHeaderInfoEx	Acquire Header and Extended Header if available
Acquisition_GetLatestFrameHeader	Retrieve Last Frame Header and Extended Header if available

**Table 18** List of XISL modules

### 5.5.1 Description of file header

The file header allows the use of specific information which can be implemented into any software.

Information	Description
File header	68 byte
WORD FileType	File ID (0x700)
WORD HeaderSize	Size of this file header in bytes
WORD HeaderVersion	yy.y
ULONG FileSize	Size of the whole file in bytes
WORD ImageHeaderSize	Size of the image header in bytes
WORD ULX, ULY, BRX, BRY	bounding rectangle of the image
WORD NrOfFrames	Number of Frames
WORD Correction	0 = none, 1 = Offset, 2 = Offset+Gain
Double IntegrationTime	frame time in microseconds
WORD TypeOfNumbers	frame time in milliseconds
WORD TypeOfNumbers	short, long integer, float, signed/unsigned, inverted, fault map, Offset/Gain correction data, badpixel correction data
BYTE x[WINRESTSIZE]	fill up to 68 byte

**Table 19** File header description

### 5.5.2 Interrupt sources

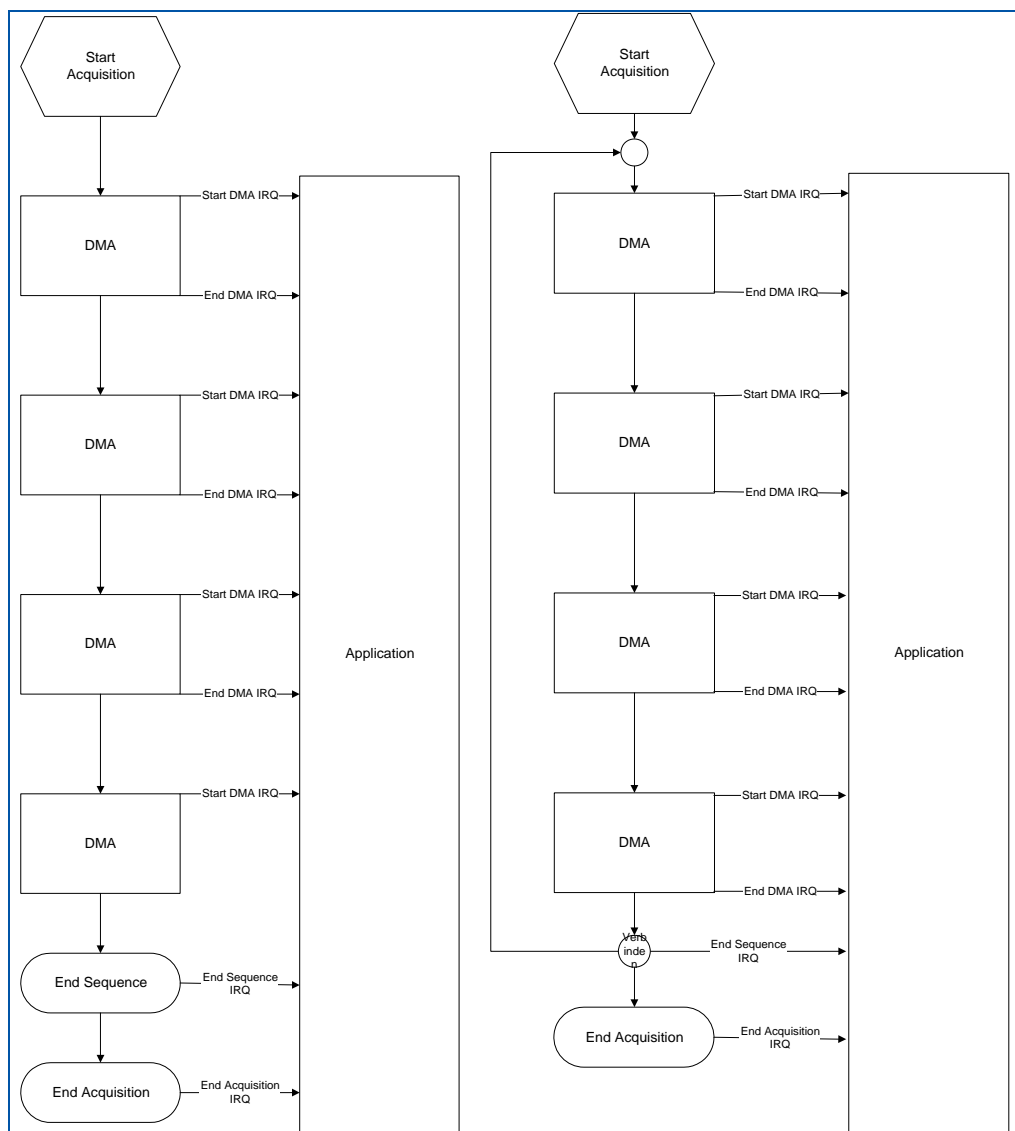
Interrupts allow the application to wait passively for changes in the acquisition status of the hardware.

There are four interrupt sources:

- start of DMA
- end of DMA
- end of sequence
- end of acquisition

These interrupts occur if the acquisition status changes to allow the application to react.

The acquisition mode (Continuous, Single Shot, Sequence) influences the data flow and therefore the acquisition status. The following diagrams illustrate the data flow and the corresponding interrupts.



**Figure 9 The Interrupt sources at a) sequence (4 frames) and b) continuous acquisition mode**

After the application has begun the acquisition, one interrupt is created by the beginning of DMA (start DMA interrupt). If the whole frame data is transferred the end of DMA interrupt is signalled. Both interrupts show the same behaviour in all acquisition modes. If the end of DMA buffer is full, the resulting action depends on the acquisition mode. In sequence or single shot acquisition mode an end of sequence interrupt occurs and then an end of acquisition interrupt is created. In continuous acquisition mode an end of sequence interrupt is created and the data transfer is continuous at start of DMA buffer. If the acquisition is cancelled an end of acquisition interrupt is signalled. If interrupts are enabled the end of frame, end of sequence and the end of acquisition interrupts are used.

### 5.5.3 Sorting schemes overview

The XISL sorts the data in an internal buffer with highly optimized routines written in machine code. Figure 10 shows the read out scheme of the **XRD 1621** sensor.

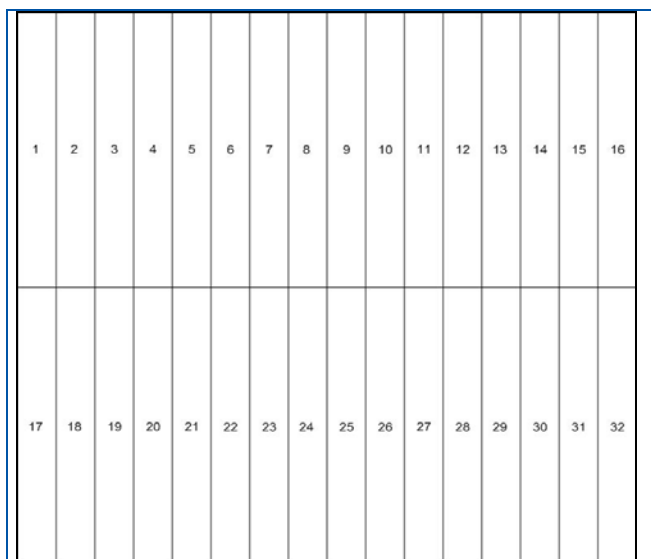


Figure 10 Sorting scheme of the **XRD 1621**

The sensor is divided into an upper and a lower part. Both sections are electrically separated. The data of each section is transferred by 32 "read out groups" (ROG). Each ROG has 128 channels for the detector. The upper groups scan the sensor columns from left to right. The lower groups scan from right to left. The upper groups are transferred first, followed by the lower groups. The upper groups start read out from the upper row. The lower groups start read out from the last row.

The following Table 20 displays the data stream for **XRD 1621**:

data stream no.	sensor pixel (row, column)	ROG no.
1	(1,1)	1
2	(1,129)	2
3	(1,257)	3
4	(1,385)	4
5	(1,513)	5
6	...	
15	(1,1793)	15
16	(1,1921)	16
17	(2048, 128)	18
18	(2048, 256)	17
19	(2048, 384)	20
20	(2048, 512)	19
...	...	...

Table 20 Sorting scheme of the **XRD 1621**

## 6 Operational Functions

### 6.1 Getting Started - The first image

#### 6.1.1 Introduction

This chapter describes the procedures to obtain initial x-ray images with adequate quality. It explains how correction files are used with appropriate settings of the detector integration time and x-ray source parameters. In this example the Demo Software XIS is used to describe the mechanism. The XIS is intended to be used for demonstration purposes only and should not be used as standard software detector operation. Detailed information about the XIS and the XISL are provided in the XIS-Reference Book.

#### 6.1.2 General considerations

In principal the detector can produce images without any correction. These images contain the offset of the readout electronics, the individual offsets of each pixel (dark current) as well as the electronics and pixel gain differences, apart from the x-ray source non-uniformities.

Each column is connected to one channel of the readout electronics with the specific channel offset resulting in a dark image with vertical stripes caused by the individual channel offsets. The dark image may also contain pixels which are brighter than the others caused by a higher dark current. The detector is arranged in groups of 128 readout channels. The groups can deviate in their gain such that one can distinguish blocks of 128 channels in a bright image caused by this gain difference. The panel itself may contain pixels and perhaps row or columns which are underperforming.

To eliminate these detector specific effects and obtain good quality results, each image will be 'offset' and 'gain' corrected, and if required, the underperforming pixels will also be corrected. The creation of the correction files is described in the chapter 'How to perform corrections'.

#### 6.1.3 Connection of the XRD 1621

Before starting the connection of the **XRD 1621** ensure that the optical frame grabber and the software are installed as described in the chapter 5.4.3. If not please begin with the frame grabber and software installation.

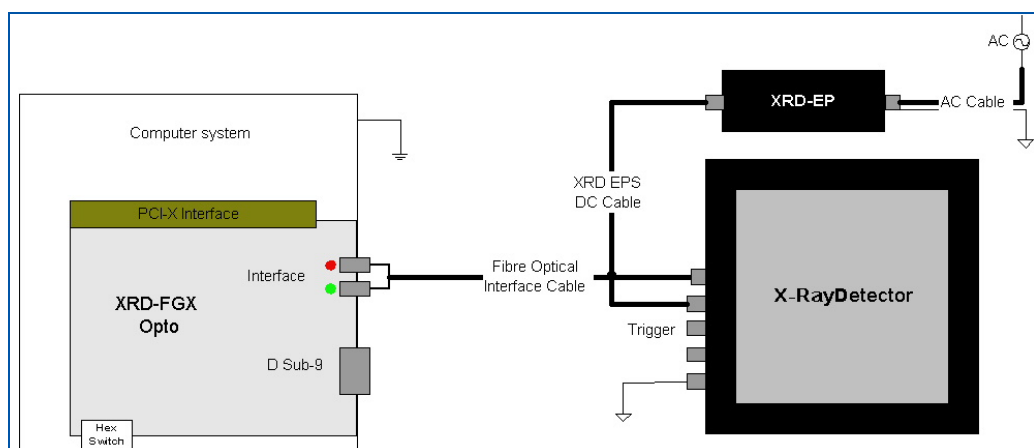


Figure 11 Connections of the XRD 1621

The computer with the frame grabber and the monitor need to be grounded through the protection earth conductors within the power cords. The required potential equalization of the **XRD 1621** and the **XRD-EP** power supply has to be managed through the labelled connectors and the potential equalization between both devices is managed through the **XRD-EPS DC Cable**. For safety reasons only original cables and connectors should be used. The **XRD 1621** should be connected as described in the following manner and as shown in Figure 11.

- 1) Shut down the computer
- 2) Connect the **XRD 1621** and the **XRD-EP** with the potential equalization
- 3) Connect the **Frame Grabber** and the **XRD 1621** via **Fibre Optical Interface Cable**

- 4) Connect the **XRD EPS DC Cable** with the Power Connector of the **XRD 1621**
- 5) Connect the **XRD-EP** with the power supply via **AC Cable**
- 6) Switch on the **XRD-EP**
- 7) Switch on the Computer

#### 6.1.4 The first image

The detector is powered on and all cables connected. At startup the frame grabber board will be initialized and afterwards a dialog box is displayed in order to select the mode of the frame grabber board. "Yes" enables the Interrupt Mode and "No" the Polling Mode. In both cases the system attempts to initialize the frame grabber board(s) and the detector. The "Cancel" button starts the program without initialization. The initialization can take some time depending on the number of frame grabber boards and detectors. If more than one detector is connected a dialog box is displayed containing a list of all recognized detectors. An active detector has to be selected, and all following actions will correspond to the active detector. The system is now ready to acquire the first image.

The Acquire\Single Shot command acquires a single image. If the detector was not irradiated only a dark image is displayed. The image can be enhanced by the brightness and contrast settings. As explained above, the uncorrected dark image contains vertical stripes caused by the electronics offset. By choosing the Continuous acquisition mode the image is refreshed on the display in the selected frame rate.

In the next step the detector should run in the continuous mode and the x-ray source should be switched on to irradiate the detector. The brightness and contrast should be set to default (F2-KEY: 0-65535). If a grey image is displayed, the parameters of the x-ray source and detector are within appropriate limits. If a white or a black image is displayed the x-ray source needs to be adjusted accordingly.

## 6.2 How to perform corrections

The **X-Ray Detector** works as an independent detector to acquire X-ray images. After starting the XIS.EXE software, the detector is automatically initialized and provides images in the fastest setting (TIMING 0) (Timings menu: list of possible frame times).

The X-Ray Detectors need an Offset correction to account for the dark current of each pixel. In particular, during the warm-up phase of the detector, the Offset correction should be repeated periodically. Periodic refresh of the Offset correction is **required** during operation in order to meet the full performance specifications.

Additionally, a Gain correction is required to homogenize differences in pixel sensitivities and to take into account the X-ray beam illumination. It is therefore very important that the whole image area is illuminated homogeneously. The Gain correction images should be applied under optimum dynamic range (70-80 % of the full scale range FSR) and in the dynamic ranges of interest. It is possible to use up to 10 different gain images.

The radiation intensity used to create the gain images can depend on the application, e.g. if the typical grey level is between 5.000ADU and 10.000 ADU and the remaining area is saturated, it is recommended to use gain images created at 5.000 ADU, 10.000 ADU and 45.000 ADU. The use of an Offset corrected Gain calibration eliminates offset dependency and therefore any stored Gain correction can be used for a specific frame time for longer time periods.

The Pixel correction allows a 'software repair' of underperforming pixels to enhance image quality. Underperforming pixel values are replaced with the averaged value of the surrounding eight adjacent pixels where underperforming pixels are not used. The pixel correction is only performed on specific pixels, mapped in the file PXMLMASK.HIS. Each detector is shipped from PerkinElmer with the PXMLMASK.HIS file for that specific detector. The user can also generate a correction file.

**Note:** To fully meet all performance specifications, all corrections and the correction files must be acquired at the same readout mode, gain setting integration time and X-Ray setting (e.g. energy and prefilter) as the images to be corrected

### 6.2.1 Use of the Offset Correction

The offset correction of images should be used to eliminate the effects of pixel dark currents on the acquired image.

To obtain an Offset correction file the following steps are required:

- 1) Select the desired integration time, readout mode and gain setting.
- 2) Switch off the X-ray source so that the detector only transfers its "dark image".
- 3) Wait a few seconds until the detector archives an equilibrium.
- 4) Start the Get Offset Image. / Start All Offset Images.
- 5) Select a number of frames.  
It is recommended to use between 20 to 100 frame cycles which will be averaged.  
The averaged image is qualified as the new Offset Image of the selected frame time and automatically linked to later acquired images.
- 6) Control the new acquired image using the Options/View command and/or Brightness, Contrast or LUT range.
- 7) The Offset correction file can be saved if desired.  
**Note:** A warning appears if the program is quit without saving new acquired Offset correction files.

The Offset correction should be repeated periodically in order to meet the full performance specifications. In particular during the warming-up period of the system, the dark current of the pixels may change considerably.

To interrupt the procedure the <ESC> key can be used.

**NOTE:** If the item **Get All Offset Images** is used, step 4 is automatically performed for all available frame times. Please check the total time necessary before selecting the number of frames to avoid longer waiting periods.

### 6.2.2 Use of Single/Multiple Gain Correction

The Gain Correction is used to eliminate the effects of pixel sensitivities and the X-ray source on the acquired image.

To obtain a Multiple Gain Correction file the following steps are required:

- 1) Select the desired integration time, readout mode and gain setting
- 2) Acquire a new Offset correction image.
- 3) Switch on the X-Ray source and adjust the brightness of the acquired image in the desired read out settings. The detector's acquired intensity should be in the dynamic range of the ROI. The whole image should be illuminated homogeneously.
- 4) Start the Acquire Sequence
- 5) Select a number of frames and the average mode.  
20 to 100 frame cycles should be used which will be averaged.
- 6) Adjust the new acquired image by using the Options/View command and/or Brightness, Contrast or LUT range.
- 7) Store the Offset corrected bright image
- 8) For Multiple Gain Correction repeat the steps 3-7 for each intensity of interest. Up to 10 gain images can be used for the MGC.
- 9) Create a Gain –Sequence with Acquire=>Build Gain Sequence
- 10) Start a new acquisition.
- 11) Link the created Gain-Sequence file with Acquire=>Link Gain Sequence
- 12) Store the Offset correction file if desired.  
**Note:** A warning appears if the program is quit without saving new acquired Offset correction files.

### 6.2.3 Use and generation of the Pixel Correction

The Pixel Correction of images is used to eliminate the effects of underperforming pixels of the detector on acquired images.

To get a Pixel correction file the following steps have to be performed:

- 1) Select the desired frame time (see Timings menu).
- 2) Link correction files.
- 3) Switch on the X-ray source and in the continuous mode, adjust the brightness of the acquired image. The detector's acquired intensity should be between 70-80 % of its maximum signal.
- 4) Start an image acquisition as for the Get Gain/Offset Image (no sample in front of the detector).
- 5) Adjust the new acquired image by using the Options/View command and/or Brightness, Contrast or LUT range.
- 6) The window should show an homogenous corrected image. Intensity deviations are the result of marginal pixels.
- 7) Adjust the x-ray source such that the detector's acquired intensity should be about 50 % of its maximum signal.
- 8) Go to Select by Value in the Edit Menu.
- 9) Enter desired range of good pixels (e.g. 15000-45000 out of 0-65535)
- 10) Select "Out of range" button. (All selected pixels are marked.)
- 11) Call Create Pixel Map in the Edit Menu.
- 12) The Pixel Map is created and can be stored as new PXMLMASK.HIS.

**NOTE:** The new PXMLMASK.HIS is automatically linked to new acquisitions and the acquired start-up image (see 4.) is also corrected.

### 6.2.4 Correct previously acquired images

It is possible to correct previously acquired uncorrected images by selecting the desired image by the Window Command and use one of the Link Commands (Link Offset Correction, Link Gain Correction or Link Pixel Correction). The active image is automatically corrected.

These settings are also used for the next acquisitions.

**NOTE:** It is not recommended to close linked correction files during a running acquisition. This can cause the application to close.

## 6.3 How to RUN the Detector

### 6.3.1 Free Running

Eight different frame times are available and the detector automatically starts in the first free running timing (Timing 0) which is the fastest readout time. This means that the detector needs a minimum of 133.2 ms (ES 66.5 ms @ 400 $\mu$ m) for one frame (ES-Version: 66.7ms @ 200 $\mu$ m and 33.5ms @ 400 $\mu$ m). Each pixel is readout every 133.2 ms and during this time the pixel integrates radiation. For details of the readout scheme see the chapter Sorting. The structure of higher timings is a first readout using the slowest readout time and a following delay. To realize delay using the fastest readout, use the internal trigger mode with a frame time of the selected timing plus the delay time.

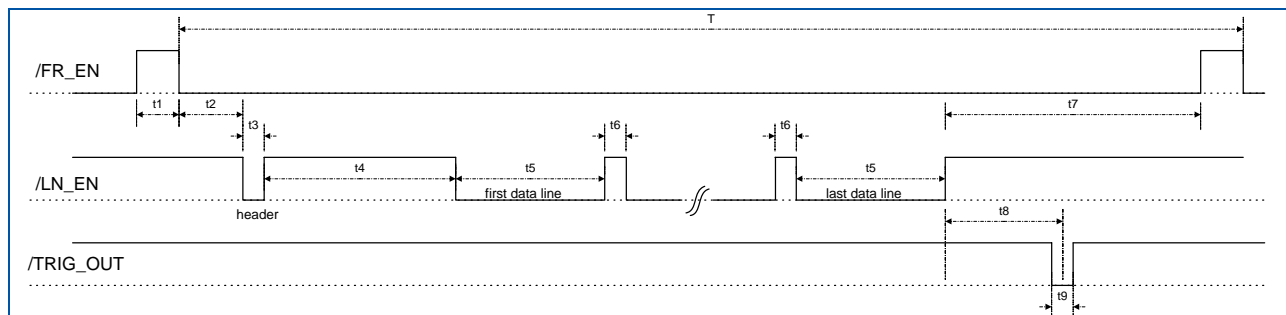


Figure 12 General timing diagram in continuous mode

### 6.3.2 Trigger Modes

If a pulsed x-ray source is used exposure should occur during the delay of the detector since the x-ray pulse appears during the readout time the information is split into two frames. In addition if these frames are summarized there could be artefacts which are not correctable. In order to expose during the delay the detector allows triggering of the x-ray source and the detector itself.

#### 6.3.2.1 External Trigger

Triggering the detector attempts to synchronise the detector to other devices e.g. x-ray sources having specific schemes of radiating x-ray pulses. The current mode is triggering the detector on a frame basis, meaning the detector sends a frame after triggering by an external pulse and ignores all other incoming pulses until the selected frame time has elapsed. After that the detector can be triggered by a new pulse.

In order to trigger the detector a 20  $\mu$ s wide low active trigger pulse (LVDS-signal) has to be transmitted to the device. The trigger signal has to be generated externally and can then be connected to the 7-pin round connector, (/TRIG\_IN) located directly at the detector device, or connected to the D sub-9 located on the rear side of the frame grabber. Trigger pulses are accepted from both sources. Prior to this the detector has to be set by command into the external trigger mode. The waveform of the trigger pulse as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** describes the triggering mode on a frame by frame basis. The period of the trigger waveform determines the integration time. The /TRIG\_OUT signal with a pulse width of 62.5 ns indicates the start of a new frame and can be used to synchronise the x-ray source.

#### 6.3.2.2 Internal Trigger

The internal trigger mode works in the same way as the external trigger mode, and also triggers the detector on a frame by frame basis. This means that the detector sends a frame after triggering by an external pulse and ignores all other incoming pulses until the selected frame time has elapsed. After that the detector can be triggered by a new pulse. The trigger pulse is supported by the frame grabber and is a fixed pulse with frequency of between the fastest free running mode of the detector and 5 seconds, in steps of 1 $\mu$ s. The frame grabber sends the RS422 signal /FR\_SYNC over the optical interface to the detector. The /TRIG\_OUT signal with a pulse width of 62.5 ns indicates the start of a new frame and can be used to synchronise the x-ray source.



### 6.3.2.3 Frame-wise (default)

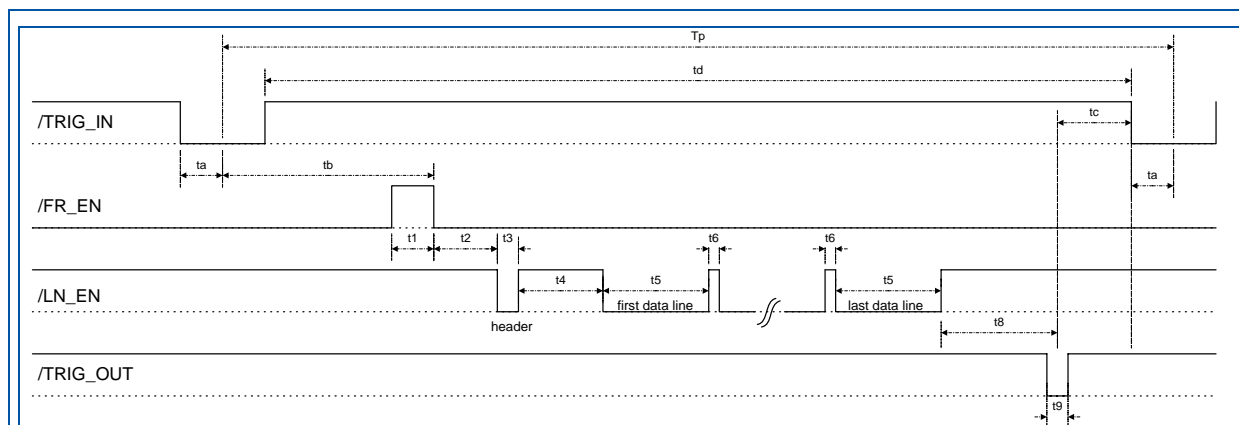


Figure 13: General timing diagram in frame-wise triggered mode

This is the most general trigger mode. Once the detector has been set to trigger mode the detector will synchronize to trigger events and perform a complete detector scan and transmit one image. This is a frame wise trigger mode which allows the operator to take control of the integration time of the detector. Trigger events during the scan process are ignored. Thus the shortest possible integration is equivalent to the integration time of the fastest mode in free running.

### 6.3.2.4 Data Delivered on Demand (D<sup>3</sup>) triggered mode<sup>1</sup>

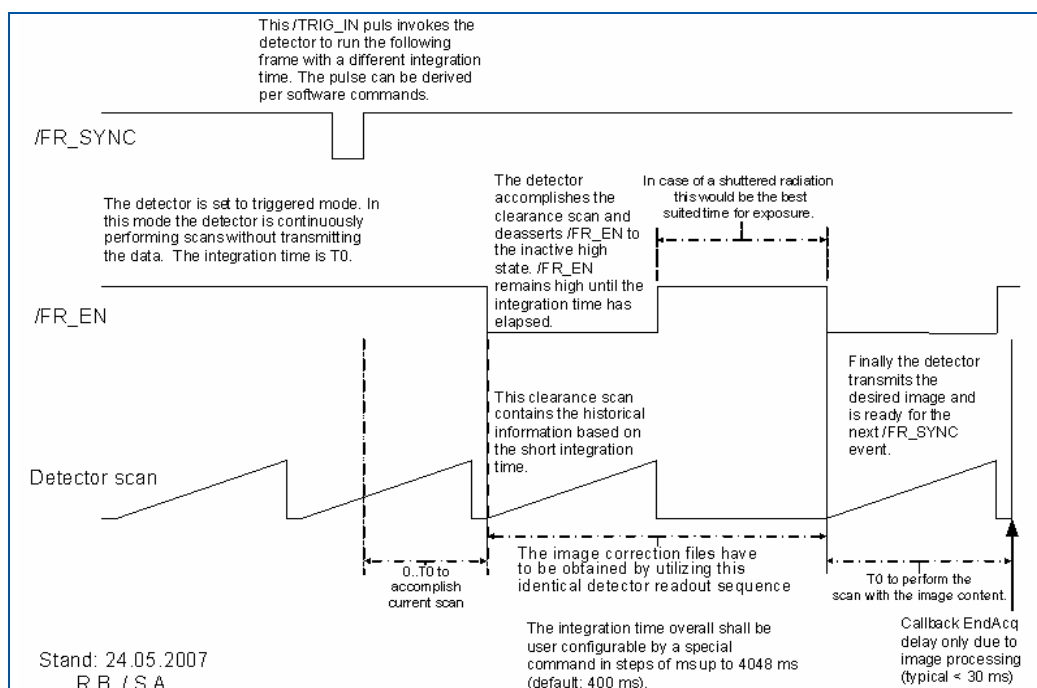


Figure 14: timing diagram for 'Data Delivered on Demand' triggered mode

The detector is running in a "silent" mode, like free running mode but without transferring image data. If the user application (Software, Frame Grabber or external Source) sends a triggers signal to the detector, the detector accomplishes the current frame. The next frame is processed also with the fastest integration time and a delay time appears which is the best time suited for

<sup>1</sup> Trigger with DDD mode is available for detectors with HeaderID 14 and CameraType 2

exposure in case of pulsed or shuttered radiation. After this delay the detector performs the image scan and transfers the desired data. After this the detector returns to the silent mode until the next trigger pulse is sent.

### 6.3.3 How to use the internal trigger mode

The following method describes how the internal trigger can be used to implement different integration times or to use one of the readout schemes with a customized delay. The detector starts in the first timing and in free running mode when the power switched on and the Interface Bus is connected. To use the internal trigger mode the following steps are required:

- 1) The detector is set to the desired readout time using the Timings menu  
*XISL: Acquisition\_SetCameraMode(hAcqDesc, 0..7)*  
 -> The detector runs continuously (free running) in the desired timing and readout scheme.
- 2) The detector is set to the internal trigger mode using the Detector Mode menu  
*XISL: Acquisition\_SetFrameSyncMode(hAcqDesc, HIS\_SYNCMODE\_INTERNAL\_TIMER).*  
 -> The detector aborts the current frame and waits for a trigger signal.  
 -> The shortest repeat time of an trigger pulse is the selected timing (readout time).
- 3) Select the frame rate (readout plus delay time) in the appearing dialog (readout time ... 5s)  
*XISL: Acquisition\_SetTimerSync(hAcqDesc, frame\_rate).*
- 4) The frame grabber sends the /FR\_SYNC signal directly via the optical Interface to the detector in the selected frame rate.  
 -> The detector runs "continuously" with the selected frame rate.
- 5) Start the acquisition  
*XISL: Acquisition\_AquireImage(hAcqDesc, frames, ...)*  
 -> The frame grabber places the data into the memory.

### 6.4 How to use the detector gain setting

This paragraph describes how to change the detector gain setting. The XRD 1621 AN detector supports up to 6 different gain settings (Table 21). The detector is starting with the 1pF capacity when it is powered on. The detector gain will be set bitwise by the **XIS** dialog **Options/Detector Options** or by the library function *Acquisition\_SetCameraGain(hAcqDesc, 0..5)*. The Table 21 will give an overview of the different gain settings. It is very important for the image quality that the correction files were obtained in the same gain setting as in the current working operating mode.

Selected Value	Capacity
0	0.25
1	0.5 pF
2	1 pF
3	2 pF
4	4 pF
5	8 pF

**Table 21** Overview of the six Detector Gain Settings

## 6.5 How to use the detector binning setting

This paragraph describes the change of the detector binning modes. The **XRD 1621 detector series supports** different binning modes. When the detector is powered on it runs without binning (default mode). The detector binning will be set by the **XIS** dialog **Options/Detector Options** or by the library function `Acquisition_SetCameraBinningMode(..)`. The following table describes the different binning modes. It is very important for the image quality that the correction files are obtained in the same binning mode, gain setting and integration time as for the measurements.

Selected Value Bit	Binning mode
0	No binning
1	2 x 2 binning
8	Averaged binning
9	Accumulated binning

Table 22: Overview of the detector binning modes

## 6.6 Maintenance

In principle the detector assembly is maintenance-free.

However it is important that all correction files are regularly updated and used for image processing. In some applications it is advantageous to update the offset correction file directly before each image.

Although the a-Si detectors are resistant to x-rays they can exhibit degradation over time when exposed to high X-Ray dose environments. Sensitivity and uniformity may change depending on the weekly exposure duration and X-Ray dose. Therefore the pixel correction files should be checked and compared regularly to determine changes in underperforming pixels and clusters.

## 6.7 Disposal

This label on the product and its literature indicates that it should not be disposed with other waste at the end of its working life. To prevent possible harm to the environment or human health from uncontrolled waste disposal, please separate this from other types of waste and recycle it responsibly to promote the sustainable reuse of material resources.

Please contact your supplier or distributor and check the terms of conditions of the purchase contract. This product should not mix with other commercial wastes for disposal.



## 7 After-Sales Service for PerkinElmer Products

Please contact your distributor for after-sales service (including warranty conditions) or any other information. In case information is not available, please contact one PerkinElmer Optoelectronics subsidiaries (regional service headquarters) listed below.

For product returns, please contact your distributor or PerkinElmer Optoelectronics for shipping and packaging instructions. Please do not return product to PerkinElmer Optoelectronics for repair without advance notification.

## 8 Guidance and Manufacturer's Declaration

Guidance and Manufacturer's Declaration of Electromagnetic Emissions		
The X-Ray Detector is intended for use in the electromagnetic environment specified below. The customer or the user of the X-Ray Detector should assure that it is used in such an environment.		
Emissions test	Compliance	Electromagnetic Environment – Guidance
RF-emissions CISPR 11	Group 1	The X-Ray Detector uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF-emissions CISPR 11	Class B	
Harmonic emissions IEC 61000-3-2	Class A	


**Table 23** Guidance and Manufacturer's Declaration of Electromagnetic Emissions

Guidance and Manufacturer's Declaration of Electromagnetic Immunity			
The X-Ray Detector is intended for use in the electromagnetic environment specified below. The customer or the user of the X-Ray Detector should assure that it is used in such an environment.			
Immunity Test	IEC 60601 Test	Compliance	Electromagnetic Environment – Guidance
Electrostatic Discharge (ESD) IEC 61000-4-2	Contact: 6 kV Air: 8 kV	Contact: 6 kV Air: 8 kV	Floors should be made of wood, concrete, or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transients (Burst) IEC 61000-4-4	0.5 kV (AC) 1kV (DC)	0.5 kV (AC) 1kV (DC)	Mains power quality should be that of a typical commercial and/or hospital environment.
Transients-Surges IEC 61000-4-5	1 kV / 2 kV	1 kV / 2 kV	Mains power quality should be that of a typical commercial and/or hospital environment.
Power frequency magnetic field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial and/or hospital environment.
Voltage dips and short interruptions IEC 61000-4-11	-95% / 10 ms -60% / 100 ms -30% / 500 ms >-95% / 5000 ms	-95% / 10 ms -60% / 100 ms -30% / 500ms >-95% / 5000 ms	Mains power quality should be that of a typical commercial or hospital environment. If the user of the X-Ray Detector requires continued operation during power mains interruptions, it is recommended that the X-Ray Detector be powered from an uninterruptible power supply or battery.

**Table 24** Guidance and Manufacturer's Declaration of Electromagnetic Immunity

Recommended Separation Distance between Portable and Mobile RF-Communication Equipment and the X-Ray Detector			
The X-Ray Detector is intended for use in the electromagnetic environment specified below. The customer or the user of the X-Ray Detector should assure that it is used in such an environment.			
Rated Maximum Output Power of the Transmitter (W)	150 kHz to 80 MHz	80 MHz to 800 MHz	800 MHz to 2.5 GHz
	$d = \frac{3.5}{V_1} \sqrt{P}$	$d = \frac{3.5}{E_1} \sqrt{P}$	$d = \frac{7}{E_1} \sqrt{P}$
0,01	0.12	0.12	0.23
0,1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23
For transmitter rated at a maximum output power not listed above, the separation distance can be estimated using the equation in the corresponding column, where P is the maximum output (power rating of the transmitter in watt (W)) according to the transmitter manufacture and d as the recommended separation distance in meter (m).. Note: These guideline may not apply in all situations. Electromagnetic propagation is absorption and reflection from structures, objects, and people.			

**Table 25** Recommended Separation Distance between Portable and Mobile RF-Communication Equipment and the X-Ray Detector

Guidance and Manufacturer's Declaration of Electromagnetic Immunity			
The X-Ray Detector is intended for use in the electromagnetic environment specified below. The customer or the user of the X-Ray Detector should assure that it is used in such an environment.			
Immunity Test	IEC 60601 Test	Compliance	Electromagnetic Environment – Guidance
Conducted radio-frequency fields (CEF) IEC 61000-4-6	3 V 150 kHz to 80 MHz	[V <sub>1</sub> ] 3 V 150 kHz to 80 MHz	Portable and mobile RF-communication equipment should no closer to any part of the X-Ray Detector including the data cables, than the recommended separation distance calculated from the equation appropriate for the frequency of the transmitter  $d = \frac{3.5}{V_1} \sqrt{P}$ $d = \frac{3.5}{E_1} \sqrt{P}, \text{ for 80 MHz to 800 Mhz}$ $d = \frac{7}{E_1} \sqrt{P}, \text{ for 800 MHz to 2.5 Ghz}$ using P as the maximum output of the transmitter in watt (W) according to the transmitter manufacture and d as the recommended separation distance in meter (m). Field strengths outside the shielded location from fixed RF transmitters, as determined by an electromagnetic site survey <sup>a</sup> , should be less than 3 V/m. Interference may occur in the vicinity of equipment marked with the following symbol: 
Radiated electromagnetic field (REF) IEC 61000-4-3	3 V/m 80 MHz to 2.5 GHz	[E <sub>1</sub> ] 3 V/m 80 MHz to 2.5 GHz	
NOTE 1 These guidelines may not apply all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			
NOTE 2 It is essential that the actual shielding effectiveness and filter attenuation of the shielded location be verified to assure that they meet the minimum specification.			
<sup>a</sup> Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, armature radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the X-Ray Detector is used exceeds the applicable RF compliance level above, the XRD should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the X-Ray Detector.			

**Table 26 Guidance and Manufacturer's Declaration of Electromagnetic Immunity (Portable Equipment)**

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