PerkinElmer®

precisely.

XRD 1620 AN
X-Ray Detector
Reference Manual
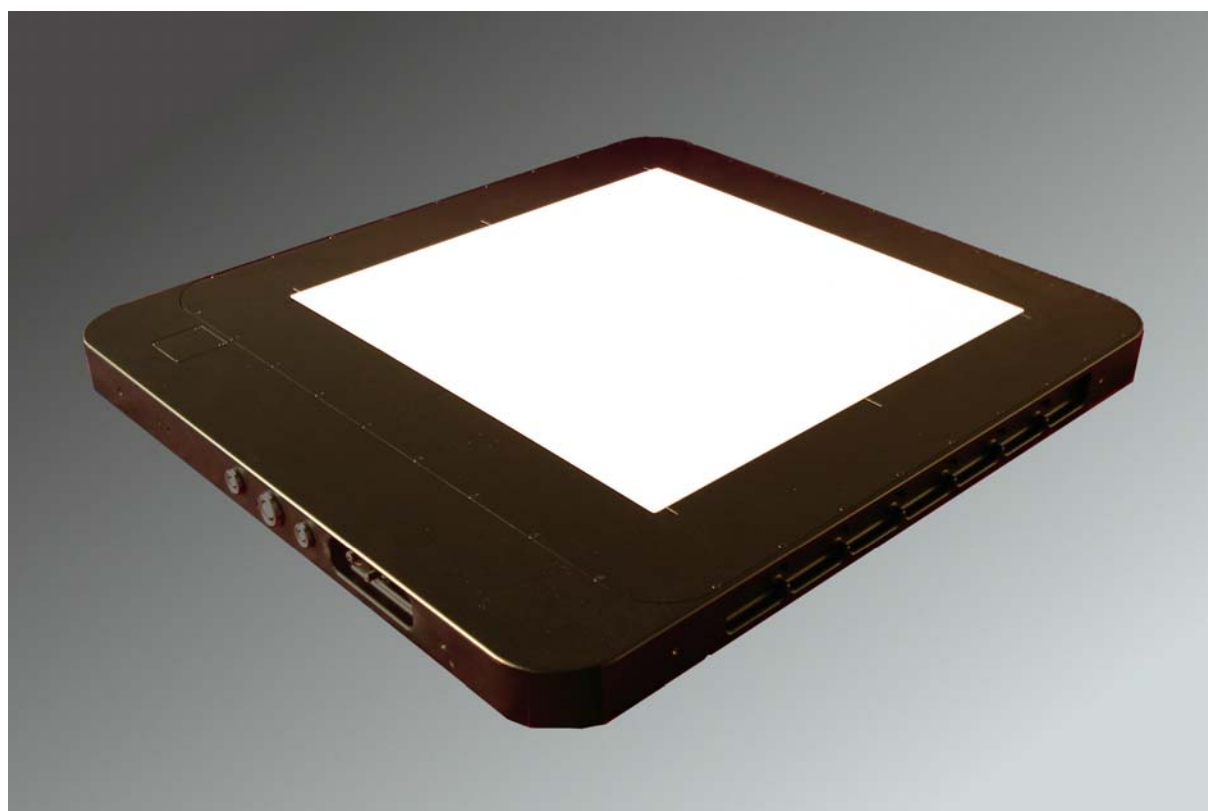
FOR YOUR SAFETY

Warning

➢ Read the manual and all accompanying papers carefully before operating the **XRD 1620** 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 labeled connectors at the and the **XRD-EP** power supply.

➢ To avoid electrical shock, plug the power cords into a properly wired receptacle <u>before</u> 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 32) 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 32). Using the X-Ray Detector or the power supply any longer may cause fire, electrical shock or other damage.

➢ Install the X-Ray Detector on a flat, stable surface. 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 1620**.
  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 1620**.

- ➢ 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 1620** 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 1620**, 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.

  o Thinner

  o Benzine

  o Abrasive cleaner

  o Wax

  o Acid or Alkaline solvent

  o Spray-type cleaner

Table of Contents

AS (Rev 1.2 / 95510862 / 2005-12-15) Specifications are subject to change without notice

List of Tables

1 Scope

This document describes design elements and respective interfaces. Where applicable mechanical, electronic, and software interfaces will be addressed

2 Regulatory Requirements

The assembly of the X-Ray Detector **XRD 1620** 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
INTERNATIONAL	
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)
EUROPEAN	
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[1]		Operation
Ambient temperature	0° to +50°C	0° to +45°C (CsJ)[2]	+15° to +35°C
Relative humidity[3]	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 6-10ms)		2g (duration 11ms)

Note: [1] In original transport container
[2] Temp. Gradient: max 4.5 K/hour
[3] No condensation

Table 2 Environnemental Considerations

4 Description of the XRD 1620

4.1 Principle of the XRD 1620

The detector **XRD 1620** 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 aluminum 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 1620** 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[®] 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 1620** 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 fiber optic taper or reducing lens.
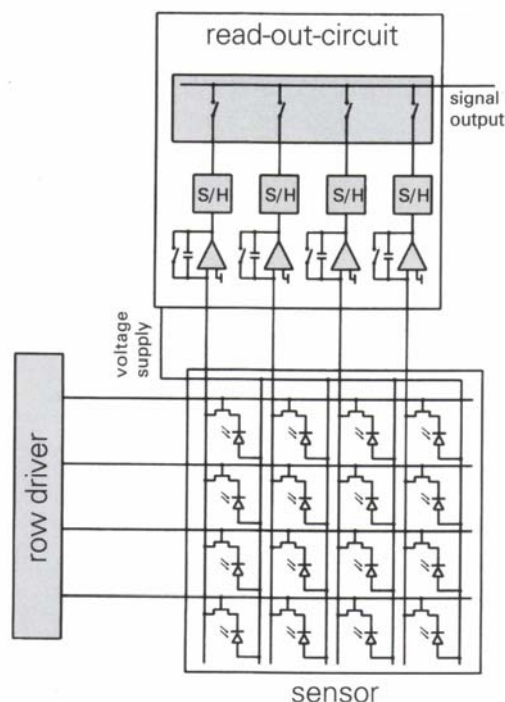
Fig. 1 Principle electronic arrangement of XRD 1620

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 analog 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 analog sections. The digital control is reprogrammable through a PROM to enable future upgrades or modifications.

4.3 Structure of the XRD 1620 AN
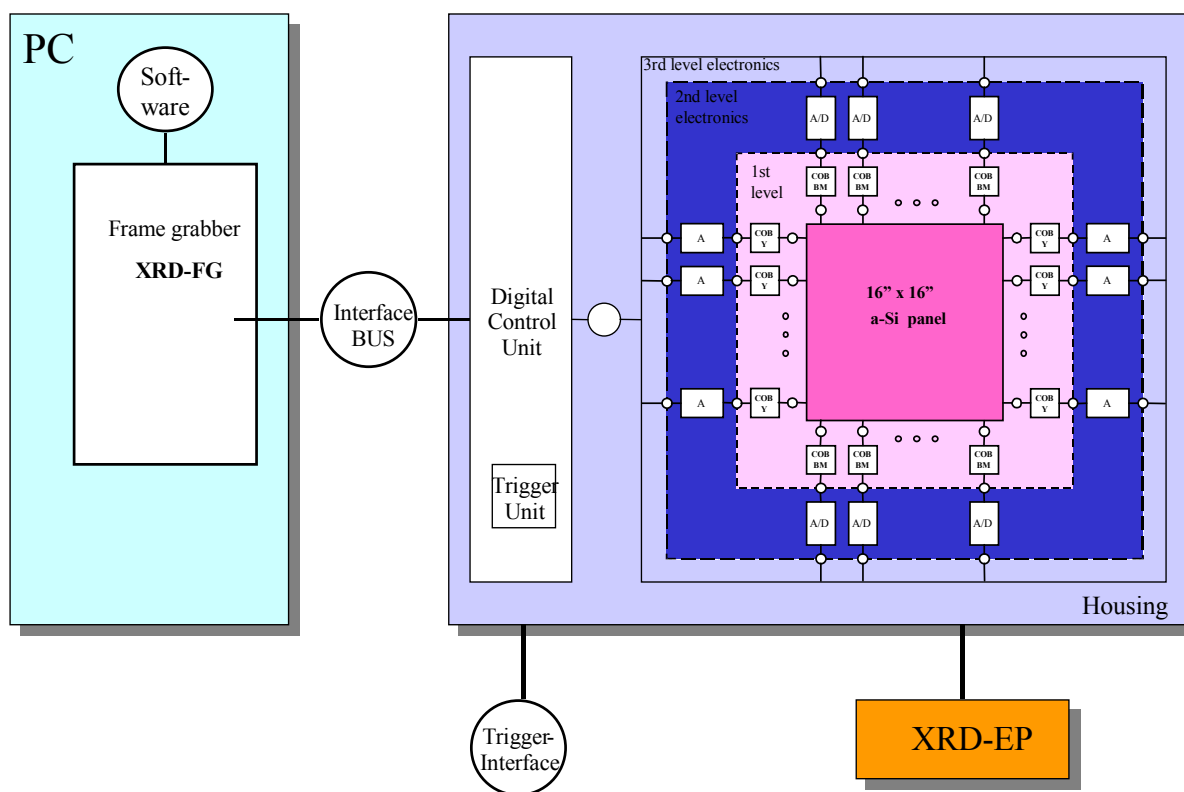
Fig. 2 Structure of the XRD 1620 AN

4.4 Detector Overview

Fig. 3 Detector Overview

1	Potential Equalization
2	Ground Connector
3	Trigger Input (page 7)
4	Power Input (page 3)
5	XRD Interface Bus
6	Detector Mode and Frame Rate (page 9)
	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 1620 Specification

5.1 Technical data of the XRD 1620

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>:   50-PIN mini delta ribbon female 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 fiber core (thickness 3 mm);
    Detector: single glass substrate;
    Contacts: heat sealing contacts (including bias voltages);
    Scintillator: Kodak™ LANEX® fast, LANEX® fine,
                                optional: CsI (Tl) needles directly deposited on the aSi photodiodes
                                A graphite sheet or a molybdenum plate protects the scintillator,
                                (active thickness of the protection is about 0.5 mm (0.9 mm AL3).
        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 center.
  Electronics :   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;
  Housing: aluminum profiles.
                                8 screw holes on the side of the imager
  Top plate: aluminum plate for protection of sensor/scintillator,
                                (Thickness 0.75 mm).
  Shielding   **No lead shielding** - The FOV (Field of view) of the detector is restricted to the maximum of 40,96 x 40,96 cm ² active area, otherwise electronics X-ray destruction might occur at any X-ray energy

  Table 4 Mechanical specification
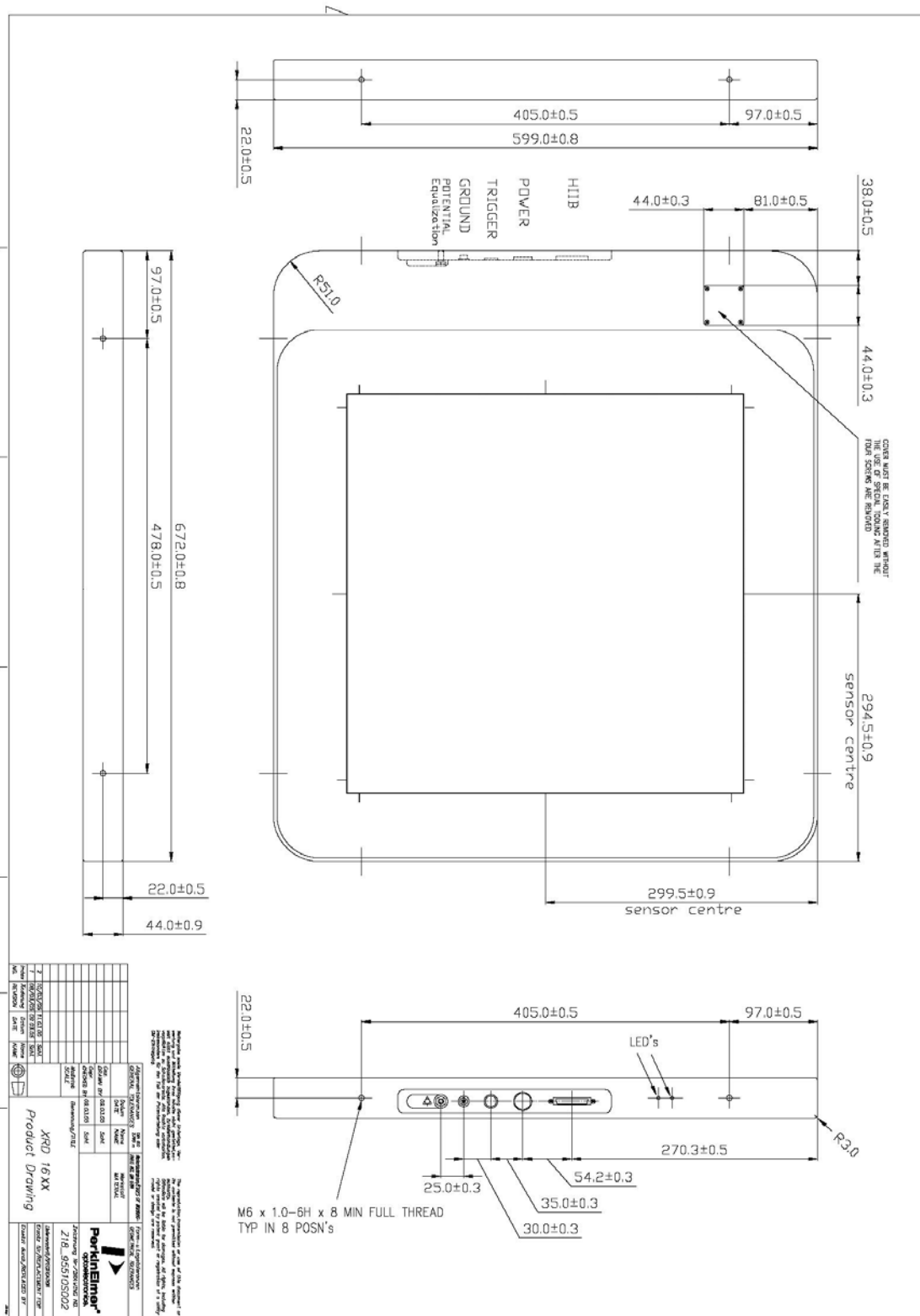
Fig. 4 Mechanical drawing of the XRD 1620 A

5.1.2 Readout Specification

Sensor:

Total pixel number	2048 x 2048
Active pixel number	2024 x 2024
Pitch	200 µm
Total area	409.6 x 409.6 mm²
Diode capacity	2.1 pF
Dark current	<1 pA/Pixel (10V)

For CsI Option (75 kVp, 20mm Al filtration, 7mm Al HVL):

MTF (0.5 lp/mm)	80% (typical 90%)
MTF (2.0 lp/mm)	30% (typical 38%)
DQE (0.5 lp/mm)	56% (typical 58%)
DQE (2.0 lp/mm)	28% (typical 37%)

Electronics:

Charge amplifier	32 x 128 channel ASIC
ADC	32 (16bit, 1 MSps)
Gain (e^-/ADU):	0.,5 pF, 1 pF, 2 pF, 4 pF, 8 pF
Integration time (minimum)	285.6 ms
Non-Linearity:	< 1 % (10 % to 90 % FSR))

Detector:

Protection Class	☐ - protection class II
Dynamic range	> 75 dB
Response Non-*Uniformity*	< ± 2 % (10 % to 90 % of FSR)
Image lag (standard)	< 8 % (1st frame
(CsI-option)	< 10 % (1st frame)
Maximum frame rate	3.5 fps
Scintillator	Lanex® fast, Lanex® fine
Optional	CsI (Tl) (direct deposition on aSi photodiodes)
Radiation energy	40 keV – 15 MeV

Table 5 Readout Specification accomplished at Timing 0 and 1pF

5.1.3 Connectors of the XRD 1620 AN

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	Connection
1	TRIGIN_+
2	TRIGOUT_+
3	TRIG_IN-
4	TRIGOUT_-
5	FGND
6	5PF
7	

Table 6 PIN assignment of Trigger signal (LVDS Signals)

Fig. 5 Drawing of the connectors for Power and Trigger (front view)
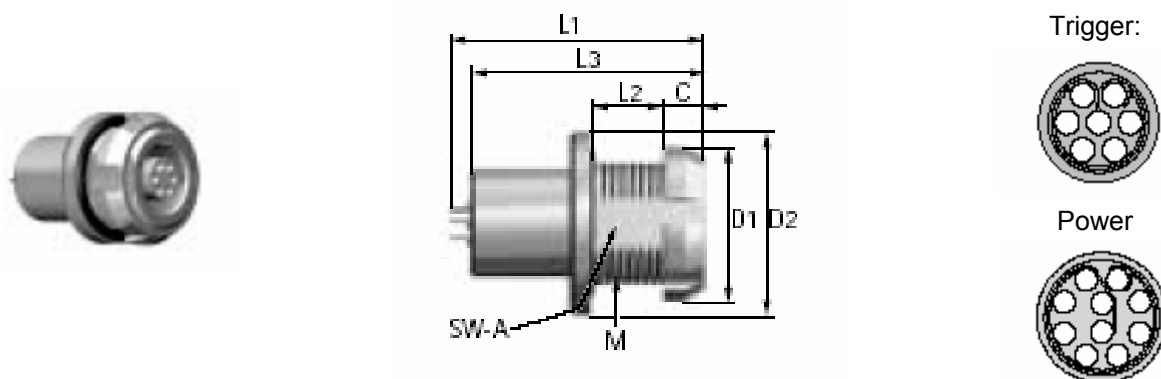
Type of Plug	L1	L2	L3	M	D1	D2	C
Trigger	26	4	22.5	14x1	18	4	12
Power	33	6	26.5	20x1	25	26	6

5.1.4   Accessories

On safety reasons the **XRD 1620** 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 behavior of the detector system.

PerkinElmer Art. No.	Description
95510214	PCI Frame Grabber XRD-FG
95510225	Interface Cable 100FT / 30.5M
95510227	Interface Cable 50FT / 15.25M
95510228	Interface Cable 25FT/ 7.6Mt
95510590	XRD-DETEKTOR TRIGGERKABEL 25FT / 7,6M
95510254	Power Supply XRD-EP
95510581	XRD-EPS DC Cable 25FT / 7.6M
95510582	XRD-EPS DC Cable 50 FT / 15,25M
95510583	XRD-EPS DC Cable 100 FT / 30.5 M
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

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

Table 7 Accessories for the XRD 1620

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.

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 285.6 ms for one frame. Each pixel is read out every 285.6 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 32).

5.2 Pixel Defect Specification

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

5.2.1   General Definitions

- ➢ All pixel defects are defined at the 200 micron pixel size.
- ➢ All tests are accomplished in the Timing 0 (285.6 ms) 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

- ➢ Line defects are more than 10 consecutive defect pixels
- ➢ Full cumulative defect lines are 2048 defect pixels which are parts of line defects
- ➢ Adjacent line defects are pairs of neighbored lines
- ➢ Cluster pixels are counted if they are connected by their sides (4-neighborhood)

5.2.3   Definition of Panel Regions

- ➢ Central: The central region is defined as the inner 1024 by 1024 pixels If a defect 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 is given for this region since the behavior of the sensor can not be guaranteed in this area.
- ➢ General: This is the total sensor area minus rim.

5.2.4   Definition of Bad 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
$\bar{x}$:	median value
σ:	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 (285.6 ms).

- ➢ **Bright pixels**: value is greater than 150% of the median bright
- ➢ **Dark pixels**: value below 20% of the median bright (dark pixel with no response)
- ➢ **Badly correctable pixels**: value is between 20% and 45% of the mean

5.2.4.2 Bright Noise:

A sequence of 100 bright images in the first free running timing is acquired. The bright image has a nominal value of roughly 30000 units. The pixel sigma for each pixel across the 100 images is calculated. The on-site median and sigma for the pixel sigma's are calculated. A bright noise pixel is a pixel that exceeds the on-site sigma by $\pm$ 6 sigma.

$$\sigma(i) = \sqrt{\frac{1}{m} \sum_{j=1}^{m} \left(\bar{x}(i) - x(i,j) \right)^2} \qquad \text{(time base sigma)}$$

$$\Rightarrow \qquad sort_i\left(\sigma(i)\right)$$

$$\Rightarrow \qquad \bar{\sigma} = \sigma_{50\%}(i) \qquad \text{(on-site median)}$$

$$\Rightarrow \qquad \Sigma = \left(\sigma_{82\%}(i) - \sigma_{18\%}(i)\right)/2 \qquad \text{(on-site sigma)}$$

For (i =1, n, i++) if $\left(\left(\sigma(i) > \bar{\sigma} + 6\Sigma\right) \| \left(\sigma(i) < \bar{\sigma} - 6\Sigma\right)\right)$ => pixel is bad

5.2.4.3 Dark Noise

A sequence of 100 dark images is acquired in two free running timings (285.6 ms and 1 s). The pixel sigma for each pixel across the 100 images is calculated. The on-site median and sigma for the pixel sigma's are calculated. A dark noise pixel is a pixel that exceeds the overall sigma by $\pm$ 9 sigma.

$$\sigma(i) = \sqrt{\frac{1}{m} \sum_{j=1}^{m} \left(\bar{x}(i) - x(i,j) \right)^2} \qquad \text{(time base sigma)}$$

$$\Rightarrow \qquad sort_i\left(\sigma(i)\right)$$

$$\Rightarrow \qquad \bar{\sigma} = \sigma_{50\%}(i) \qquad \text{(on-site median)}$$

$$\Rightarrow \qquad \Sigma = \left(\sigma_{82\%}(i) - \sigma_{18\%}(i)\right)/2 \qquad \text{(on-site sigma)}$$

For (i =1, n, i++) if $\left(\left(\sigma(i) > \bar{\sigma} + 9\Sigma\right) \| \left(\sigma(i) < \bar{\sigma} - 9\Sigma\right)\right)$ => pixel is bad

5.2.4.4 Uniformity

Analysis performed on Offset correction image acquired at 285.6 ms and Gain correction image acquired at 285.6 ms having a nominal value of 45000 digits. Using a flood image of nominal value of 30000 units at 285.6 ms. This tests the success of the offset and gain correction at about 50% exposure level.

half_og: offset and gain corrected bright image at a nominal value at 30.000 ADU

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

➢ **Global uniformity:**

A pixel is marked as defective if its value exceeds a deviation of more than +/- 2% for fixed Integration time of 285.6 ms, corrected with gain-and offset- images acquired at 285.6 ms both.

For (i=1, n, i++) if $\left(\left(x(i) > 1.02\bar{x} \right) \| \left(x(i) < 0.98\bar{x} \right) \right)$ => pixel i is bad

➢ **Local uniformity**

A pixel is marked as defective if its value exceeds a deviation of more than +/-1 % of the median value of its 9x9 neighbors in the corrected image for fixed Integration time of 285.6 ms ms, corrected with gain-and offset- images acquired at 285. ms both.

For (i=1,n, i++) if $\left(\left(x(i) > 1.01\bar{x}_{9x9} \right) \| \left(x(i) < 0.99\bar{x}_{9x9} \right) \right)$ => pixel i is bad

5.2.4.5 LAG

The detector is set to a 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 defective if its value exceeds the following limit: 8% in 1st Frame, 4% in 2nd frame; and for the CsI 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 bad

5.2.5 Number of Pixel Defect

5.2.5.1 Standard Grade

Defect type	Limit per region		Max # pixels
	Central	General	
Lines:			
2 Adjacent line defects	4	8	
Cumulative line defects	8	20	40960
Clusters:			
Mega cluster (maximum 50 pixels)	2	7	350
Large cluster (maximum 17 pixels, no 4x4)	15	40	680
Medium cluster (4-9, no 3x3)	125	400	3600
Density:			
Pixel density (number of pixels in a 51x51 block)	10%	10%	260
Total number of pixel defects		2%	83800

5.2.5.2   CT-Grade

Defect type	Limit per region		Max # pixels
	Central	**General**	
Lines:			
2 Adjacent line defects	0	1	
Cumulative line defects	5	11	22528
Clusters:			
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
Density:			
Pixel density (number of pixels in a 51x51 block)	10%	10%	260
Total number of pixel defects		1 %	40000

5.3 Power supply XRD-EP

The enhanced power supply **XRD-EP** is a stand-alone unit to support the XRD 1620 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 8 Status Lights of the XRD-EP

Fig. 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

Table 9 Electrical and Mechanical Specification of the XRD-EP

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 10 PIN assignment of power supply 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 11 Environmental Considerations for the Power Supplies

5.4 Frame Grabber Board

The **XRD 1620** can be directly be operated by the PCI Frame Grabber **XRD-FG** Board over the **XRD Interface Bus**. The **XRD-FG** utilizes the PCI bus for 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, Windows®2000, Windows®NT and Windows®98 and is used to set internal DLL parameters to drive and read-out the **XRD 1620** detectors (Table 14).

5.4.1   The XRD-FG PCI interface board

The **XRD-FG** is a small board designed for a PCI 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 transfer speed is gated by the PC motherboard , since the speed of the PCI bus is 132 MB/s (peak) and 90 MB/s (average). With a chip set using fast PCI-to-memory, a 40 MB/s transfer rate can be expected , thus the PCI bus is lightly loaded during image transfer. (see   Table 12).

Specifications	XRD-FG
Physical Dimension	120 mm x 107 mm Small sized
PCI Compliant	PCI 2.2
DMA	Bus master
DMA addressing	Scatter–gather
PCI-Power Supply (+/- 5%)	5 V, 0.5 A (typ.) 0.7 A (max) 3.3 V, 0.18 A (typ.) 0.2 A (max)
PCI-Bus	32 bit 33 MHz
Bandwidth (typical)	> 80 MB/s
Bandwidth (max.)	132 MB/s
Operation System	Windows® NT 4.0, Windows® 2000, Windows® 98, Windows® ME

Table 12 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 85%

Note: No condensation

Table 13 Environmental Considerations for the Frame Grabber

5.4.2 Connectors of the Frame Grabber

The connectors of the **XRD-FG** PCI interface board link the **XRD 1620** detector to the personal computer. The female 50-PIN mini delta ribbon connector on the module can be used to plug in the Interface cable. The module allows data acquisition via the parallel interface, detector mode control via the serial configuration bus and generation of external triggering.
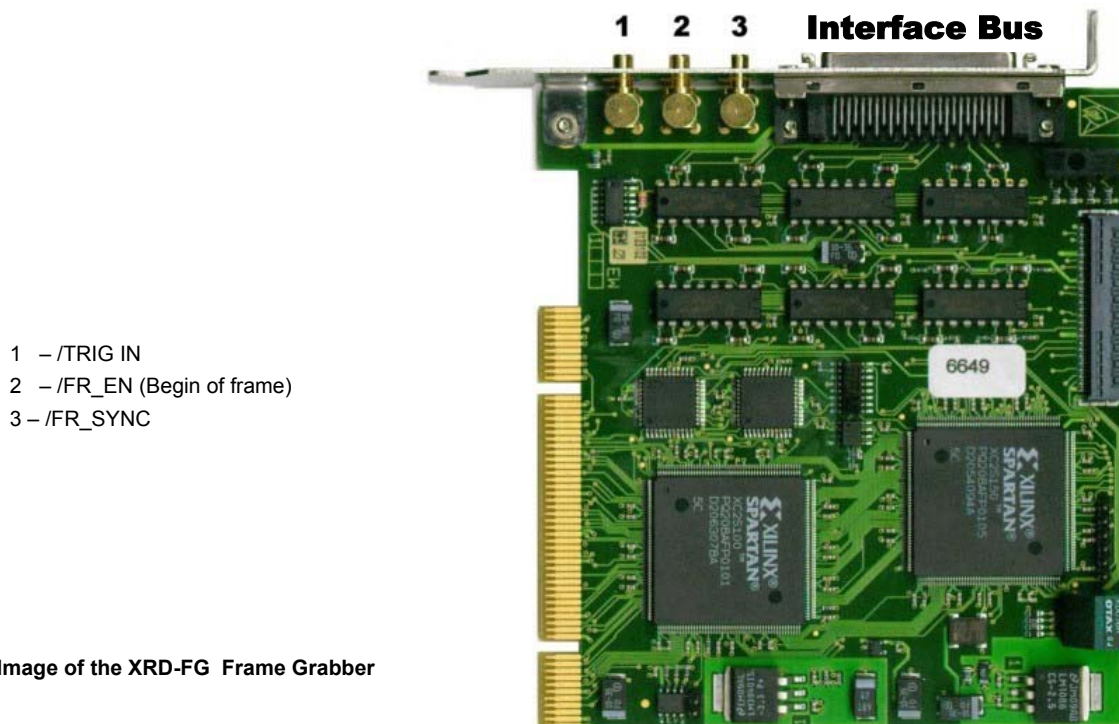
1 – /TRIG IN
2 – /FR_EN (Begin of frame)
3 – /FR_SYNC

Fig. 7 Image of the XRD-FG Frame Grabber

Two further HIIB signals, /FR_ENB and
FR_SYNC, are also externally connectable as TTL signals (SMB-Subclic connectors). These two signals are capable of generating maskable interrupt requests in order to interrupt software support.

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 grabbers 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, but please be aware that only one type of frame grabber can be used in one computer system.

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-FG** on Windows®XP, Windows®2000 or Windows®98(ME)

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-FG** as a new device
4. After installation of the **XRD-FG** 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.

5.4.3.3   Installation of the **XRD-FG** on Windows®NT

1. Plug in the XIS Installation CD-ROM
2. If the Setup does not start automatically start the START.EXE in the root directory of the CD
3. Select the XIS SETUP in the appearing menu
4. The SETUP program will lead you through the installation process
5. Select the **XRD-FG** as your favorite frame grabber
6. Restart the computer system The XIS is now ready to start
7. If the initialization of the frame grabber and the detector is successful a corresponding message appears in the status bar.

5.5 X-Ray Imaging Software Library (XISL)

The **X**-Ray **I**maging **S**oftware **L**ibrary (**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	Explantation
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

Table 14 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 15 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.
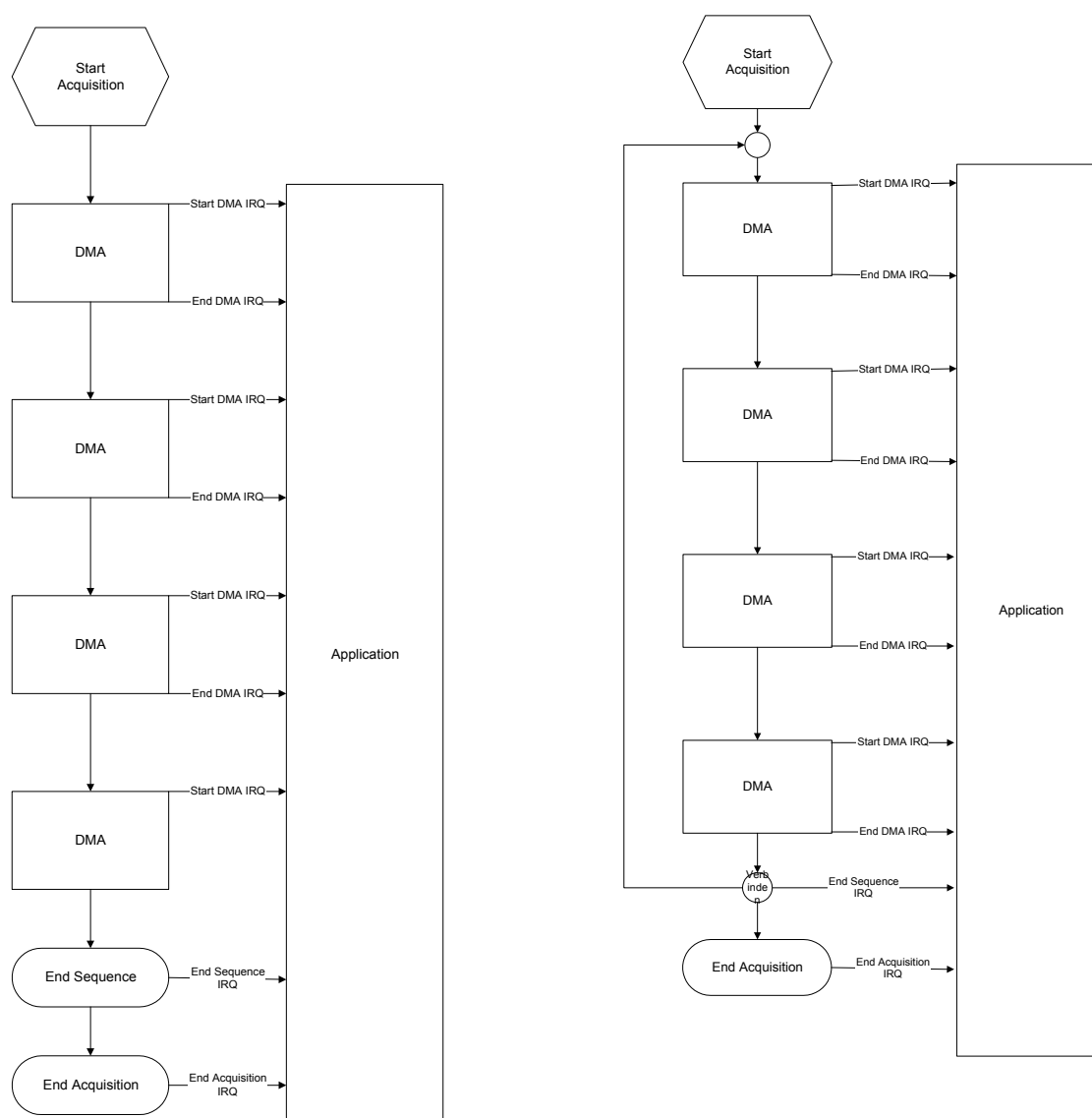
Fig. 8 Interrupt sources at a) sequence (4 frames) and b) continuous acquisition mode

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 signaled. Both interrupts show the same behavior 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 signaled. 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. Fig. 9 shows the read out scheme of the **XRD 1620** sensor.
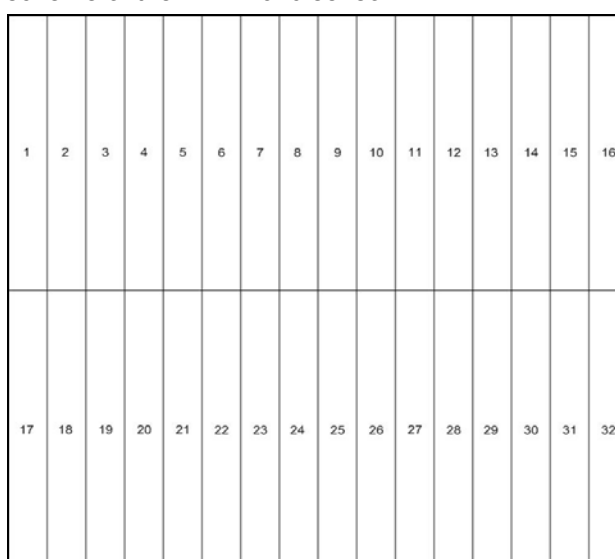
Fig. 9 Sorting scheme of the XRD 1620

The sensor is divided into an upper and a lower part. Both sections are electrically separated. The data of each section is transferred by 16 "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 list displays the data stream for **XRD 1620**:

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	(2048,256)	18
18	(2048,128)	17
19	(2048,512)	20
20	(2048,384)	19
…	…	…

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 to 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 defective (completely black or white).

To eliminate these detector specific effects and obtain good quality results, each image will be 'offset' and 'gain' corrected, and if required, the defective 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 1620

Before starting the connection of the **XRD 1620** ensure that the frame grabber and the software is installed as described in the chapter 5.4.3. If not please begin with the frame grabber and software installation.
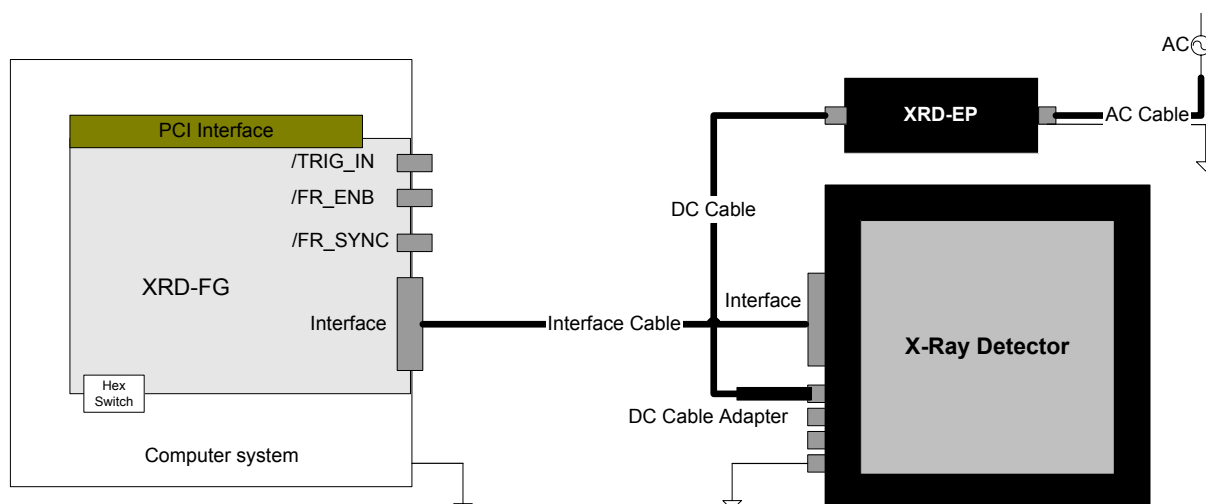

Fig. 10 Connections of the XRD 1620

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 1620** and the **XRD-EP** power supply has to be managed through the labeled connectors and the potential equalization between both devices is managed through the **XRD-EP DC Cable and XRD-EP DC Adapter.** For safety reasons only original cables and connectors should be used.

The **XRD 1620** should be connected as described in the following manner and as shown in Fig. 10

1. Shut down the computer
2. Connect the **XRD 1620** and the **XRD-EP** with the potential equalization
3. Connect the **Frame Grabber** and the **XRD 1620** via **Interface Cable**
4. Connect the **DC Cable Adapter** with the Power Connector of the **XRD 1620**
5. Connect the **XRD-EP** and the **DC Cable Adapter** via **DC Cable**
6. Connect the **XRD-EP** with the power supply via **AC Cable**.
7. Switch on the **XRD-EP**
8. 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 gray 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 homogenously. The Gain correction should be applied under optimum dynamic range (70-80 % of the full scale range FSR) or in the dynamic range of interest. The radiation intensity used to create the gain image can depend on the application, e.g. if the typical grey level is about 10.000 ADU

and the remaining area is saturated, it is recommended to use a gain created at 10.000 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 image performance can be enhanced by using the Multiple Gain Correction. For each dynamic range of interest a separate offset corrected and averaged bright image is used as an interpolation point. The maximum number of interpolation points depends on the installed computer memory. It is important that each bright image is completely and homogenously illuminated.

The Pixel correction allows a 'software repair' of defective pixels to enhance image quality. Improper pixel values are replaced with the averaged value of the surrounding eight adjacent pixels where defective pixels are not used. The pixel correction is only performed on specific pixels, mapped in the file PXLMASK.HIS. Each detector is shipped from PerkinElmer with the PXLMASK.HIS file for that specific detector The user can also generate a correction file. Please be aware that the number of pixels used for the mean correction should be minimized. The pixel correction procedure requires CPU time and depending on its speed, a slower presentation of the acquired images on screen may occur depending on the selected timing mode of the system. The main screen of the XIS software displays a warning message if all of the acquired images are not accepted by the computer.

Note:To fully meet all performance specifications, all corrections and the correction files must be acquired at the same readout mode, gain setting and integration time 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 the Gain/Offset Correction

The Gain/Offset correction of images is used to eliminate the effects of pixel sensitivies and the X-ray source on the acquired image.

To obtain a Gain/Offset 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 between 70-80 % of FSR or in the dynamic range of the ROI. The gain intensity depends on the application, but the entire image area should be illuminated homogenously.

4. Start the Get Gain/Offset Image.

5. Select a number of frames.
20 to 100 frame cycles should be used which will be averaged. The averaged image is implemented as the new Gain/Offset Image of the selected frame time and automatically linked to later acquired images.

6. Adjust the new acquired image by using the Options/View command and/or Brightness, Contrast or LUT range.

7. Store the Offset correction file if desired.
Note: A warning appears if the program is quit without saving new acquired Offset correction files.

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

NOTE: The Gain image is automatically Offset corrected with the currently linked Offset correction file. To obtain best quality of the correction file, please perform a new Offset correction before starting Gain/Offset correction.

6.2.3 Use of Multiple Gain Correction

The Multiple Gain Correction is used to eliminate the effects of pixel sensitivies 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.

8. 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 homogenously.

3. Start the Acquire Sequence

4. Select a number of frames and the average mode.
20 to 100 frame cycles should be used which will be averaged.

5. Adjust the new acquired image by using the Options/View command and/or Brightness, Contrast or LUT range.

6. Store the Offset corrected bright image

7. Repeat the steps 3-7 for each intensity of interest.

8. Create a Gain –Sequence with Acquire=>Build Gain Sequence

9. Start a new acquisition.

10. Link the created Gain-Sequence file with Acquire=>Link Gain Sequence

11. Store the Offset correction file if desired.
Note: A warning appears if the program is quit without saving new acquired Offset correction files.

6.2.4   Use and generation of the Pixel Correction

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

To get an 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 PXLMASK.HIS.

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

6.2.5   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 285. ms (**XRD 1620**) for one frame. Each pixel is readout every 285. 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.

6.3.2 Internal Trigger

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 artifacts which are not correctable. In order to expose during the delay the detector allows triggering of the x-ray source and the detector itself.
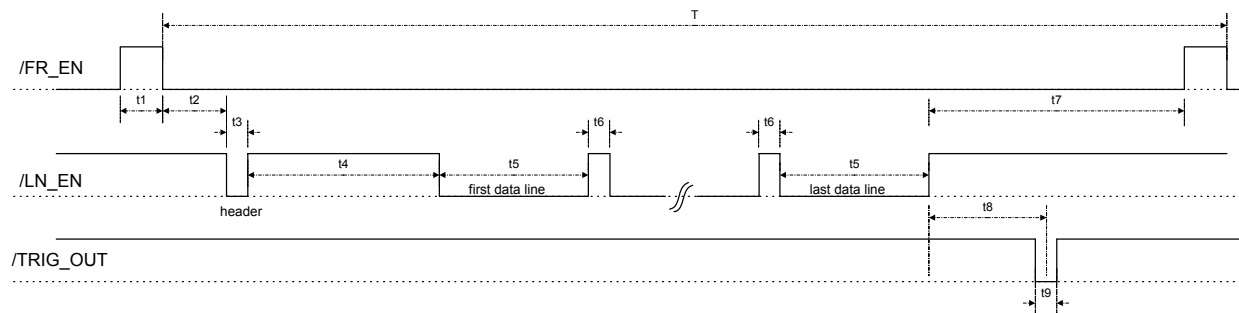

Fig. 11 General timing diagram in continuous mode

6.3.3 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 µs 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 sub-click located on the rear side of the frame grabber (/TRIG_IN converted to RS422 signal as /FR_SYNC). 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 Fig. 12 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.
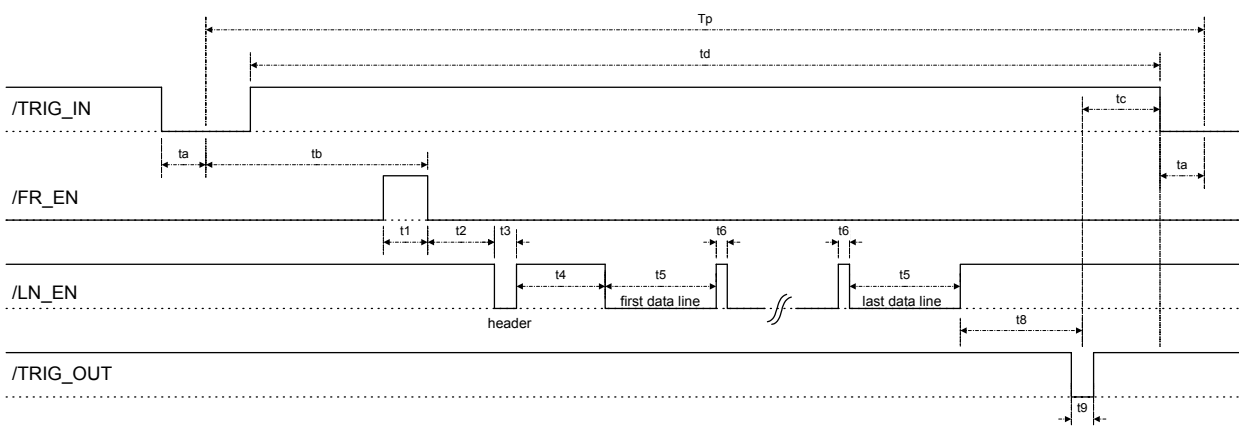

Fig. 12 General timing diagram in triggered mode

6.3.4   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 1µs. The frame grabber sends the RS422 signal /FR_SYNC over the HIIB 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.

6.3.5   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 an customized delay. If the Interface Bus is connected and the power is switched on the detector runs in the first free running mode. 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 HIIB 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 1620 AN supports up to 5 different gain settings (Table 16). When the detector is powered on the XRD 1620 AN runs with 1pF capacity. The detector gain will be set bitwise by the **XIS** dialog **Options/Detector Options** or by the library function Acquisition_SetCameraGain(*hAcqDesc, 1..5).* The Table 16 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
1	0,5 pF
2	1 pF
3	2 pF
4	4 pF
5	8 pF

Table 16 Overview of the five Detector Gain Settings

6.5 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 bad pixels and clusters.

6.6 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 mixed 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.

USA
PerkinElmer Optoelectronics
2175 Mission College Boulevard
Santa Clara, CA 95054
Telephone: +1 408-565-0850
Email: opto@perkinelmer.com

Europe
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Germany
Telehone: +49 611 492 430
Fax: +49 611 942 165
Email: opto.Europe@perkinelmer.com

ASIA
PerkinElmer Optoelectronics
47 Ayer Rajah Crescent #06-12
Singapore 139947
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Email: opto.Asia@perkinelmer.com

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	The X-Ray Detector is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/ flicker emissions IEC 61000-3-3	Complies	

Table 17 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) ICE 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) ICE 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 ICE 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 ICE 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 ICE 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 18 Guidance and Manufacturer's Declaration of Electromagnetic Immunity

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
			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 $$d = \frac{3.5}{V_1}\sqrt{P}$$
Conducted radio-frequency fields (CEF) ICE 61000-4-6	3 V 150 kHz to 80 MHz	[V₁] 3 V 150 kHz to 80 MHz	$$d = \frac{3.5}{E_1}\sqrt{P} \text{ ,for 80 MHz to 800 Mhz}$$ $$d = \frac{7}{E_1}\sqrt{P} \text{ ,for 800 MHz to 2.5 Ghz}$$
Radiated electromagnetic field (REF) ICE 61000-4-3	3 V/m 80 MHz to 2.5 GHz	[E₁] 3 V/m 80 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[a], should be less than 3 V/m. Interference may occur in the vicinity of equipment marked with the following symbol:
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.			
[a] 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 19 Guidance and Manufacturer's Declaration of Electromagnetic Immunity (Portable Equipment)

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 $d = \dfrac{3.5}{V_1}\sqrt{P}$	80 MHz to 800 MHz $d = \dfrac{3.5}{E_1}\sqrt{P}$	800 MHz to 2.5 GHz $d = \dfrac{7}{E_1}\sqrt{P}$
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 20 Recommended Separation Distance between Portable and Mobile RF-Communication Equipment and the X-Ray Detector