XRD 4343 Digital X-ray Detector Reference Manual

Before using the X-ray detector, be sure to read this manual thoroughly along with any other manuals for the software and other system components. Keep this manual where it is easily accessible.

VAREX IMAGING

REFERENCE MANUAL

Before You Begin

- To avoid personal injury or product damage, read the manual and all accompanying information carefully before installing and using the X-ray detector.
- The X-ray detector is intended to be installed, maintained, and used by qualified professional personnel who are trained and qualified in the installation, maintenance, and use of X-ray equipment.
- The user is responsible for using and maintaining the X-ray detector according to prescribed installation, usage, maintenance, handling, and storage specifications. To keep the X-ray detector and its accessories in a safe and proper condition, only trained and qualified professional person(s) shall be in charge of maintenance.
- X-ray imaging, image processing, image acquisition, and data storage must be performed in accordance with the applicable laws. The user is also responsible for compliance to laws pertaining to the privacy of image data.
- In no event is X-ray detector manufacturer liable for direct, indirect, or consequential injury, damage, or loss of equipment operation time or image data arising from the use of the X-ray detector, its components, and/or accessories.

Protection Against Ionizing Radiation

- Exposure of any part of the human body to X-radiation may be harmful to health. Whenever X-ray equipment or radioactive sources are in use, appropriate safety precautions and measures shall be instituted, and all regulatory requirements must be met. It is the responsibility of the X-ray system installer, operator, and user to comply with applicable requirements.
- The X-ray detector does not contain a primary barrier for X-rays or Gamma rays. The X-ray system installer or X-ray system manufacturer must provide the necessary protection based on the X-ray system's intended use.

For Your Safety

To avoid personal injury or product damage, read this manual and all accompanying information carefully before handling, installing, or using the X-ray detector. Follow all instructions, warnings, and cautions in this manual and all warnings and cautions printed on the warning label. Ignoring instructions, warnings, or cautions in the handling, installing, or using of the X-ray detector may result in personal injury, death, or product damage. Keep this manual for future reference.

Meaning of Alerts and Notes

 **DANGER**	**This indicates a potentially hazardous situation which, if ignored, will result in severe personal injury, death, or substantial product damage.**
 **WARNING**	**This indicates a potentially hazardous situation which, if ignored, may result in severe personal injury, death, or substantial product damage.**
 **Caution**	**This indicates a potential hazardous situation which, if ignored, may result in minor or moderate personal injury or damage to the product.**
 **Note**	This emphasizes or supplements important information about the main text.

REFERENCE MANUAL

Installation and Environment of Use

WARNING	**Do not operate the X-ray detector in or around flammable gases, gas mixtures, liquids, chemicals, or other substances. Ignoring this warning may result in explosion, fire, or electric shock, which may result in severe personal injury, death, or substantial product damage.**
Caution	**Do not operate the X-ray detector in a location with the following conditions:** • **Close to fluid or places where fluid is used** • **Close to heat sources, such as a heater** • **High temperature environment** • **High humidity environment** • **High condensation environment** • **Extreme cold environment** • **Dusty environment** • **Salty or sulphurous environment** • **Near a vibrating environment** **Ignoring this caution may result in personal injury or damage to the product.**
WARNING	**Do not connect the X-ray detector to any component or accessory other than the manufacturer's specified components and accessories. Ignoring this warning may result in explosion, fire, or electric shock, which may result in severe personal injury, death, or substantial product damage.**
WARNING	**Do not modify or alter the X-ray detector, its components, or accessories. Ignoring this warning may result in explosion, fire, or electric shock, which may result in severe personal injury, death, or substantial product damage.**

Power Supply and Cables

 **WARNING**	**Be sure to turn off the power of the X-ray detector, including turning off the power supply before servicing, maintaining, connecting, or disconnecting the cables or accessories.** **Do not touch the power supply, X-ray detector, cable, connector, or any other electrical component or equipment with wet hands. Ignoring this warning may cause electrical shock, which may result in severe personal injury, death, or substantial product damage.**
 **WARNING**	**Disconnect the cables by pulling on the connector and not the cable itself. Ignoring this warning may cause electrical shock, which may result in severe personal injury, death, or substantial product damage.**
 **WARNING**	**Do not modify the cables or subject the cable to external stress or damage. Avoid placing anything heavy, including the X-ray detector, on the cable, stepping on the cable, pulling the cable, or subjecting the cable to excessive bending or bundling. Ignoring this warning may cause cable failure resulting in electrical shock, which may result in severe personal injury, death, or substantial product damage.**
 **WARNING**	**Do not turn on the power supply or X-ray detector when condensation is on the X-ray detector or any of its components or accessories. Ignoring this warning may cause electrical shock, which may result in severe personal injury, death, or substantial product damage.**

Handling

 **WARNING**	**Never disassemble, modify, or alter the X-ray detector, its components, or accessories. Ignoring this warning may cause electrical shock and/or unknown hazards, which may result in severe personal injury, death, or substantial product damage.**
 **WARNING**	**Do not touch the detector, power supply or cable and the patient at the same time. Do not let the patient touch the detector,power supply or cable. Ignoring this warning may cause electrical shock and/or unknown hazards, which may result in severe personal injury, death, or substantial product damage.**
 **Caution**	**Place the X-ray detector horizontally on a flat, stable surface. If the X-ray detector is placed vertically or in any tilted position, the X-ray detector must be securely fastened to the X-ray detector enclosure or support structure. Ignoring this caution may result in personal injury or damage to the product.**
 **Caution**	**Do not drop the X-ray detector. If the X-ray detector is dropped, remove the X-ray detector from service, and immediately ask your establishment's safety representative to verify or re-validate the proper function of the X-ray detector prior to resuming use of the X-ray detector. Further use under abnormal conditions may result in severe personal injury, death, or substantial product damage.**

If a Problem Occurs

WARNING	**If any abnormal condition, such as smoke, fumes, or strange sounds, is evident, turn off the X-ray detector, unplug the power supply from the AC outlet, and immediately ask your establishment's safety representative to contact your dealer, distributor, or device manufacturer.** **Further use under abnormal conditions may result in severe personal injury, death, or substantial product damage.**
WARNING	**When liquid has been spilled into or on any part of the X-ray detector or power supply, or when the X-ray detector, its component, or accessory is dropped, unplug the power supply from the AC outlet, and immediately ask your establishment's safety representative immediately to contact your dealer, distributor, or device manufacturer.** **Further use under abnormal conditions may result in severe personal injury, death, or substantial product damage.**

Maintenance and Inspection

WARNING	**Turn OFF the power of the X-ray detector when the inspections indicated in this manual are going to be performed. Ignoring this warning may result in electric shock, which may result in severe personal injury, death, or substantial product damage.**
WARNING	**When the X-ray detector system is going to be cleaned, turn OFF the X-ray detector. Turn off the power switch and unplug the power supply cable from the AC outlet. Never use thinner, benzine, acetone, or other flammable cleaning agents. Ignoring this warning may result in explosion, fire, or electric shock, which may result in severe personal injury, death, or substantial product damage.**
WARNING	**The X-ray detector must be repaired by the X-ray detector manufacturer-authorized personnel only. Ignoring this warning may result in explosion, fire, electric shock, or unknown hazards, which may result in severe personal injury, death, or substantial product damage.**
Caution	**Follow the manufacturer's recommendations for inspecting the X-ray detector before use.**

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1.0 Scope

This document describes design elements and respective interfaces for the XRD 4343RF and the XRD 4343CT X-ray detectors (unless otherwise indicated, the term **XRD 4343** used in this manual applies to both). Applicable mechanical, electronic, and software interfaces are addressed.

Varex Imaging Digital X-ray Flat Panel Detectors and their accessories are components designed to be integrated into products by X-ray system manufacturers. Manufacturers are responsible for qualifying, validating, and certifying their products for their intended uses and meeting all applicable regulatory requirements. Final application and intended use is based on the completed X-ray system design.

The Digital Radiography Software referred to in this manual is medical imaging software for radiography, which is typically supplied by the X-ray system manufacturer or third-party provider and is not part of the Varex Imaging XRD 4343 X-ray detectors.

2.0 Uses

The detector is a component of a digital X-ray imaging system used for generating radiographic, fluoroscopic, and Cone Beam Computed Tomography (CBCT) images. Final application is based on the completed X-ray system design. It is the responsibility of the final device manufacturer to confirm the safety, efficacy, and compliance of the system for its intended use. Manufacturers are responsible for qualifying, validating, certifying their intended use on their specific application, and meeting all applicable regulatory requirements established by local or national government authorities.

3.0 Audience

This document is for professional users from Original Equipment Manufacturers (OEMs) of X-ray systems, and X-ray system installers who are responsible for installing the X-ray detector into an X-ray system.

4.0 Abbreviations

Table 1 includes a list of abbreviations used in this manual and a description of each abbreviation.

Table 1 Abbreviations

Abbreviation	Description
ADU	Analogue Digital Unit (Grey Level)
CBCT	Cone Beam Computed Tomography
DDD	Data Delivery on Demand
FoV	Field of View
FPGA	Field Programmable Gate Array
fps	Frames per second
FSR	Full scale range
G-ESD	Good Electro Static Discharge
I/F	Interface
IQI	Image Quality Indicator
LED	Light Emitting Diode
OEM	Original Equipment Manufacturer
PROM	Programmable Read Only Memory
REF	Radiated Electromagnetic Field
RoHS	Restriction of Hazardous Substance
ROI	Region of Interest
SDK	Software Development Kit
TFT	Thin Film Transistor
TTL	Transistor to Transistor Logic
VCT	Volts center tapped
WEEE	Waste Electrical and Electronic Equipment
XISL	X-ray Imaging Software Library
XRD 4343RF / XRD 4343CT	X-ray detector model name

5.0 References

Table 2 includes a list of documents referred to in this manual. For access to the following references, contact your establishment's representative or your dealer, distributor, or device manufacturer.

Table 2 References

	Document Name	Document #
1	XIS Reference Book	1000952
2	XISL API Description	895695
3	XRD 4343 Detector Integration Guide	98712

6.0 Definition of Symbols

Table 3 includes a list of symbols and a description of each symbol.

Table 3 Symbols

Symbol	Description
	This Way Up
	Handle with Care
	Keep Dry
	Reusable
	Disposal (WEEE)
	Read the Instruction Manual
	Caution
	Manufacturer‘s name and address.
	Date of Manufacture, YYYY-MM, YYYY=Year, MM=Month.
	Material Number
	Serial Number
~	AC Input
⎓	D.C. Voltage
	Temperature Limitation
	Relative Humidity Limitation
	Potential Equalization
	Functional Earth Connection
	Protection Class I
	Non-Ionizing Radiation
	Detector Mode and Frame Rate Indicator
	Power On and Detector Status Indicator
CE	European Conformity marking for the product

7.0 Standards and Regulations

The assembly of the X-ray Detector is designed to be compliant with the requirements detailed in Table 4. All regulatory certificates are valid only if the original accessories listed are used. All regulatory certificates and warranty are void if any modification and/or alteration to the product is made, or any portion thereof, without obtaining the prior written authorization of Varex Imaging.

Table 4 Regulatory Requirements

Standard	Description
ANSI/AAMI Std ES60601-1:2005	Medical electrical equipment Part 1: General Requirements for Basic Safety and Essential Performance
IEC 60601-1:2005, EN 60601-1:2006	General Requirements for Basic Safety for Medical Electrical Equipment
IEC/EN 60601-1-2:2007	Medical Electrical Equipment, Part 1-2: General Requirements for Safety and Essential Performance – Collateral Standard: Electromagnetic Compatibility
CAN CSA C22.2 No 60601-1 08	Medical Electrical Equipment Part 1: General Requirements for Basic Safety and Essential Performance
IEC 60721-3-7	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities
DIN EN 60068-2-27	Basic environmental testing procedures - Part 2: Tests; test Ea and guidance: Shock
DIN EN 60068-2-64	Environmental testing - Part 2: Test methods; test Fh: Vibration, broad-band random (digital control) and guidance
EN 60529:1991 + A1:2000	Degrees of Protection Provided by Enclosures (IP-code)

8.0 Description of the X-ray Detector

The XRD 4343 X-ray detector is a flat panel detector for digital radiography, fluoroscopy and CBCT.

8.1 Overview of the X-ray Detector

Figure 1 shows the front and back views of the X-ray detector, and Table 5 includes a brief description of each feature.

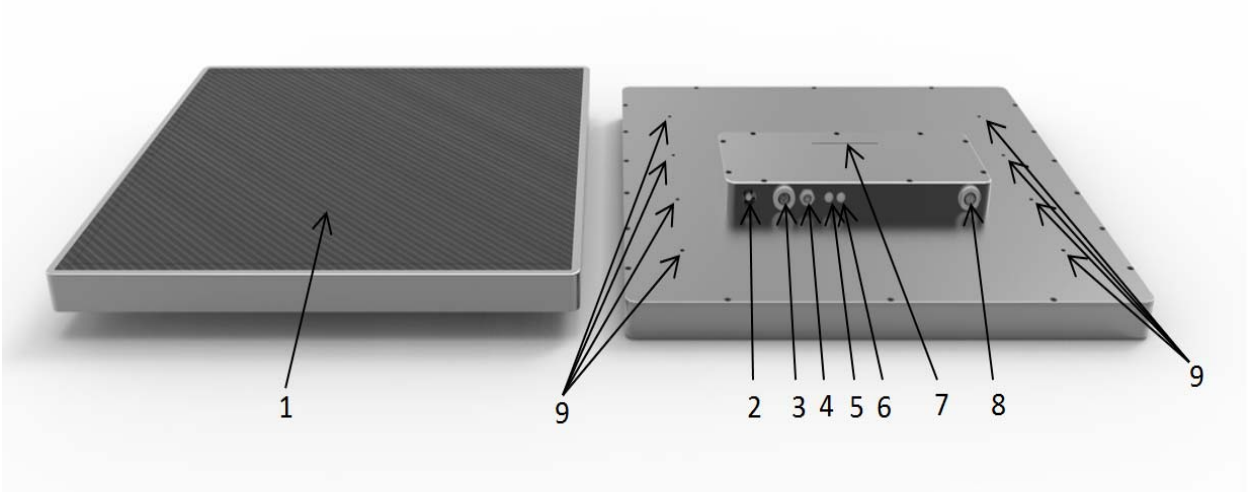


Figure 1 X-ray Detector (a) Front Side (b) Back Side

Table 5 Overview of the X-ray Detector

1	Active Area	
2	Potential Equalization	
3	Optical I/F Connector	
4	Trigger Input (see Figure 3)	
5	Detector Mode and Frame Rate (↑)	
	Green	Free Running (flashing)
	Yellow	Trigger Mode (flashing)
	Orange	During Boot-up and Self test
	No Light	Controlled communication is missed
6	Power On and Detector Status (☼)	
	Green	Power ON
	Orange	During Boot-up and Self test
	Red	Self test failed
7	Detector Label	
8	DC Power Input	
9	Mounting Positions 8 × M5	

9.0 X-ray Detector Specification

9.1 Technical Data for the X-ray Detector

Table 6 includes technical information for the XRD 4343 X-ray detector.

Table 6 Detector Specification

Sensor					
Panel	Single substrate amorphous silicon active TFT/diode array				
Scintillator Options	Direct deposition CsI:T1 Various Gd_2O_2S:Tb (Gadox)				
Pixel Matrix	2880 × 2880 @ 150 µm				
Total Area	432 mm × 432 mm				
Electronics					
Amplifiers	Low noise ASICs with user selectable gain settings				
ADC	16-bit				
Readout Mode	**Field of View (mm^2)**	**Pixel Matrix**	**Binning**	**Pixel Pitch (µm)**	**Max. Frame Rate (fps)**
	432 × 432	2880 × 2880 1440 × 1440 960 × 960	1 × 1 2 × 2 3 × 3	150 300 450	15 30 45
	288 × 288	1920 × 1920 960 × 960 640 × 640	1 × 1 2 × 2 3 × 3	150 300 450	20 40 60
	216 × 216	1440 × 1440 736 × 720 480 × 480	1 × 1 2 × 2 3 × 3	150 300 450	25 50 70
	432 × 216	2880 × 1440 1440 × 720 960 × 480	1 × 1 2 × 2 3 × 3	150 300 450	25 50 70
	432 × 72	2880 × 480 1440 × 240 960 × 160	1 × 1 2 × 2 3 × 3	150 300 450	60 85 100
Mechanical					
Size	470 mm (w) × 470 mm (l) × 57 mm (h)				
Weight	12 kg (XRD 4343RF) 16 kg (XRD 4343CT)				
Housing	Aluminum housing with a carbon fiber entrance window				

Table 6 Detector Specification

Communication	
Data I/F	Fiber optical with PCIe ×4 image processor
X-ray I/F	Integrated X-ray trigger control
Corrections	Offset, Gain, Bad Pixel
Image Performance	
Typical DQE[a]	76% (0 cy/mm), 60% (1 cy/mm), 44% (2 cy/mm), 32% (3 cy/mm) for RQA5
Typical MTF[a]	66% (1 cy/mm), 34% (2 cy/mm), 18% (3 cy/mm) for RQA5
Lag	< 4% (1st frame) for Radiography < 8% (1st frame) for Dynamic Imaging
Saturation Dose[a]	80 µGy at Gain 7
Energy range	40 - 150 kV (XRD 4343RF) 40 - 225 kV (XRD 4343CT)[b]
Power	
Supply	100 – 240 VAC, 50/60 Hz, XRD-EPS Power Supply
Dissipation	25 W

a. Typical MTF, DQE and saturation dose with CsI scintillator
b. In micro-focus applications.

9.1.1 Carrying and Mounting the X-ray Detector

The X-ray detector is a component of a digital imaging system and needs to be properly integrated into the complete X-ray system. The X-ray detector should only be lifted, carried, and installed by personnel who are familiar with the installation of electrical equipment and the use of X-ray systems.

The X-ray detector must be used horizontally on a flat, stable surface, or if the detector is placed vertically or in any tilted position, the detector must be securely fastened in that position. To fasten the detector, use the eight M5 screws at the detector back, which are shown in Figure 2.

9.1.2 Mechanical Drawing for the X-ray Detector

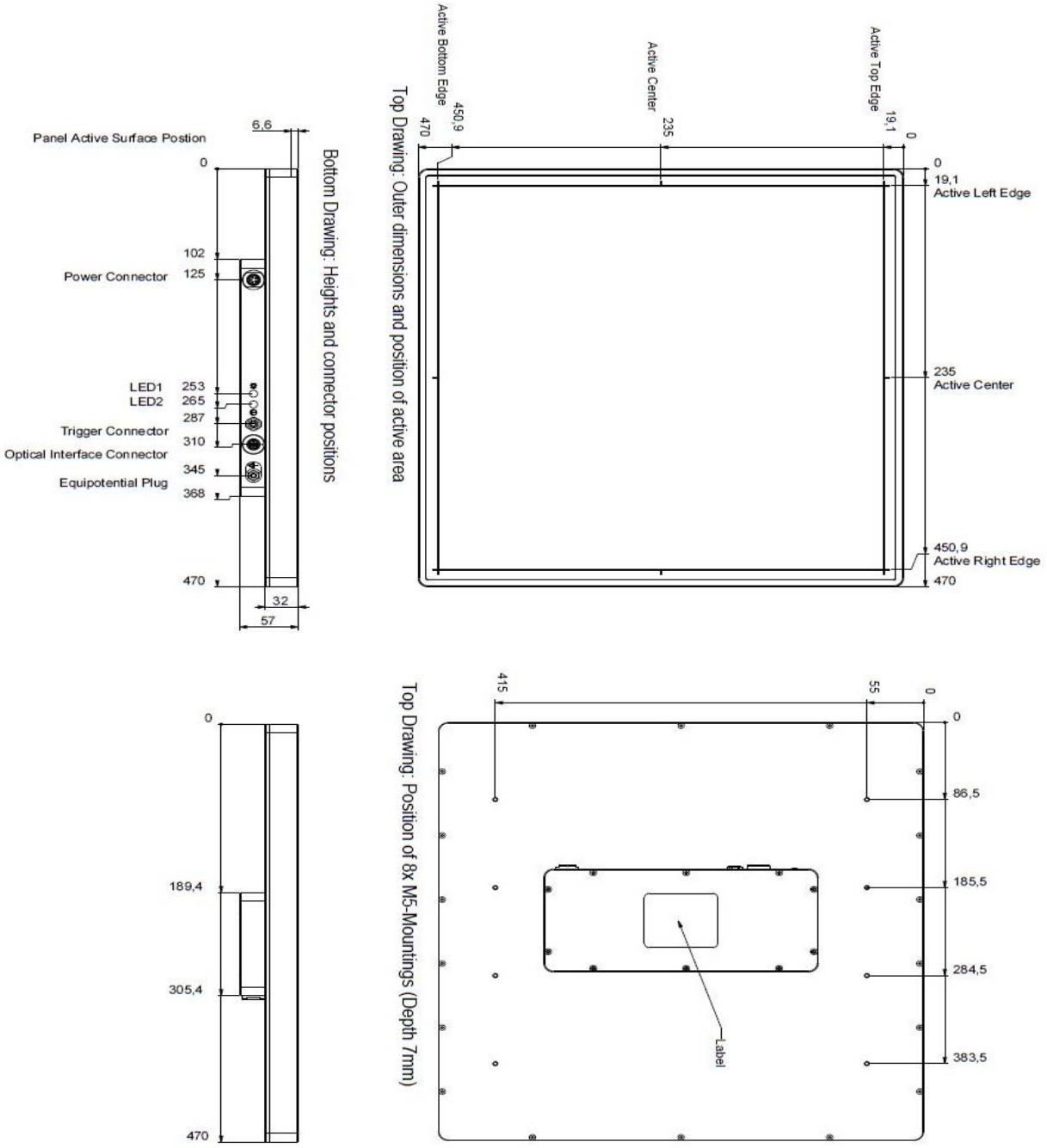


Figure 2 Mechanical Drawing for the X-ray Detector[1]

1. Flatness of entrance window due to temperature changes ± 0.5 mm.

9.1.3 Environmental Considerations

WARNING	**Environmental conditions outside of the specifications listed in Table 7 may cause fire, cause electrical shock, reduce the lifetime of the product, and irreparably damage the product.**

Table 7 Environmental Considerations

	Transportation/Storage[a]	Operation[b]
Ambient Temperature (30d/365d)	-10°C to +50°C[b] / 0° to +50°C[c]	+10°C to +35°C
Relative Humidity[d]	5% to 90%	30% to 70%
Atmospheric Pressure	700 hPa to 1250 hPa	800 hPa to 1250 hPa
Vibration[e](EN60068-2-64)	5 m^2/s^3 (10 Hz to 100 Hz) 1 m^2/s^3 (100 Hz to 2000 Hz)	1.0 m^2/s^3 (10 Hz to 100 Hz) 0.5 m^2/s^3 (100 Hz to 2000 Hz)
Shock[e] (EN 60068-2-27)	25 g (duration 11 ms)	15 g (duration 11 ms)
Ingress protection rating	IP44 rated (protection against particles > 1 mm and protected against water splashed from all directions).	

a. In original transport container for 365 days.

b. Flatness of entrance window due to temperature changes ± 0.5mm.

c. Temp. Gradient: max 4.5 K/hour.

d. No condensation.

e. Image quality cannot be guaranteed.

9.1.4 Connectors for the X-ray Detector

The backside of the housing contains the connectors for Optical Fiber I/F (data transfer), power supply, housing ground, and trigger input (see Figure 3).

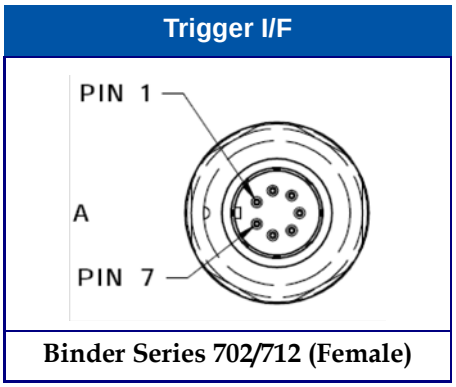


Figure 3 Trigger Connector (Front View) on detector

Table 8 includes the PIN assignments for the trigger signal (TTL Signals).

Table 8 PIN Assignments for the Trigger Signal (TTL Signals)

PIN	Connection
1	TRIG IN
2	TRIG Out
3	NC
4	NC
5	GND
6	5 V
7	NC

9.2 Detector Acquisition Modes

The X-ray detector can acquire images in a “Free Running” mode or a “Trigger” mode.
In addition, there are three different modes of triggering: External Trigger, Software Trigger, and Internal Trigger (see Table 9).

Table 9 Detector Acquisition Modes

Mode	Description
Free Running	The detector sends out frames continuously according to the selected frame time (default mode). Eight different frame times are available, and the detector starts automatically in the first timing (Timing 0).
External Trigger	The detector is synchronized by an external trigger source. The detector ignores all other incoming trigger pulses until the selected frame time has elapsed. After that, the detector can be triggered by a new pulse.
Internal Trigger	Each frame time can be selected between the fastest timing and five seconds.
Software Trigger	The detector is synchronized by a trigger pulse that is initiated by the Application Software. The detector ignores all other incoming trigger pulses until the selected frame time has elapsed. After that, the detector can be triggered by a new pulse.

⚠ **Caution**	**It is very important for the image quality that the correction files are obtained in the same acquisition mode, binning mode, gain setting, and integration time as for measurements.**

9.2.1 Free Running Acquisition Mode

Eight different frame times are available. The detector automatically starts in the first free running timing (Timing 0), which is the fastest frame time. Each pixel is readout every T0 and during this time the pixel integrates radiation.The timings are implemented as T0 plus a consecutive delay to get the desired frame time.

9.2.2 Trigger Modes

Triggering the X-ray detector attempts to synchronize the detector to other devices, for example, X-ray sources that have specific schemes of radiating X-ray pulses. If there is no synchronization between the pulsed X-ray source and the detector, image artifacts can occur.

The XRD 4343 X-ray detector family supports different trigger methods such as frame-wise and data delivered on demand triggered mode. Depending on the selected trigger method, the detector finishes the regime of the selected method, like readout of the complete frame

(frame-wise) until accepting a new trigger pulse. If a trigger signal is sent during the regime, it is ignored, and the trigger lost flag will be set in the image header.

If no trigger signals are applied from an external source or software to the detector in a frame time of 20s ± 2s, the detector will go into idle mode. To reset the detector into trigger mode, a new trigger signal must be sent. After this, the detector is ready for the next trigger pulses.

9.2.2.1 External Trigger Mode

The external trigger mode means that the detector is synchronized by an external pulse.

The detector requires a 20 µs wide low active trigger pulse (TTL-signal) 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. Prior to this, the detector has to be set by command into the external trigger mode. The frequency of the trigger determines the frame time. The/TRIG_OUT signal indicates the start of a new frame and can be used to synchronize the X-ray source.

9.2.2.2 Internal Trigger Mode

The internal trigger mode combines the advantages of the free running mode and the external trigger mode with all different trigger modes. The detector is synchronized by itself (self-triggering), and the frame time can be selected between the fastest free running mode T0 and 5 seconds, in steps of 1 ms.

9.2.2.3 Software Trigger Mode

The software trigger mode works in the same way as the external trigger mode and supports all trigger methods. This means that the detector is synchronized by a software function, and the trigger signal is generated by the detector itself.

9.2.3 Trigger Methods

9.2.3.1 Frame-wise (Default) Readout

The frame-wise trigger readout regime is the default and most general one. Once the detector has been set to trigger mode, the detector will synchronize to trigger events and perform a complete frame scan. The frame-wise trigger method allows the operator to take control of the integration time of the detector. Trigger events during the scan process are ignored, and the trigger lost flag is set so the shortest possible frame time is equivalent to the frame time of the fastest mode in free running T0.

9.2.3.2 Data Delivered on Demand (DDD) Trigger Method

The Data Delivered on Demand (DDD) trigger method is recommended for applications where single shots at a precise time or image sequences with longer interrupts have to be performed. This mode has the option to define the exposure time (no active scan) between zero and 4048 ms. The default time in this mode is 400 ms. The complete frame time is the selected Timing T0, T1,...T7 plus the selected exposure time.

The regime of DDD mode is shown in Figure 4 and works in the following way: The detector is running in "silent" mode, like free running mode but without transferring image data. If the user application (external, internal, or software trigger) sends a trigger signal to the detector, the detector accomplishes the current frame. The next frame (clearance scan) is processed also with the fastest integration time. After that, the detector waits until a customer-defined time has elapsed (delay time). During this time, the detector shall be exposed in case of pulsed or shuttered radiation. When this time has elapsed, the detector performs the image scan and transfers the desired data. After this, the detector returns to silent mode until the next trigger pulse is sent.

Note	If desired, you can skip the clearance scan. (Refer to the *X-ray Imaging Software Book*.)

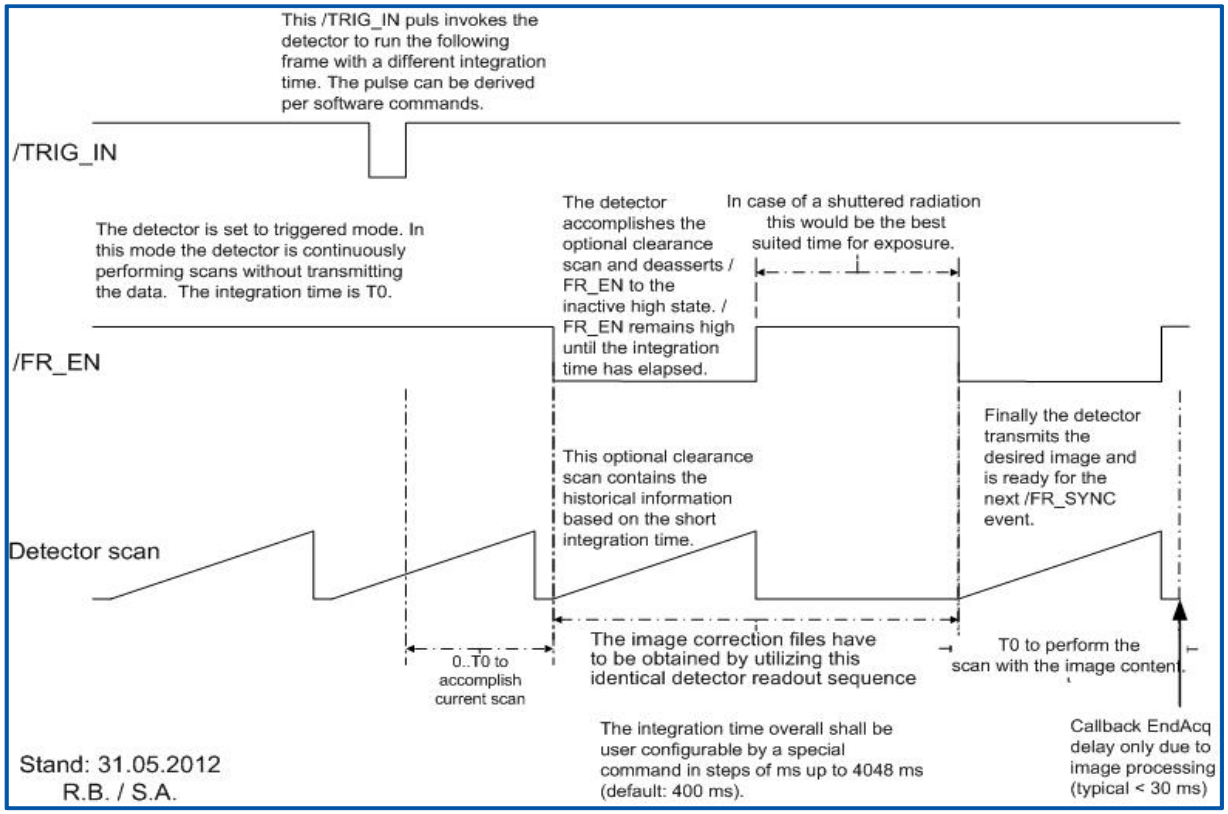


Figure 4 Timing Diagram for Data Delivered on Demand Trigger Regime

9.2.4 Trig Out Options

The X-ray detector supports different trigger output signals at the trigger connector. These trigger output signals can be modified to perform an optimum synchronization between the detector and other devices, such as X-ray sources having specific schemes of radiating X-ray pulses.

The following trigger output options are available and are described in detail in the *X-ray Imaging Software Book*.

- Exposure Pulse Width (FRM_EN_PWM)
- Defined Exposure Pulse in a Sequence (EP)
- Data Delivered on Demand Pulse
- Constant Ground (GND)
- Constant High (VCC)

WARNING	**The detector must not be used in a situation where it controls the X-ray dose delivered to the patient.**

WARNING	**The trigger signals from the detector must not be the only activation means for X-ray delivery, and must be used in association with other control inputs: for example, a hand switch, safety interlocks, and a means of controlling the beam duration**

9.2.5 Examples of Trigger Modes

Once the X-ray detector is powered up, it starts in the free running acquisition mode in Timing mode T0, which is in most cases the fastest frame rate of the detector. When the detector is set to one of the trigger modes, it is waiting for the next trigger signal to transmit the data to the computer. The X-ray detector has a timeout of 20s if no trigger signals are applied and it will go into idle mode. To reset the detector to trigger mode, a new trigger signal has to be sent. After this, the detector is ready for the next trigger pulses.

Refer to the **X-ray Imaging Software Book** for a detailed description of the software implementation.

9.2.5.1 Using the Internal Trigger Mode

The following method describes how to use the internal trigger to implement customized frame times:

To use the internal trigger to implement customized frame times:

1 Set the detector to the internal trigger mode by 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 a trigger pulse is the selected timing (readout time).

2 Select the frame rate (readout plus delay time) in the dialog box that appears (T0 … 5s) *XISL*:
`Acquisition_SetTimerSync(hAcqDesc, frame_time)`.

The detector is running in its self-triggered mode in the selected frame rate.
The detector runs "continuously" with the selected frame rate.

3 Start the acquisition *XISL*:
`Acquisition_Aquire_Image()`.

The data are transferred to the computer.

9.2.5.2 Using the (DDD) Regime with the Software Trigger Mode

The following method describes how to implement the (DDD) regime and the software. The detector starts in the first timing and in free running mode when the power is switched on.

To implement the (DDD) regime and the software:

1 Set the detector to the (DDD) trigger method using the Detector Options menu *XISL*:
`Acquisition_SetCameraTriggerMode (hAcqDesc,1)`.

The detector runs continuously (silence mode) in the fastest frame rate.

2 Set the delay time of the (DDD) regime using the Detector Option menu. *XISL:*
`Acquisition_SetFrameSyncTimeMode(hAcqDesc,0,1000);`

The delay time is set to 1000 ms.

3 Set the detector software trigger mode using the Detector Mode menu *XISL*:
`Acquisition_SetFrameSyncMode(hAcqDesc, HIS_SYNCMODE_SOFT_TRIGGER)`.

The detector aborts the current frame and waits for a trigger signal.
The shortest repeat time of a trigger pulse is the selected timing (readout time).

4 Start the acquisition *XISL*:
`Acquisition_Aquire_Image()`.

9.3 Using the Detector Gain Setting

The X-ray detector supports seven different gain settings. The detector starts with Gain 3 when powered on. Set the detector gain bitwise by using the XIS dialog box called Options/Detector Options or by using the library function Acquisition_SetCameraGain(hAcqDesc, wGain). Table 10 provides an overview of the gain settings.

⚠ **Caution**	**It is very important for the image quality that the correction files are obtained in the same gain setting as in the current working operating mode.**

Table 10 Detector Gain Settings

Selected Value	Gain (e-/ADU)
1	29
2	57
3	114
4	229
5	457
6	686
7	914

9.4 Using the Detector Binning Setting

The XRD 4343 X-ray detector family supports different binning modes. When the detector is powered on, it runs without binning (default mode). Set the detector binning by using the XIS dialog box called **Options/Detector Options** or by using the library function `Acquisition_SetCameraBinningMode(..)`. Table 11 provides an overview of the different binning modes.

⚠ **Caution**	**It is very important for the image quality that the correction files are obtained in the same binning mode, gain setting, FoV setting, and integration time as the measurements.**

Table 11 Detector Binning Modes

Value	Binning Mode
1	1 × 1 binning
2	2 × 2 binning
3	3 × 3 binning

9.5 Using the X-ray Detector Field of View Setting

The X-ray detector series supports five different Field of View (FoV) modes for XRD 4343 X-ray detector family. When the detector is powered on, it runs in the Full Field (default mode). Set the detector FoV mode by using the XIS dialog box called Options/Detector Options or by using the library function Acquisition_SetCameraFOVMode (..). Table 12 describes the different FoV modes.

Table 12 X-ray Detector Field of View Modes

FoV Value	Field of View (mm^2)	Pixel Matrix Binning 1 × 1	Pixel Matrix Binning 2 × 2	Pixel Matrix Binning 3 × 3
1	432 × 432	2880 × 2880	1440 × 1440	960 × 960
2	288 × 288	1920 × 1920	960 × 960	640 × 640
3	216 × 216	1440 × 1440	736 × 720	480 × 480
4	432 × 216	2880 × 1440	1440 × 720	960 × 480
5	432 × 72	2880 × 480	1440 × 240	960 × 160

9.6 Accessories

For safety reasons, the X-ray detector shall only be used with the XRD-EPS power supply and its approved OEM cables and connectors. All regulatory certificates and warranty terms are rendered void if any modification and/or alteration to the product is made, or any portion thereof, without the prior written authorization of Varex Imaging. Table 13 includes a list of accessories for the X-ray detector.

Table 13 Accessories for the X-ray Detector

Varex Imaging Art. No.	Description
95510354H	XRD-EPS Power Supply 215W
95510586H	XRD-EPS-B2 DC Cable 25FT / 7.6M
95510587H	XRD-EPS-B2 DC Cable 50FT / 15.25M
95510256H	Trigger Cable 16.5FT / 5M
95510257H	Trigger Cable 65.5FT / 20M
95510331H	XRD-EP AC Cable EP – Germany
95510332H	XRD-EP AC Cable EP – US[a]
95510333H	XRD-EP AC Cable EP – JP
95510334H	XRD-EP AC Cable EP – UK
95510336H	XRD-EP AC Cable EP – IEC
95510544H	XRD-EP AC Cable EP – CN
95510220H	XRD-FGE Opto V3 PCI-Express Interface Frame Grabber
95510570H	XRD-FGX Optical PC Connection Cable 7.6 m/25 ft
95510571H	XRD-FGX Optical Extension Cable 7.6 m/25 ft
95510572H	XRD-FGX Optical Extension Cable 15.25 m/50 ft
95510573H	XRD-FGX Optical Extension Cable 30.5 m/100 ft
95510574H	XRD-FGX Optical Extension Cable 91.5 m/300 ft

a. Mains plug has a Hospital Grade; 125 VAC /13 A, and VCT is required.

9.7 Power Supply (XRD EPS)

The XRD EPS (see Figure 5) is a stand-alone unit designed to support the X-ray detector. The power supply belongs to the protection class I and supports 100 V to 240 V at 50/60 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. To isolate the equipment electrically from supply mains on all poles simultaneously, the supply mains switch has to be used. The required potential equalization has to be managed through the labeled connector at the power supply.

Figure 5 XRD EPS

Table 14 includes a list of lights for XRD EPS and a status of each light.

Table 14 Status Lights for the XRD EPS

Light	Status
DC-Output (Yellow LED)	The Power Supply is overloaded. The power Supply must be switched OFF.
AC-Input (Green LED)	The Power Supply is switched ON.
DC-Output (Green LED)	The DC-Output is ON.

Table 15 includes electrical and mechanical specifications for the XRD EPS.

Table 15 Electrical and Mechanical Specification for the XRD EPS

Specifications	
Physical Dimension (L,W,H)[a]	250 mm × 83 mm × 127 mm
Weight	3.1 kg

Table 15 Electrical and Mechanical Specification for the XRD EPS (Continued)

Input AC:	100 V AC / 2.7 A max; 215 W 240 V AC / 1.1 A max; 215 W 50/60 Hz
Output DC:	5.4 V / 5 A DC 12.5 V / 10 A DC -12.5 V / 5 A DC
Internal Fuse	6.3 Ampere / 250 Volts
Protection Class	⏚ protection class I

a. Without handle.

Table 16 includes a list of environmental considerations for the XRD EPS.

Table 16 Environmental Considerations for the XRD EPS

	Transportation/Storage	Operation
Ambient Temperature	-10° to +70°C	+10° to +40°C
Relative Humidity	5% to 90%	5% to 90%

Note: No condensation.

9.8 Optical Fiber Interface

The XRD 4343 X-ray detector can be directly operated by the PCIe Frame Grabber XRD-FGE Opto over the XRD Fiber Optical Interface Bus. The Frame Grabber 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 7 and is used to set internal DLL parameters to drive and read-out the XRD 4343 X-ray detectors.

9.8.1 Frame Grabber Board XRD FGE Opto

The XRD-FGE Opto is a Frame Grabber for the PCI-Express bus with 4 Lanes (PCIe x4). The Frame Grabber contains sophisticated bus-master DMA controllers for data transfer into memory using scatter-gather DMA for linear storage of image sequences. The XRD-FGE Opto provides Field Programmable Gate Arrays (FPGAs) and memory to perform on-board corrections. The optical interface 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 (see "Section 9.8.3, Installing the Frame Grabber " on page 23.)

Table 17 Specification for the Frame Grabber XRD FGE Opto

Specification	XRD-FGe
Physical Dimension	195 mm × 107 mm
PCI-X Compliant	PCIe 2.0
PCI-Bus	4-Lane
Operation System	Windows Win 7 (32-bit/64-bit)

Table 18 Environmental Considerations for the Optical Frame Grabber

	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.

9.8.2 Connectors of the Frame Grabber

The connectors of the Frame Grabber interface boards link the XRD 4343 X-ray detector to the personal computer. The fiber optical connector on the module can be used to plug in the interface cable. The module allows data acquisition using the fiber optical interface, detector mode control via the serial configuration bus, and generation of external triggering.

1 HEX Switch
2 D-sub connector (see Figure 7 and Table 19)
3 Optical Transceiver Out
4 Optical Transceiver In

Figure 6 XRD-FGE Opto Frame Grabber

Figure 7 D-sub Connector Front View

Table 19 Description of the Frame Grabber D-Sub Connector

PIN	Description	Function
1	GP_OUT0+	frame enable
2	GP_OUT1+	frame sync
3	GP_IN0+	trigger in
4	GP_IN1+	N/A
5	GND	GND
6	GP_OUT0-	frame enable
7	GP_OUT1-	frame sync
8	GP_IN0-	trigger in
9	GP_IN1-	N/A

9.8.3 Installing the Frame Grabber

To install the Frame Grabber:

1. Shut down the computer, and unplug the power supply. Failure to do so may cause severe damage to both the motherboard and Frame Grabber. In most cases, the mainboard has an onboard LED that shows the power OFF mode or the soft-off mode (power is still on).
2. Use Good Electro Static Discharge (G-ESD) practices when handling or working on electronics.
3. Hold the grabber by the edges and do not to touch the chips, leads, or connectors.
4. Place the Frame Grabber on a grounded antistatic pad whenever the grabbers are separated from the system.

   If more than one Frame Grabber has to be used in the system, set the switch on the left side of the grabber to a unique number for every board.

Before installing the Frame Grabber driver and the application software, read the readme.txt file on the installation CD for the latest information.

9.8.3.1 Installing the Hardware

To install the hardware:

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.

9.8.3.2 Installing the driver on Windows 7

To install the driver on Windows 7:

1. After logging on, the Hardware Wizard detects the new frame grabber as an multimedia device.
2. Insert the XIS Installation CD into the CD-ROM drive.
3. Follow the wizard to install the XRD-FGE Opto as a new device.
4. After the Wizard installs the XRD-FGE Opto and XISL drivers, start the XIS setup from the menu that appears. If the Setup does not start automatically, start the START.EXE in the root directory of the CD.

   The XIS SETUP program leads you through the installation process.
5. Install the "Re-distributable Visual Studio 2013" package which is located in the folder XISL.
6. Restart the computer system.

   The XIS is now ready to start.

   If the initialization of the frame grabber and the detector is successful, a corresponding message appears in the status bar.

9.8.4 Optical Fiber Cable

The robust glass fiber optical interface provides galvanic isolation between the detector and the frame grabber and IP68 proofed plugs at the detector side, and on both sides of the extension cable (see Table 20 for the optical fiber specification).

Table 20 Optical Fiber Specification

Cable 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

9.9 Minimum Computer Requirements

The following are the minimum requirements for the host computer that controls the X-ray detector.

1. Free PCIe Slot x4.
2. Intel compatible Multi Core Processor (>3 GHz).
3. RAM > 4 GB.
4. Windows 7 32-bit/64-bit.

9.10 X-ray Imaging Software Library (XISL)

The XISL allows implementation and use of all required detector functions into specific image acquisition and processing software programs. Table 21 describes a selection of important software functions of the Software Development Kit (SDK). The functions can be easily integrated in any modular programmed software. Their specific use is described in the *X-ray Imaging Software Book*.

Table 21 XISL Modules

Group	Function Name	Description
Init	Acquisition Descriptor	Basic structure for data acquisition used by XISL.
	Acquisition_EnumSensors	Enumerates all connected sensors.
	Acquisition_GetNextSensor	Iterates through all recognized sensors.
	Acquisition_Init	Initializes driver and frame grabber.
	Acquisition_GetConfiguration	Retrieves the current configuration setting of the XISL.
	Acquisition_GetIntTimes	Routine to detect the actual frame time automatically.
	Acquisition_GetHwHeaderInfo	Returns the contents of the detector's hardware header in an info structure.
	Acquisition_GetHwHeaderInfoEx	Acquire Header and Extended Header if available.
	Acquisition_Close	Closes driver and hardware of the specified camera.
Acquire / correct	Acquisition_Acquire_Image	Acquires images from the detector.
	Acquisition_Acquire_GainImage	Acquires a gain correction image.
	Acquisition_Acquire_OffsetImage	Acquires an offset correction image.
	Acquisition_DoOffsetCorrection	Performs an offset correction on an acquired image.
	Acquisition_DoGainCorrection	Performs a gain correction on an acquired image.
	Acquisition_DoOffsetGainCorrection	Performs offset and gain correction on an acquired image.
	Acquisition_DoPixelCorrection	Performs a pixel correction on an acquired image.
	Acquisition_DefineDestBuffers	Definition of the destination buffers for image capturing.
	Acquisition_CreatePixelMap	Creates a list for a mean correction of defective pixels.
	Acquisition_GetLatestFrameHeader	Retrieve Last Frame Header and Extended Header if available.
	Acquisition_Acquire_Image_PreloadCorr	Acquire Image w/o setting correction data.
	Acquisition_Acquire_GainImage_ PreloadCorr	Acquire Gain Image w/o setting correction data.
	Acquisition_Acquire_OffsetImage_ PreloadCorr	Acquire Offset Image w/o setting correction data.
	Acquisition_ Acquire_GainImage_EX_ROI	Acquire Gain Image with defined Region of interest.
	Acquisition_Acquire_GainImage_Ex _ROI_PreloadCorr	Acquire Gain Image (ROI) w/o setting correction data.

Table 21 XISL Modules (Continued)

Group	Function Name	Description
Acquire / correct (cont.)	Acquisition_IsAcquiringData	Checks if an Acquisition Thread is running sensor is about to acquire data.
	Acquisition_CreateGainMap	Create a List of Median values for the Gain-Sequence correction.
	Acquisition_Acquire_Image_Ex	Acquires images from the detector.
	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_DoOffsetGainCorrection_Ex	Performs offset and gain-sequence correction on an acquired image.
	Acquisition_SetAcqData	Sets a 32-bit value/pointer that can be extracted by Acqusition_GetAcqData during acquisition time.
	Acquisition_Abort	Aborts a running acquisition.
	Acquisition_AbortCurrentFrame	Aborts the transmission of the current frame and immediately starts a new transfer.
Detector settings	Acquisition_SetCameraMode	Allows setting of detector frame time.
	Acquisition_SetCameraGain	Set Detector Gain (not available for all detectors).
	Acquisition_SetCameraBinningMode	Set binning mode (not available for all detectors).
	Acquisition_GetCameraBinningMode	Retrieve actual binning mode.
	Acquisition_SetCameraTriggerMode	Set trigger mode (not available for all detectors).
	Acquisition_GetCameraTriggerMode	Retrieve actual trigger mode.
	Acquisition_ResetFrameCnt	Reset detector Frame counter (not for all detectors).
	Acquisition_SetFrameSyncTimeMode	Set Parameters for 'Data Delivered on Demand' trigger mode.
	Acquisition_SetTimerSync	Set Internal Trigger Time.
	Acquisition_SetTriggerOutSignalOptions	This function defines the behavior of the '/TrigOut' - signal of the detector trigger connector.
	Acquisition_SetCameraROI	This function enables a selectable Regions of Interest for Readout.
	Acquisition_GetCameraROI	This function returns the current activated Region of Interest for Readout.
	Acquisition_SetDACoffset	Use this function to sets the DAC for offset floor level within the detector
	Acquisition_ SetDACOffsetFloorValueByMode	This function changes the detector DAC Offset setting for the selected mode.
	Acquisition_ SetDACOffsetFloorValueInFlash	This function writes the desired offset value to the detector memory for the selected mode. It must be set using Acquisition_SetDACoffset.

Table 21 XISL Modules (Continued)

Group	Function Name	Description
	Acquisition_ GetDACOffsetFloorValueFromFlash	This function reads the desired offset value from the detector memory for the selected mode. It must be set using Acquisition_SetDACoffset.
	Acquisition_ActivateServiceMode	This function activates the Service Mode.
CallBack	Acquisition_GetReady	Informs the user if image processing is flagged as ready.
	Acquisition_SetReady	Informs the XISL that the user image processing is ready.
	Acquisition_IsAcquiringData	Checks if an Acquisition Thread is running.
	Acquisition_GetWinHandle	Returns the handle of the current acquisition window.
	Acquisition_GetAcqData	Extracts a 32-bit value/pointer at acquisition time that was set by Acqusition_SetAcqData.
	Acquisition_GetActFrame	Retrieves the nr of the current frame in the ring buffer.
Error Handling	Acquisition_GetErrorCode	Returns extended information if an error occurred.

9.11 Description of the Hardware Header

The Hardware Header is transferred at the beginning of each frame. Table 22 shows the structure of the header. HeaderID is the type of the header, and if this number is zero then the whole hardware header is invalid.

Table 22 Image Header for the X-ray Detector

Type	Parameter	Description
WORD	wHeaderID	Identifies the used header version (>=14).
WORD	wPROMID	Identifies the detector's PROM set.
WORD	wResolutionX	Detector's pixel resolution in x direction.
WORD	wResolutionY	Detector's pixel resolution in y direction.
WORD	wNrRows	Number of sensor rows.
WORD	wNrColumns	Number of sensor columns.
WORD	wZoomULRow	Row of the upper left edge of zoom region.
WORD	wZoomULColumn	Column of the upper left edge of zoom region.
WORD	wZoomBRRow	Row of bottom right edge of zoom region.
WORD	wZoomBRColumn	Column of bottom right edge of zoom region.
WORD	wFrmNrRows	Number of rows used to synthesize the frame scheme of the detector. It results from the number of sensor rows plus the number of rows in which the sensor only integrates charge but does not transfer data to the frame grabber.
WORD	wFrmRowType	Identifies the implemented Row scheme.
WORD	wRowTime	Detector row time in 32-MHz Ticks (6-bit shifted to the left).
WORD	wClock	Detector row time in MHz (6-bit shifted to the left).
WORD	wDataSorting	See sorting.
WORD	wTiming;	Selected integration time.
WORD	wGain;	Selected detector gain.
WORD	wLeakRows;	Number of rows without driven gates.
WORD	wAccess;	Access mode.
WORD	wBias;	Selected detector Bias mode.
WORD	wUgComp;	Selected detector compensation.
WORD	wCameratype;	Detector type (1 support Binning, 2 supports Binning and special TriggerModes.)
WORD	wFrameCnt;	Internal Frame counter of the detector.
WORD	wBinningMode;	Selected detector binning mode (see Section 9.4).
WORD	wRealInttime_milliSec;	Measured integration time of actual frame (millisec).
WORD	wRealInttime_microSec;	Measured integration time of actual frame (microsec).

Table 22 Image Header for the X-ray Detector (Continued)

Type	Parameter	Description
WORD	wStatus;	Detector status word: Bit 0: 0 - OK 1 – Trigger lost Bit 1-3 Trigger mode: Value 0: Data Delivered on Demand 1: Data Delivered on Demand with clearance scan 2: reserved 3: Frame wise (default) Bit 4: reserved Bit 5: DAC Error Code Bit 0 Bit 6: DAC Error Code Bit 1 Bit 7: DAC Error Code Bit 2 Bit 8: Trigger Switch Current Setting 0 internal/1 external
WORD	wCommand1	Reserved.
WORD	wCommand2	Reserved.
WORD	wCommand3	Reserved.
WORD	wCommand4	Reserved.
WORD	wDummy	Contains the revision of the PROM ID (wPROMID).

9.12 Description of the File Header

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

Table 23 Description of the File Header

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, bad pixel correction data
BYTE x[WINRESTSIZE]	Fill up to 68-byte

10.0 Operational Functions

10.1 Getting the First Image

10.1.1 Introduction

This section describes how to obtain initial X-ray images. 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 not to be used for standard detector operation. Refer to the **X-ray Imaging Software Book** for detailed information about the XIS and the XISL.

10.1.2 General Considerations

In principal, the detector can produce images without any correction. These non-corrected images are containing the offset of the readout electronics, the gain variations and the X-ray source geometries. The Offset has the information of the dark current of each diode and the readout electronics. The Gain variations are resulting from the variation between the single diodes and the A/D converters.

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 that are brighter than the others caused by a higher dark current. The detector is arranged in blocks of readout channels. The groups can deviate in their gain such that one can distinguish these blocks in a bright image caused by this gain difference. The panel itself may contain pixels and perhaps row or columns that are under-performing.

To eliminate these detector specific effects and obtain good quality results, each image will be “offset” and “gain” corrected, and if required, the under-performing pixels will also be corrected. The creation of the correction files is described in Section 10.2, Performing Corrections. Never acquire calibration files while the detector is not completely stationary, such as during detector handling or transportation.

10.1.3 Connecting the X-ray Detector with the Optical Fiber I/F

Before connecting the X-ray detector, ensure that the XIS is installed as described in “Section 9.8.1, Frame Grabber Board XRD FGE Opto” on page 21. Figure 8 shows the connection of the X-ray detector with the computer system via the Optical Fiber I/F and the XRD EPS.

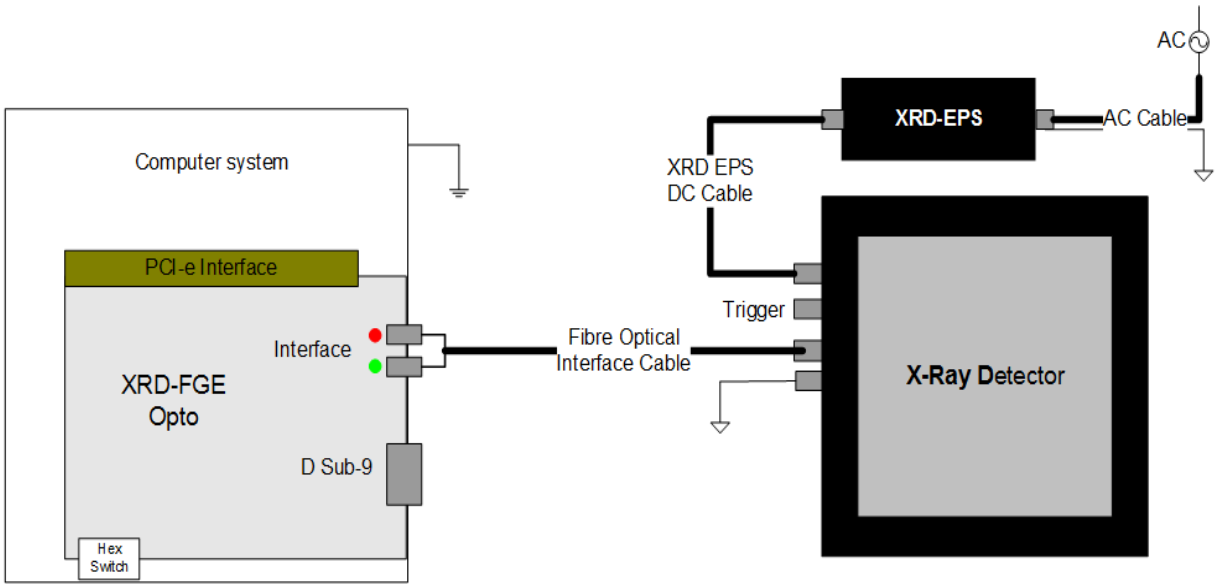


Figure 8 Connections of the XRD 4343 X-ray detector with the XRD EPS Power Supply

The computer with the monitor and the power supply needs to be grounded through the protection earth conductors within the power cords. The required potential equalization of the X-ray detector and the XRD EPS must be managed through the labeled connectors. The socket-outlet shall be installed near the equipment and shall be easily accessible. The X-ray detector should be connected as described in the following manner and as shown in Figure 8.

To connect the X-ray detector:

1. Connect the X-ray detector and the XRD EPS with the potential equalization.
2. Connect the Computer and the X-ray detector using the Optical Interface Cable.
3. Connect the XRD EPS-B2 DC cable to the Power Connector of the X-ray detector.
4. Connect the XRD EPS and the XRD EPS-B2 DC cable.
5. Connect the XRD EPS with the mains and protective earth using the XRD EP AC cable2.
6. Turn on the power supply at the supply main switch.
7. Turn on the computer.
8. Start the Application Software, for example, XIS.

10.1.4 Acquiring the First Image with the Optical Fiber I/F

To acquire the first image follow the steps below.

Note	Sudden cooling or heating of the room will cause condensation. In this case, wait until condensation disappears before powering on the X-ray detector system.

WARNING	**If the detector system is used under condensation conditions, problems in image quality or malfunction of the detector system may occur. In addition, this may cause fire, electrical shock, and unknown hazards, which may result in severe personal injury, death, or substantial product damage.**

1. Ensure that the X-ray detector is connected to the frame grabber and is powered on.

   When XIS starts, a dialog box asks you to select the working mode of the system.

2. Choose **Yes** to enable the Interrupt Mode.

   The Cancel button starts the program without initialization. The initialization can take some time depending on the number of connected detectors. If more than one detector is connected, a dialog box appears that contains a list of all recognized detectors.

3. Select an active detector. All of the following actions apply to that active sensor until you select a different one.

   The Acquire\Single Shot command acquires a single image. If the detector was not irradiated, only a dark image is displayed.

4. If desired, enhance the image using the brightness and contrast settings. As explained above, the uncorrected dark image contains vertical stripes caused by the electronics offset.
5. To refresh the image on the display in the selected frame rate, choose **Continuous Acquisition** mode.
6. Run the detector in continuous mode, and turn on the X-ray source to irradiate the detector.
7. Set the brightness and contrast 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, adjust the X-ray source accordingly.

After applying the required corrections, the image should look like a clear grey image without any artifacts. The next steps are acquisitions of average images of 10 frames at the gain range and at 50% of the gain range. Both averaged images should not show any image artifacts. These files can be stored as a quality verification test files, which should be acquired on a monthly base.

10.1.5 Stopping the Operation of the Detector

To stop the detector operation, turn off the power supply switch, which isolates the equipment electrically from supply mains on all poles simultaneously.

WARNING	**If the detector has to be disconnected, make sure that the XRD EPS is turned off first. The cables must be disconnected by using the connectors and not by the cable itself as stressing the cable will destroy the cable and may cause fire or electrical shock. Do not disassemble the detector system with wet hands.**

10.2 Performing Corrections

After starting the XIS.EXE software, the detector is automatically initialized and provides images in the fastest setting (Timing 0). The X-ray detector needs an Offset correction to account for the dark current of each pixel. Initially, during warm-up period, measurements should not been taken since offset value may not be stable. The Warm-up of the detector takes a few minutes and can be reviewed by the stability of the offset values.

In general, a periodic refresh of the Offset Correction File is required during operation to meet the full performance specifications. Never acquire calibration files while handling or transporting the detector.

In addition, a Gain correction is required to account for differences in pixel sensitivities. The X-ray beam also has uniformities due to its shape. These uniformities will also be corrected. 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 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 under performing pixels to enhance image quality. Under performing pixel values are replaced with the averaged value of the surrounding eight adjacent pixels where under performing pixels are not used. The pixel correction is only performed on specific pixels mapped in the file PXLMASK.HIS. Each detector is shipped from Varex Imaging with the PXLMASK.HIS file for that specific detector. The user can also generate a correction file.

Note	To fully meet all performance specifications, all correction files must be acquired using the same detector and X-ray settings as the images to be corrected.

Caution	**Do not acquire images and calibration files while handling the detector. This can disturb the image quality and result in the wrong diagnosis.**

10.2.1 Using 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:

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 achieves equilibrium.
4. Start the Get Offset Image/Start All Offset Images Select a number of frames.
   We recommend you use between 20 and 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.
5. Control the new acquired image using the Options/View command and/or Brightness, Contrast or LUT range.
6. Save the Offset correction file, if desired.

Note	If you close the program without saving the newly acquired Offset correction file, a warning appears and you can save the Offset. 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.

10.2.2 Using 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:

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 readout 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. Store the Offset corrected bright image.
7. For Multiple Gain Correction, repeat steps 3-6 for all signal intensities of interest. Up to 10 gain images can be used for the Multi Gain Correction (MGC).
8. Create the Gain Sequence of all Bright Images 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 Gain correction file, if desired.

Note	If the program is closed without saving the new Gain correction file, a warning appears, and you can save the Gain files.

10.2.3 Using and Generating Pixel Correction

The Pixel Correction of images is used to eliminate the effects of under performing pixels of the detector on acquired images. Each detector is shipped with the original bad pixel map(s) that can be directly used for pixel correction. The method below describes how to generate a user created bad pixel map when desired.

To get a Pixel correction file:

1 Select the desired frame time (see the Timings menu).

2 Link correction files.

3 Switch on the X-ray source and start the continuous mode.

The detector's acquired intensity should be about 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 Look up Table (LUT) range.

The window should show a homogenous corrected image. Intensity deviations are the result of marginal pixels.

6 Adjust the X-ray source so that the detector's acquired intensity is about 30-40% of its maximum signal.

7 Acquire an average image of 20-100 frames.

8 From the Edit menu, select **Value**.

9 Enter the desired range of good pixels (for example, ±10% around the selected gray value).

10 Click the **Out of range** button.

All selected pixels are marked.

11 From the Edit menu, choose **Create Pixel Map**.

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 Step 4) is also corrected.

10.2.4 Correcting Previously Acquired Images

You can correct previously acquired uncorrected images by selecting the desired image using the Window Command and a Link Command (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	We recommend you do not close linked correction files during a running acquisition. This can cause the application to close.

10.3 Procedure for offset setting

10.3.1 Introduction

The XRD 4343 X-ray detector operates in a wide range of imaging modes, and the offset characteristics varies with imaging modes due to the well-known intrinsic nature of amorphous silicon material. To leverage the full potential of the imaging capability the XRD 4343 X-ray detector offers, the offset floor needs to be adjusted for the imaging mode the user chooses. The offset floor (or load zero offset value) can be changed by adjusting an offset floor setting value, v1, either in XIS or using an XISL function. One can use the expression provided below to estimate the shift in offset in ADU as the function of change, Δv1.

$$ShiftInOffset(ADU) \approx \frac{1300e/(ADU) \times \Delta v1(ADU)}{gain\left(\frac{e}{ADU}\right)}$$

One can see that the offset can be adjusted up or down by increasing or decreasing v1 value. The recommended v1 values for various imaging modes are listed in the column of “offset floor” in Table 24, in Section 10.3.3, Recommended offset floor setting values.

Caution	**One may need to make a slightly adjustment around these recommended values to assure that, there will be no low clipped pixels and the dynamic range is not compromised.**

10.3.2 Offset adjustment using XISL call function

The offset setting value, v1, can be set by using the following XISL function. The `wDACoffsetValue` is v1.

```
HIS_RETURN Acquisition_SetDACoffset(HACQDESC hAcqDesc, WORD
wDACoffsetValue).
```

`hAcqDesc:` Pointer to acquisition descriptor structure.

`wDACoffsetValue:` Offset floor setting value v1.

The detector offers predefined image modes where the offset floor value is stored in the detector memory. These predefined Modes # are listed in the Table 24 and can be accessed by the following XISL function.

```
HIS_RETURN Acquisition_SetDACOffsetFloorValueByMode(HACQDESC
hAcqDesc,unsigned int uiMode);
```

`hAcqDesc`: Pointer to acquisition descriptor structure.

`uiMode`: Predefined Mode # from Table 24.

10.3.3 Recommended offset floor setting values

The recommended offset floor setting values are listed in Table 24 for different imaging modes for users' reference. These values may vary a little from detector to detector, and some fine adjustment may be required for a specific detector. A general guidance is that the offset floor should be adjusted to such a level that it does not have clipped pixels on an offset image and meantime allows the detector to maintain a desired dynamic range.

Table 24 Predefined imaging modes for XRD 4343 detector

Mode #	Mode	Field of View (W × H mm^2)	Frame Rate (fps)	Gain	Offset floor (v1)	Application Examples
0	1 × 1 Full	432 × 432	15	1 ~ 7	300	CBCT
1	1 × 1 Full	432 × 432	6	4,5,6,7	700	CBCT
2	1 × 1 Full	432 × 432	4	4,5,6,7	700	Rad/CBCT
3	1 × 1 Full	432 × 432	1	4,5,6,7	700	Rad/CBCT
4	1 × 1 Full	432 × 432	0.4	4,5,6,7	700	TOMO 2s
5	1 × 1 Full	432 × 432	0.2	4,5,6,7	700	TOMO 4s
6	2 × 2 Full	432 × 432	12	4,5,6,7	450	Rad/CBCT
7	3 × 3 Full	432 × 432	20	1,2,3	500	Continuous Fluoro
8	3 × 3 Full	432 × 432	15.2	1,2,3	500	Pulsed Fluoro
9	2 × 2 Med.	288 × 288	20	1,2,3	400	Continuous Fluoro

Table 24 Predefined imaging modes for XRD 4343 detector

Mode #	Mode	Field of View (W × H mm^2)	Frame Rate (fps)	Gain	Offset floor (v1)	Application Examples
10	2 × 2 Med.	288 × 288	15	1,2,3	400	Pulsed Fluoro
11	1 × 1 Small	216 × 216	20	1,2,3	150	Continuous Fluoro
12	1 × 1 Small	216 × 216	15	1,2,3	150	Pulsed Fluoro
13	2 × 2 Small	216 × 216	30	1,2,3	300	Continuous Fluoro
14	2 × 2 Small	216 × 216	15.2	1,2,3	300	Pulsed Fluoro
15	1 × 1 Rect. Full	432 × 216	19	1,2,3	200	CBCT (2ms exposure time, fastest speed)
16	1 × 1 Rect. Full	432 × 216	12	1,2,3	200	CBCT (low exposure)
17	2 × 2 Rect. Full	432 × 216	37	1,2,3	300	CBCT (2ms exposure time, fastest speed)
18	2 × 2 Rect. Full	432 × 216	18	1,2,3	350	CBCT (low exposure)
19	2 × 2 Rect. Full	432 × 216	8	4,5,6,7	700	CBCT (high exposure)
20	3 × 3 Rect. Full	432 × 216	53	1,2,3	300	CBCT (2ms exposure time, fastest speed)
21	3 × 3 Rect. Full	432 × 216	21	1,2,3	500	CBCT (low exposure)
22	3 × 3 Rect. Full	432 × 216	8	4,5,6,7	700	CBCT (high exposure)
23	1 × 1 Rect. Med.	432 × 72	53	1,2,3	200	CBCT (2ms exposure time, fastest speed)
24	1 × 1 Rect. Med.	432 × 72	21	1,2,3	200	CBCT (low exposure)
25	1 × 1 Rect. Med.	432 × 72	8	4,5,6,7	700	CBCT (high exposure)
26	2 × 2 Rect. Med.	432 × 72	72	1,2,3	200	CBCT (2ms exposure time, fastest speed)
27	2 × 2 Rect. Med.	432 × 72	23	1,2,3	350	CBCT (low exposure)
28	2 × 2 Rect. Med.	432 × 72	8	4,5,6,7	700	CBCT (high exposure)
29	3 × 3 Rect. Med.	432 × 72	83	2,3	200	CBCT (2ms exposure time, fastest speed)
30	3 × 3 Rect. Med.	432 × 72	25	1,2,3	500	CBCT (low exposure)
31	3 × 3 Rect. Med.	432 × 72	9	4,5,6,7	700	CBCT (high exposure)

11.0 Inspection and Maintenance

WARNING	**The X-ray detector must be repaired by Varex Imaging authorized personnel only. Ignoring this warning may result in explosion, fire, electric shock, or unknown hazards, which may result in severe personal injury, death, or substantial product damage.**
Caution	**Inspect the X-ray detector before use. In addition, carry out prescribed, regular inspections per the instructions in this manual.**

It is important that the X-ray detector is used safely and as intended. Inspect the X-ray detector and its accessories before use. If any problem is found during the inspection, correct the problem, and take the measures indicated in this section. If the problem cannot be corrected, contact your dealer, distributor, or any Varex Imaging subsidiaries (regional service headquarters) listed on the last page of this document.

We recommend that records of the inspection be kept close to the X-ray detector. You can use copies of the checklist in this section, or you can make your own copies of the checklist.

11.1 Daily Inspection

Perform the following inspection daily. If there is any problem, immediately ask your establishment's safety representative to contact your dealer, distributor, or device manufacturer.

11.1.1 Before Turning On the Power

	Inspection	Result Date/	Date/	Date/	Remedy
Cables	Check all cables (AC-cable, DC-cable, Optical Fiber cable, Sync cable) to ensure that they are not damaged and the insulation is not damaged.	Good/Bad	Good/Bad	Good/Bad	Contact your dealer, distributor, or device manufacturer if there is a problem.
	Check all connector plugs and locks to ensure they are not loose.	Good/Bad	Good/Bad	Good/Bad	Fully insert the connectors and lock them.

Detector	Check that the X-ray detector is not damaged.	Good/Bad	Good/Bad	Good/Bad	Contact your dealer, distributor, or device manufacturer if there is a problem.
	Check that the X-ray detector is not loose and all screws are fixed.	Good/Bad	Good/Bad	Good/Bad	Contact your dealer, distributor, or device manufacturer if there is a problem.

11.1.2 After Turning On the Power

	Inspection	Result Date/	Date/	Date/	Remedy
General	Check that the X-ray detector's power ON LED is green.	Good/Bad	Good/Bad	Good/Bad	Connect the power cable and the AC cable properly. Check the status LED at your power supply, if applicable.
	Check that the detector mode LED is flashing.	Good/Bad	Good/Bad	Good/Bad	Connect the data cable properly, and ensure that the Digital Radiography Software is started.
	Perform test exposure as described in the System Manual supplied by the system manufacturer or third party provider.	Good/Bad	Good/Bad	Good/Bad	If any error messages appear, follow the instructions in the System Manual supplied by the system manufacturer or third party provider. If there is a problem, contact your dealer, distributor, or device manufacturer.

11.1.3 After Turning Off the Power

	Inspection	Result Date/	Date/	Date/	Remedy
General	Check that the X-ray detector is turned off normally and that all LEDs are OFF.	Good/Bad	Good/Bad	Good/Bad	See Section 10.1.5 for turning off the X-ray detector.
General	Make sure that the X-ray detector is clean and disinfected.	Good/Bad	Good/Bad	Good/Bad	See "Section 11.5, Cleaning the X-ray Detector" on page 45 for cleaning the X-ray detector.

11.2 Monthly Inspection

Perform the following inspection at least once a month. If there is a problem, immediately ask your establishment's safety department to contact your dealer, distributor, or device manufacturer.

	Inspection	Result Date/	Date/	Date/	Remedy
General	Execute an Image Performance Test using a phantom or an Image Quality Indicator (IQI) as described in the User Acceptance Test or, if applicable, in national standards and guidelines.	Good/Bad	Good/Bad	Good/Bad	If there are changes in performance, acquire new calibration files as described in Section 10.2. Contact your dealer, distributor, or device manufacturer if there is a problem.

11.3 Yearly Inspection

Perform the following inspection at least once a year. If there is any problem, immediately ask your establishment's safety department to contact your dealer, distributor, or device manufacturer.

	Inspection	Result Date/	Date/	Date/	Remedy
General	Execute an Image Performance Test using a phantom or an Image Quality Indicator (IQI) as described in the User Acceptance Test or, if applicable, in national standards and guidelines.	Good/Bad	Good/Bad	Good/Bad	If there are changes in performance, acquire new calibration files as described in Section 10.2. Contact your dealer, distributor, or device manufacturer if there is a problem.

11.4 Calibrating the X-ray Detector

When exposure conditions have changed significantly (for example, new energy settings, new X-ray tube, new distances), acquire new gain calibration files. Follow the instructions in Section 10.2.

11.5 Cleaning the X-ray Detector

WARNING	**When the X-ray detector system is going to be cleaned, turn off the X-ray detector by turning off the power supply. Turn off the power switch, and unplug the power cable. Never use thinner, benzine, acetone, or other flammable cleaning agents. Ignoring this warning may result in explosion, fire, or electric shock, which may result in severe personal injury, death, or substantial product damage.**

To clean the X-ray detector:

1. Turn off the X-ray detector.
2. Unplug the power cable, if applicable.
3. Wipe the X-ray detector surface with commercially available ethanol papers or a cleaning cloth dampened with ethanol or a diluted neutral detergent.

Note	If you are using a disinfectant other than those specified, we recommend you consult a specialist for the procedure for disinfection.

4 Remove any excess detergent or solution.
5 Wipe the X-ray detector surface with a clean cloth to completely dry the X-ray detector.
6 Allow the X-ray detector to completely air dry before turning on or storing the X-ray detector.

11.6 Troubleshooting and FAQs

For a list of Frequently Asked Questions (FAQs) about XIS and XISL go the following web address:

http://shop.perkinelmer.com/downloads/walluf/XIS_XISL_FAQ.pdf

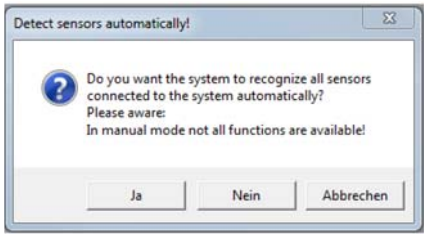
If any error messages appear, follow the instructions in the **X-ray Imaging Software Book**. If there is any problem that is not described in the manual, immediately ask your establishment's safety representative to contact your dealer, distributor, or device manufacturer.

WARNING	**If any abnormal condition, such as smoke, fumes, or strange sounds, is evident, turn off the X-ray detector, turn off and unplug the power supply from the AC outlet, and immediately ask your establishment's safety representative to contact your dealer, distributor, or device manufacturer.** **Further use under abnormal conditions may result in severe personal injury, death, or substantial product damage.**

Table 25 Troubleshooting Errors

Error	Description/Resolution
XISL Error 1	If the function Acquisition_Acquire_Image returns 1, one possible reason can be the memory situation of the host system. Check your "boot.ini" file to see if the flag/3GB is set. If it is, remove the flag and try to acquire image data after rebooting the system. If the function is not able to allocate enough memory for image acquisition (which at least is the size of the internal, 8 images comprising ring buffer), it also returns this error.

Table 25 Troubleshooting Errors (Continued)

XIS Error 2 // Eltec Error –41: Virtual device driver not present	No driver is loaded. Check that the driver for the optical interface is loaded.
XIS Error 23: Hardware header invalid	1 Check the connections of the detector to the Frame Grabber. 2 Check if there are older libraries of an earlier installation.  3 Use the Option/Acquisition dialog box to run the detector setup. 4 Note the header information, and contact your vendor.

12.0 After-Sales Service for Varex Imaging Products

Contact your distributor for after-sales service (including warranty conditions) or any other information. In case information is not available, contact one of the Varex Imaging subsidiaries (regional service headquarters) listed on the last page of this document.

Field service is limited to replacement of detector or adding and replacing approved accessories by authorized personnel. The detector and its accessories are not intended to be repaired in the field. For product returns, contact your distributor or Varex Imaging for shipping and packaging instructions. Do not return products to Varex Imaging for repair or service without advance notification. Include all required papers in the shipment.

If the detector or accessories have been contaminated with potentially harmful substances or activated by high energy X-rays, gamma rays, or neutrons, they cannot be accepted without written evidence of decontamination.

13.0 Disposing of the X-ray Detector

If the X-ray detector is activated by high energy X-rays, gamma rays, or neutrons, follow the local radiation protection regulation.

Contact your supplier or distributor, and check the terms of conditions of the purchase contract. This product should not be mixed with other commercial waste for disposal.

A label with a crossed-out wheeled bin symbol and a rectangular bar indicates that the product is covered by the Waste Electrical and Electronic Equipment (WEEE) Directive and is not to be disposed of as unsorted municipal waste. Any products marked with this symbol must be collected separately, according to the regulatory guidelines in your area.

The objectives of this program are to preserve, protect, and improve the quality of the environment, protect human health, and utilize natural resources prudently and rationally. Specific treatment of WEEE is indispensable in order to avoid the dispersion of pollutants into the recycled material or waste stream. Such treatment is the most effective means of protecting the customer's environment.

Requirements for waste collection, reuse, recycling, and recovery programs vary by regulatory authority at your location. Contact your local responsible body (for example, your hospital, clinic, establishment, or site manager) or authorized representative for information regarding applicable disposal regulations. Contact Varex Imaging at the following web site for information specific to Varex Imaging products.

Web Address:

www.perkinelmer.com/weee

The Varex Imaging product may be attached as part of a component to other manufacturers' systems. These other manufacturers are directly responsible for the collection and processing of their own waste products under the terms of the WEEE Directive. Contact these producers directly before discarding any of their products. Consult the Varex Imaging web site (above) for producer names and web addresses.

13.1 Guidance and Manufacturer's Declaration

The X-ray detector is intended for use in the electromagnetic environment specified below. The X-ray system installer, X-ray system manufacturer, or user of the X-ray detector is responsible for the usage condition of the X-ray detector to be within such environment.

13.1.1 Electromagnetic Immunity

Table 26 Electromagnetic Immunity

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) 1 kV (DC)	0.5 kV (AC) 1 kV (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%/500 ms >–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, we recommend that the X-ray detector be powered from an uninterruptible power supply

13.1.2 Guidance and Manufacturer's Declaration of Electromagnetic Emissions

Table 27 Electromagnetic Emissions

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 A	The X-ray Detector is suitable for use in these environments.
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/ flicker emissions IEC 61000-3-3	Complies	

13.1.3 Recommended Separation Distance between Portable & Mobile RF-Communication Equipment and the X-ray Detector

Table 28 Recommended Separation Distance

Rated Maximum Output Power of the Transmitter (W)	150 kHz to 80 MHz $d = 1.2\sqrt{P}$	80 MHz to 800 MHz $d = 1.2\sqrt{P}$	800 MHz to 2.5 GHz $d = 2.3\sqrt{P}$
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 a 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 is the recommended separation distance in meter (m).

Note: This guideline may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people.

13.1.4 Guidance and Manufacturer's Declaration of Electromagnetic Immunity (Portable Equipment)

Table 29 Portable Equipment

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	[V1] 3 V 150 kHz to 80 MHz	Portable and mobile RF-communication equipment should not be 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.
Radiated electromagnetic field (REF) IEC 61000-4-3	3 V/m 80 MHz to 2.5 GHz	[E1] 3 V/m 80 MHz to 2.5 GHz	$d = 1.2\sqrt{P}$, for 150 kHz to 80 MHz, $d = 1.2\sqrt{P}$, for 80 MHz to 800 MHz, $d = 2.3\sqrt{P}$, for 800 MHz to 2.5 GHz, where P is the maximum output of the transmitter in watt (W) according to the transmitter manufacturer and d is 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: These guidelines may not apply to all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people. 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, amateur 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 X-ray detector 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.

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