

### **KEY FEATURES**

The XDAS-V3 system is the latest version of Sens-Tech X-ray data acquisition systems. New features include:

- Operation by external trigger
- 10  $\mu$ s minimum integration time
- 43  $\mu$ s minimum scan time for continuous operation
- 16 bit A/D conversion
- Up to 36000:1 SNR
- Programmable dynamic range from 1.875pC to 60pC in steps of 1.875 pC.
  - \* 30pC and 60pC using sub-samples
- Gain can be set for each DH board in the system
- Gain for low energy and high energy channels can be set independently
- Programmable bandwidth limiting to reduce noise
- In-system programmable Xilinx FPGA
- Front-lit detectors
- Read back of status and configuration parameters
- Programmable integration time in steps of 1 $\mu$ s
- Separate integration times for low and high energy
- USB 2.0, GigE or parallel interfaces to host
- X-ray energy range 5 keV to 320 keV
  - \* higher energy range is covered by suitable combination of photodiode and scintillator
- Software API supporting Windows and Linux





### **DESCRIPTION**

XDAS-V3 is a modular system of boards for data acquisition in X-ray line-scan, multi-view and CT systems. It consists of detector head (DH) boards, signal processing (SP) boards and host interface board.

A single energy DH board has 128 detector channels. A dual energy system requires separate DH board for low and high energy. Detector boards can be butted end-to-end to form a continuous array over 10 metres in length.

An optional low energy filter is used for enhanced low and high energy separation.

DH boards with 0.4 mm, 1.6 mm and 2.5 mm detector pitch are also available. See separate data sheets.

### **APPLICATIONS**

- |                           |                              |                              |
|---------------------------|------------------------------|------------------------------|
| • Security inspection     | • Food inspection            | • Industrial process control |
| • CT Imaging              | • Thickness measurement      | • Mineral sorting            |
| • Multi-view imaging      | • Foreign particle detection | • Waste sorting              |
| • Non-destructive testing | • Bone densitometry          |                              |



### GENERAL SPECIFICATION

<b>INTEGRATION TIME (SINGLE SAMPLE)</b> 10 μs to 50 ms	<b>INTEGRATION TIME (MULTIPLE SAMPLES)</b> 200 ms (max)							
<b>SUB-SAMPLES</b> 1, 2 or 4	<b>POWER SUPPLY INTERFACE BOARD</b> 12V (9V to 30V), 100 mVp-p ripple							
<b>CROSS-TALK (BOARD TO BOARD)</b> <0.01%	<b>CURRENT (TYPICAL)</b> DH: 125 mA to 150mA SP: 200mA to 900mA Interface board: 100mA to 500mA							
<b>CROSS-TALK (CHANNEL TO CHANNEL)</b> <0.1%								
<b>DATA RATE (MAXIMUM)</b> 48 MB/s	<b>SNR* (ELECTRONIC)</b> <table><tr><td>3.75pC</td><td>14500:1</td></tr><tr><td>15pC</td><td>19000:1</td></tr><tr><td>60pC</td><td>36000:1</td></tr></table>		3.75pC	14500:1	15pC	19000:1	60pC	36000:1
3.75pC			14500:1					
15pC			19000:1					
60pC	36000:1							
<b>NON-LINEARITY</b> <0.1%								
<b>A/D CONVERSION</b> 16 bits	<b>SNR* (&lt;10PF DETECTOR CAPACITANCE)</b> <table><tr><td>3.75pC</td><td>10000:1</td></tr><tr><td>15pC</td><td>18000:1</td></tr><tr><td>60pC</td><td>34000:1</td></tr></table>		3.75pC	10000:1	15pC	18000:1	60pC	34000:1
3.75pC			10000:1					
15pC			18000:1					
60pC	34000:1							
<b>DATA OUTPUT</b> 16 bits								
<b>DETECTOR PITCH (MM)</b> 0.8 mm	<b>NUMBER OF CHANNELS</b> up to 21504							
<b>NUMBER OF SP BOARDS</b> up to 7	<b>NUMBER OF DH BOARDS</b> up to 168							

Note 1: Interface board steps down input supply to 6V (max 5A) for SP boards. SP boards provides power to DH boards.

Note 2: SNR is calculated for ADC full scale and bandwidth limiting enabled.



### ENVIRONMENTAL SPECIFICATION

#### TEMPERATURE

Operating	0 to +60 °C
Storage	-40 °C to +70 °C

#### HUMIDITY (NON-CONDENSING)

Operating	30°C 93%
Non-operating	40°C 93%

### PRINCIPLES OF OPERATION

Current from the photodiodes is integrated by an ASIC containing 128 charge sensitive amplifiers.

**See detector head block diagram.** Correlated double sampling is used to minimise low frequency noise and reject offset error. The microcircuit provides a multiplexed serial analogue output to the signal processing board where data is converted into 16-bit format. Operation is continuous with one set of data being read out whilst the next set is acquired. Dead time is 1.6  $\mu$ s at full bandwidth.

The dynamic range of the system is programmable for each DH board and is determined by the storage capacitors within the ASIC. These can be set from 1.25 pF to 10 pF in steps of 1.25 pF, providing charge storage of 1.875 pC to 15 pC in 1.875 pC steps. The dynamic range can be set separately for high and low energy channels.

**See system configuration block diagrams, page 11**

Multiple sampling facility is available on the SP board. This enables 2 or 4 samples to be added providing a maximum dynamic range of 60 pC.

Integration time can be adjusted in 1 $\mu$ s steps. Low and high energy detectors can be set different integration times enabling fine tuning of the dynamic range for the two detectors.

The operation of the system is controlled by a gate array which provides central intelligence and control signals for signal processing. Control settings are transmitted to the SP board via a serial, USB or GIGE interface. All settings can be stored in non-volatile RAM such that on power-on, the system is initiated in the last mode saved. **See signal processing block diagram.**



### PRINCIPLES OF OPERATION

See system configuration block diagrams, page 11

A system is assembled by interconnecting multiple DH and SP boards and connecting to a processor via an interface adaptor board. The system data rate (host speed) is programmable from 3.0 to 48 MB/s.

See system block diagram.

### DATA ACQUISITION RATE AND POWER

Signal integration time in a typical line scan application is as calculated using following formula:

$$\text{Integration time (ms)} = \text{pixel width (mm)} / \text{belt speed (m/s)}$$

*Example: integration time setting for 0.8mm pixel width scanning at 1m/s belt speed shall be  $0.8 / 1 = 0.8 \text{ ms}$*

Speed of operation is normally limited by processing speed of an SP board. Two speeds are available. The SP board takes 42.7  $\mu\text{s}$  at 3MSps and 85.4  $\mu\text{s}$  at 1.5MSps to process a DH board. Minimum continuous integration time of a system can be calculated using following formula:

$$3\text{MSps: Tint (minimum)} = 1.6\mu\text{s} + (\text{num DH per SP} \times 42.7\mu\text{s})$$

$$1.5\text{MSps: Tint (minimum)} = 3.2\mu\text{s} + (\text{num DH per SP} \times 85.4\mu\text{s})$$

*Example: minimum integration time for a 9 DH board and 1 SP board system shall be  $1.6 + 9 \times 42.7 = 386 \mu\text{s}$*

Multiple SP boards process DH boards in parallel.

*Example: minimum integration time for a 18 DH board and 2 SP board system shall be  $1.6 + \frac{18}{2} \times 42.7 = 386 \mu\text{s}$*

Shorter integration time setting will switch electronics to a non-continuous mode. The SP board increases dead time to allow for ADC conversion to complete before starting the next integration cycle.

A total of 258 bytes is read out per DH board. This includes 2 bytes per pixel and 2 header bytes representing SP address and DH address. There are five host bus speed settings available: 3, 6, 12, 24 and 48 MB/s. The host data rate setting must exceed the data being produced by the system. When integration time is longer than Tint (minimum), average host data rate can be calculated using following formula:

$$\text{Data rate (MB/s)} = (258 \times \text{numSP} \times \text{numDH per SP}) / \text{Tint (us)}$$



### **DATA ACQUISITION RATE AND POWER**

*Example: data rate for a system of 2 SP boards and 9 DH boards at 500µs integration time shall be  $(258 \times 2 \times 9) / 500 = 9.3\text{MB/s}$ . Therefore, host bus speed should be set to 12MHz.*

*Example: current requirement for a system of 2 SP boards, 18 DH boards and 1 interface board shall be:  $(2 \times 900\text{mA}) + (18 \times 150\text{mA}) + (1 \times 500\text{mA}) = 5\text{A}$ .*

### **HOST DATA INTERFACE**

Four types are available, providing the following interfaces.

#### **1.**

Parallel RS485 output using up to 50 metre SCSI cable connecting to:

- USB 2.0 converter
- GIGE converter
- PCI7300 card, via an RS485 to TTL converter

#### **2.**

Local USB 2.0 output connecting to:

- laptop, PC or a single board computer
- USB 2.0 extender using fibre optic or CAT5 cable

#### **3.**

Local GIGE output connecting to:

- laptop, PC or a single board computer
- UDP protocol over 1000 BASE-T data link

#### **4.**

Channel Link (Camera Link)

- 2.2 Gb/s data rate
- Interface to Active Silicon AS-PHX-D48CL-PE4 frame grabber



### **EVALUATION SYSTEM**

An evaluation system is available, consisting of a detector head board, signal processing board, RS485/USB/GIGE output and evaluation software. This is mounted in a test box (LINX type, see data sheet) to provide electrical and radiation screening.

Demonstration software is available via download link or on a CD or download link and can be loaded on to a Windows PC (Pentium 4 or later) to check basic function of the system. A high speed USB 2.0 or Gigabit Ethernet port is required for the host interface. The software enables setting of gain and integration time and single lines of data to be acquired.

Data can be logged to a csv file and can be displayed in graphical form. Gain and offset correction can be applied via the software.

Imaging Application is available, contact Sens-Tech for details

### **ORDERING INFORMATION**

#### **DETECTORS**

Detector selection is an important part of system design. Parameters are stopping power, light output and signal decay time. Fast decay time is particularly important in CT systems.

An overview of typical scintillation materials with the main parameters is presented on page 15.



### ORDERING INFORMATION

#### DETECTOR HEAD BOARDS

0.8 mm pitch standard width

PART NUMBER	DESCRIPTION
XDAS-DH3-0210	no detectors
XDAS-DH3-0211	Gadox
XDAS-DH3-0212	CsI
XDAS-DH3-0213	CdWO4
XDAS-DH3-0214	Silicon

#### DETECTOR HEAD BOARDS

0.8 mm pitch narrow width

PART NUMBER	DESCRIPTION
XDAS-DH3-8210	no detectors
XDAS-DH3-8211	Gadox
XDAS-DH3-8212	CsI
XDAS-DH3-8213	CdWO4
XDAS-DH3-8214	Silicon





### ORDERING INFORMATION

#### SIGNAL PROCESSING BOARD

PART NUMBER	DESCRIPTION
XDAS-SP3-01	signal processing board (standard)
XDAS-SP3-801	signal processing board (narrow )

#### TERMINATORS AND ADAPTORS

PART NUMBER	DESCRIPTION
XDAS-TERMINATOR8	Local bus (standard)
XDAS-TERMINATOR31	Local bus (narrow)
XDAS-TERMINATOR3-01	System bus
XDAS-ADAPTOR3-01	DH3-8xx adaptor to XDAS-SP3-01 (DH1 to 12)
XDAS-ADAPTOR3-02	DH3-8xx adaptor to XDAS-SP3-01 (DH13 to 24)
XDAS-INTERFACE-01	Belt encoder processing board

#### INTERFACE OPTIONS

PART NUMBER	DESCRIPTION
XDAS-485A-V3	parallel RS485 over 50 way SCSI cable, board only
XDAS-USB2-1-V3	USB2 interface with USB connector, power connector and LED
XDAS-USB2-2-V3	USB2 interface board only
XDAS-USB2-3-V3	USB2 interface with USB connector LED
XDAS-USB2-4-V3	USB2 interface with USB connector
XDAS-GIGE-V3	GIGE interface board only
XDAS-GIGE-V3-1	GIGE interface, with RJ45 connector, power connector and LED
XDAS-GIGE-V3-3	GIGE interface with RJ45 and LED
XDAS-GIGE-V3-4	GIGE interface with RJ45 connector
XDAS-USB2	remote RS485 to USB converter
XDU-INT-SGI	remote RS485 to GIGE converter

Note: interface boards step down input supply to 6V for supply to SP board (max 5A).

# XDAS-V3 0.8 MM PITCH

DUAL ENERGY X-RAY DATA ACQUISITION SYSTEM



SENS - TECH

## ORDERING INFORMATION

### CABLES

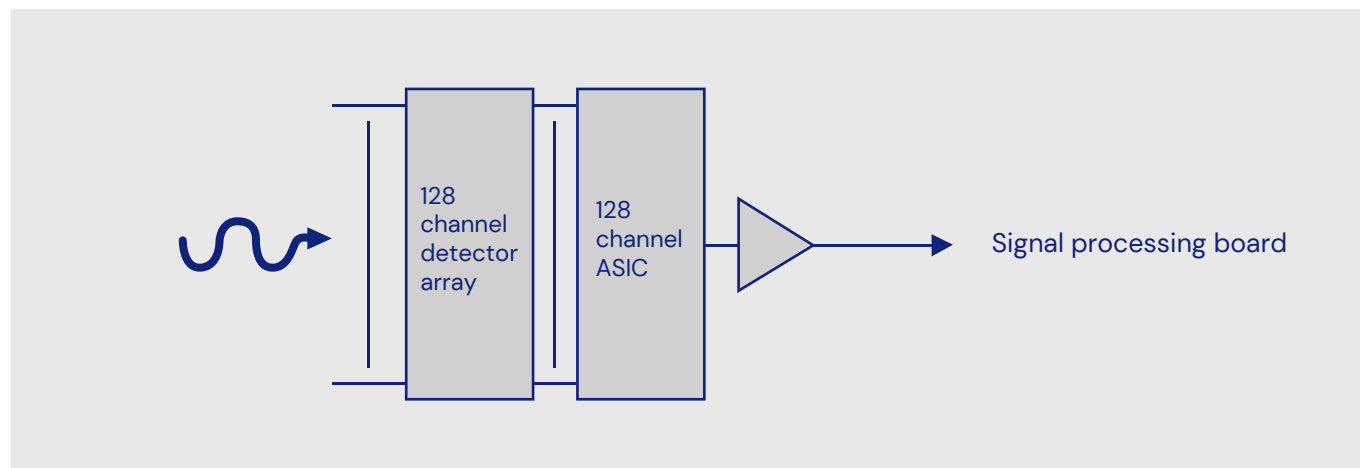
Note: see system configuration section or contact Sens-tech for cable part numbers

PART NUMBER	DESCRIPTION	PART NUMBER	DESCRIPTION
Detector board (standard)	50way 2mm pitch IDC	Detector board (narrow)	50way 1.27mm pitch IDC
CABLE-XDASPCBxx	Data cable (specify length)	Signal processing board	50way 1.27mm pitch IDC
CABLE-XDASPCB21	48mm	CABLE-XDASPCBxx	Data cable (specify length)
CABLE-XDASPCB22	75mm	CABLE-XDASPCB24	100mm
CABLE-XDASPCB17	100mm	CABLE-XDASPCB25	175mm
CABLE-XDASPCB23	110mm	CABLE-XDASPCB26	200mm
CABLE-XDASPCB18	200mm	CABLE-XDASPWR2-xx	Power cable from GIGE board to SP board (specify length)
CABLE-XDASPCB19	300mm	CABLE-XDASPWR2-02	500mm
CABLE-XDASPCB20	400mm	CABLE-XDASLED-01	Bulkhead diagnostic LED 20cm

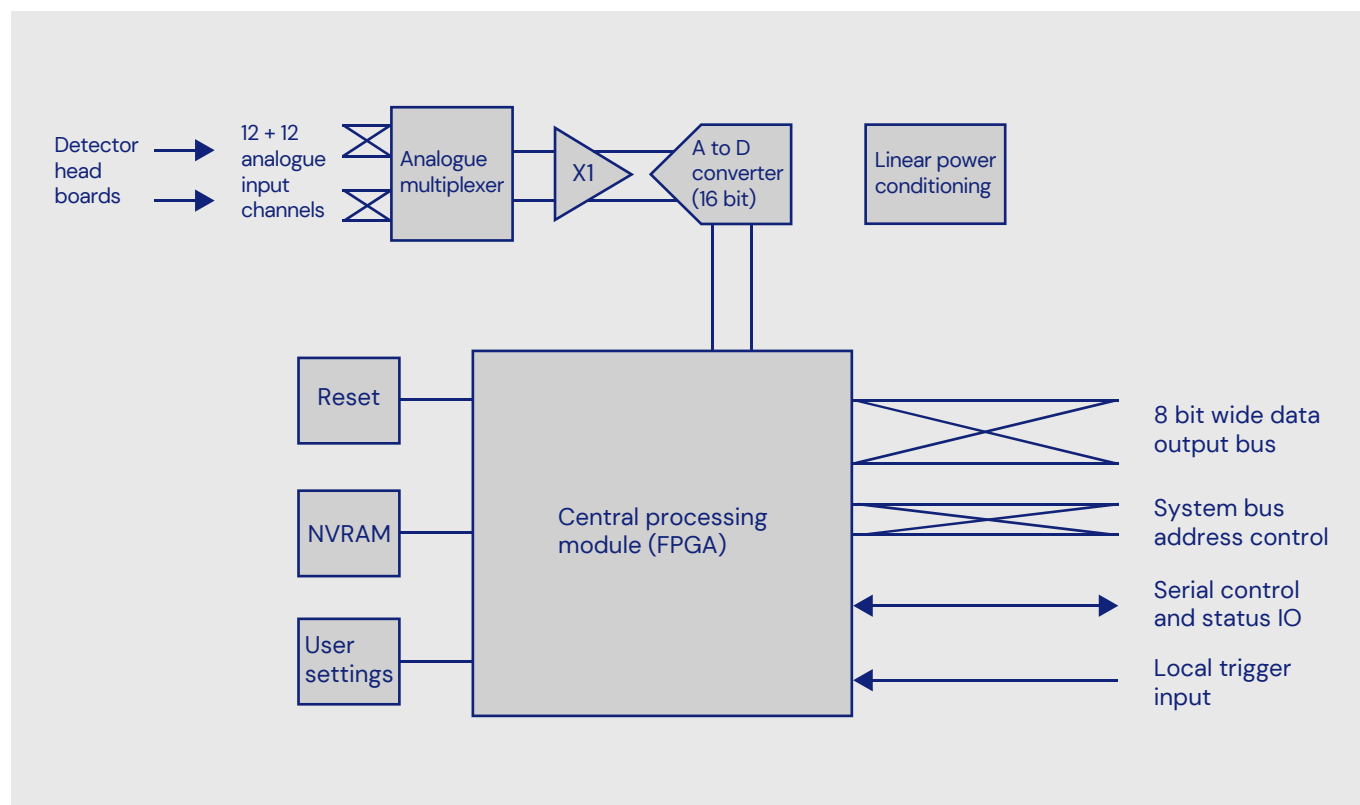
### SOFTWARE

PART NUMBER	DESCRIPTION
XDAS-SOFTWARE	evaluation software and SDK

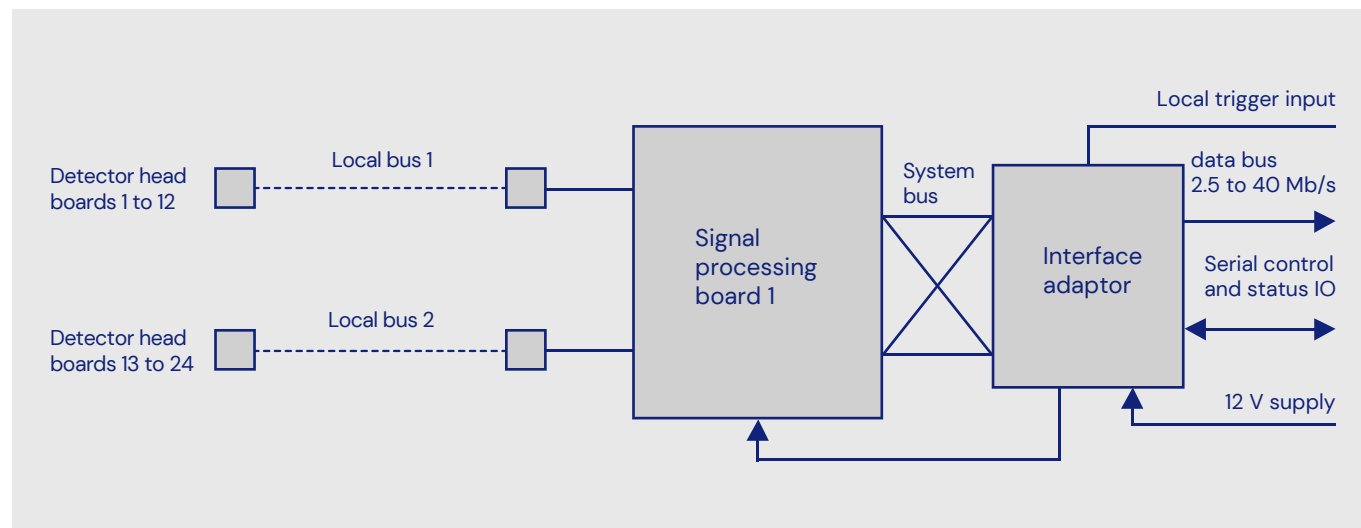
### DETECTOR HEAD BLOCK DIAGRAM



### SIGNAL PROCESSING BLOCK DIAGRAM

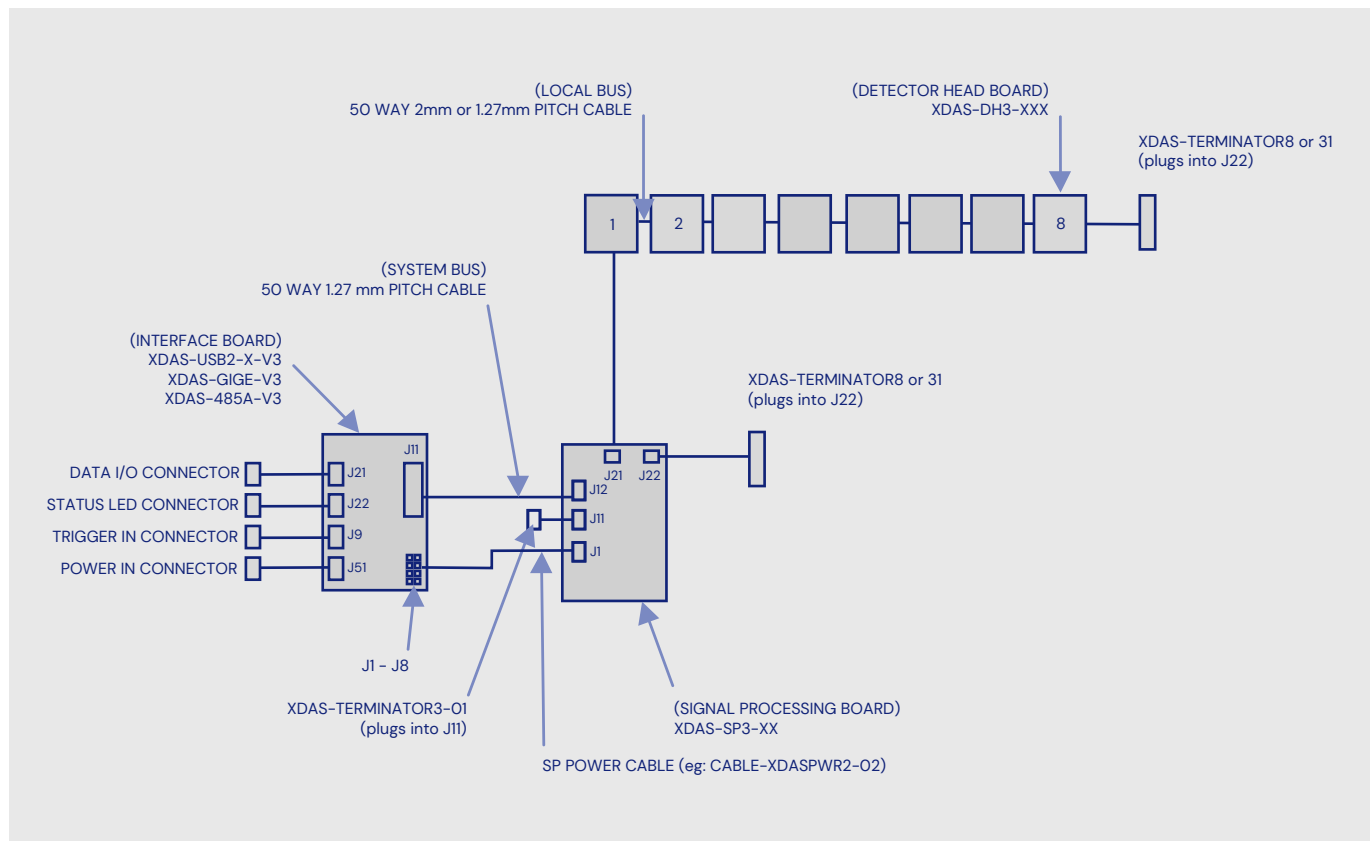


### SYSTEM BLOCK DIAGRAM



## SYSTEM CONFIGURATION

## SINGLE SP BOARD

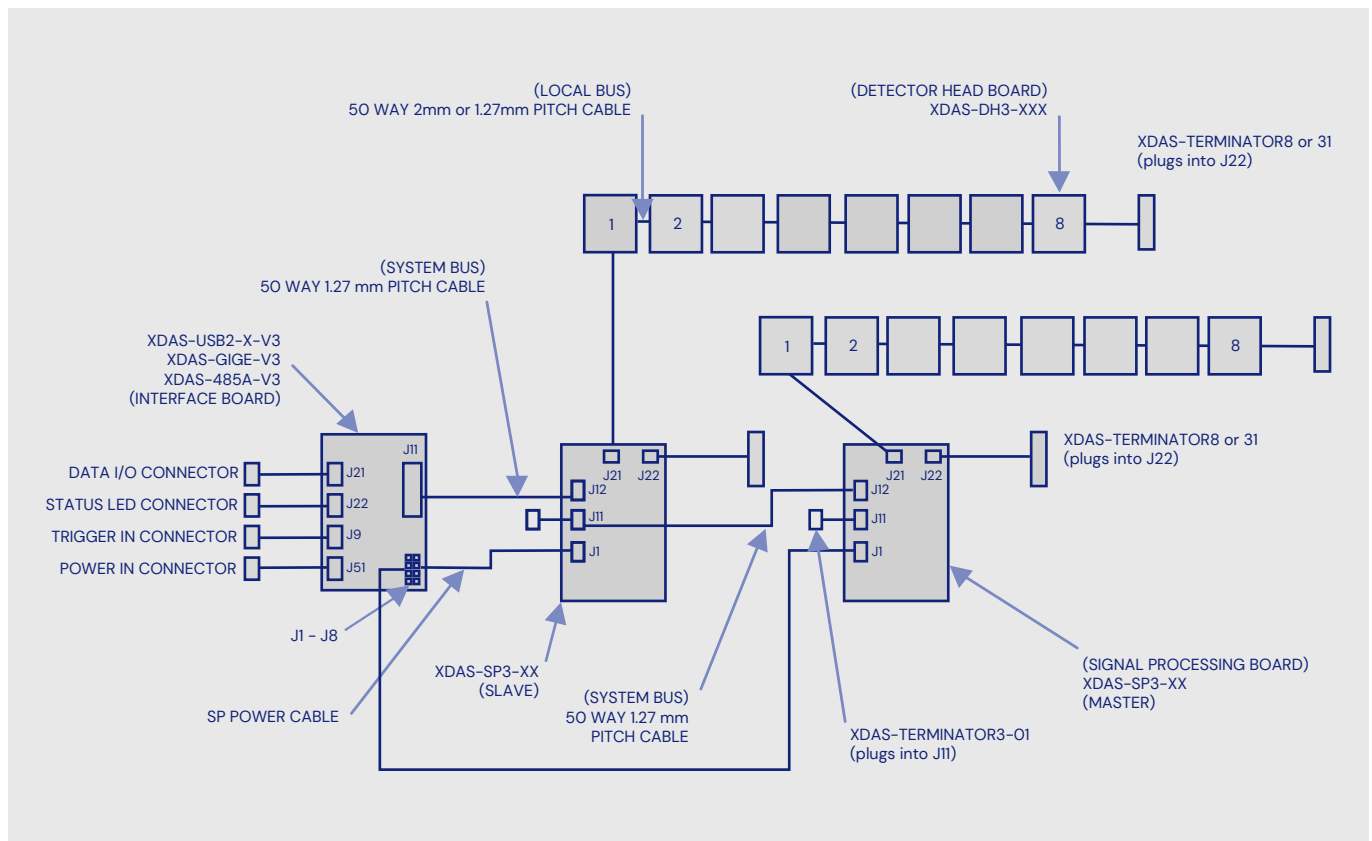


Notes:-

1. Custom cable lengths available upon request
2. Narrow format boards use 1.27mm pitch connectors and 0.635 mm cable
3. Interface boards are supplied with connectors upon request
4. XDAS-terminator3-01 is connected to master SP board for systems with multiple SP boards

### SYSTEM CONFIGURATION

#### MULTIPLE SP BOARD



#### Notes:-

1. Custom cable lengths available upon request
2. Narrow format boards use 1.27mm pitch connectors and 0.635 mm cable
3. Interface boards are supplied with connectors upon request
4. XDAS-terminator3-01 is connected to master SP board for systems with multiple SP boards



### DETECTORS

TYPE OF SCINTILLATOR	THICKNESS	ENERGY RANGE	SIGNAL OUTPUT PER UNIT ENERGY	DECAY TIME CONSTANT	COMMENTS
Silicon	0.3 mm	5 – 30 keV	highest	1 $\mu$ s for unbiased diode	Direct conversion, no scintillator cost
Gadox (Tb)	0.2 mm 0.3 mm 0.4 mm	20 – 120 keV	20% lower similar to CSI 20% lower	<1 ms 2 – 3 ms <1 ms	Phosphor strip
Csl	2.5 mm	40 – 160 keV	best light output	2 components, slow decay of secondary component (seconds)	Pixelated arrays to reduce crosstalk
CdWO4	2.5 mm	80 – 320 keV	25% of CSI	20 $\mu$ s	Pixelated arrays, highest cost material

Note 1: Thicknesses shown are of standard products. Other thicknesses are available on order which will cover wide energy ranges

# XDAS-V3 0.8 MM PITCH



## DUAL ENERGY X-RAY DATA ACQUISITION SYSTEM

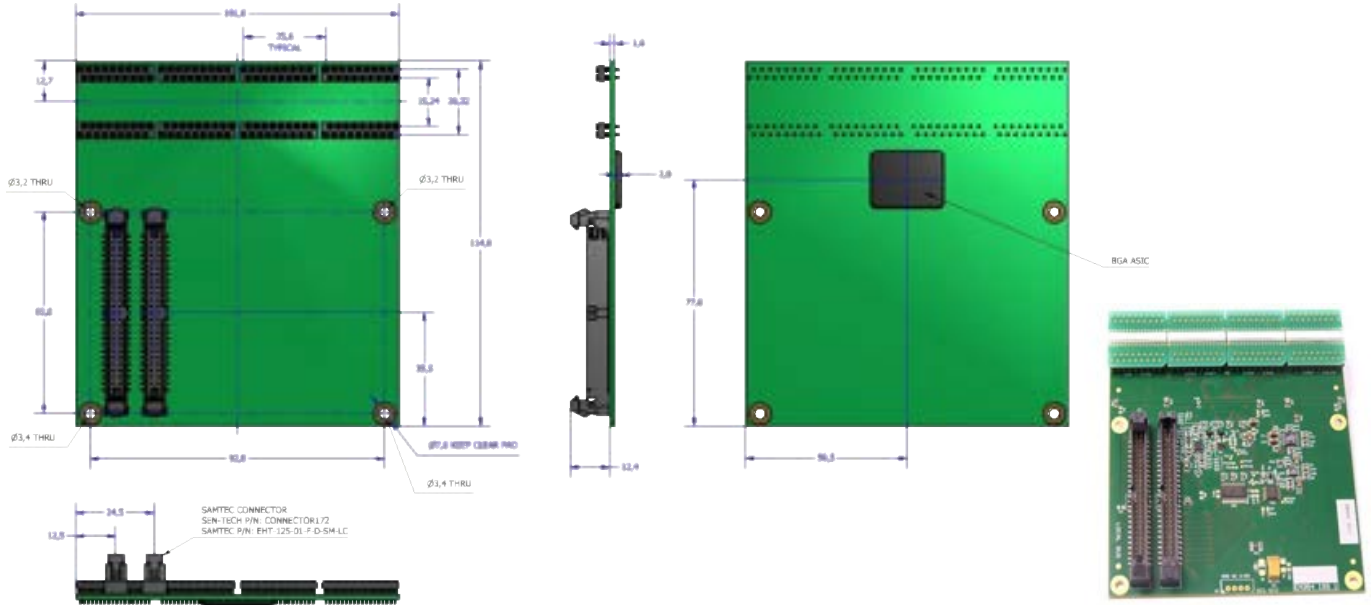
## SENS - TECH

Note: Following drawings are for reference only. Contact Sens-tech for latest mechanical drawings and 3D CAD models.

## OUTLINE DRAWINGS

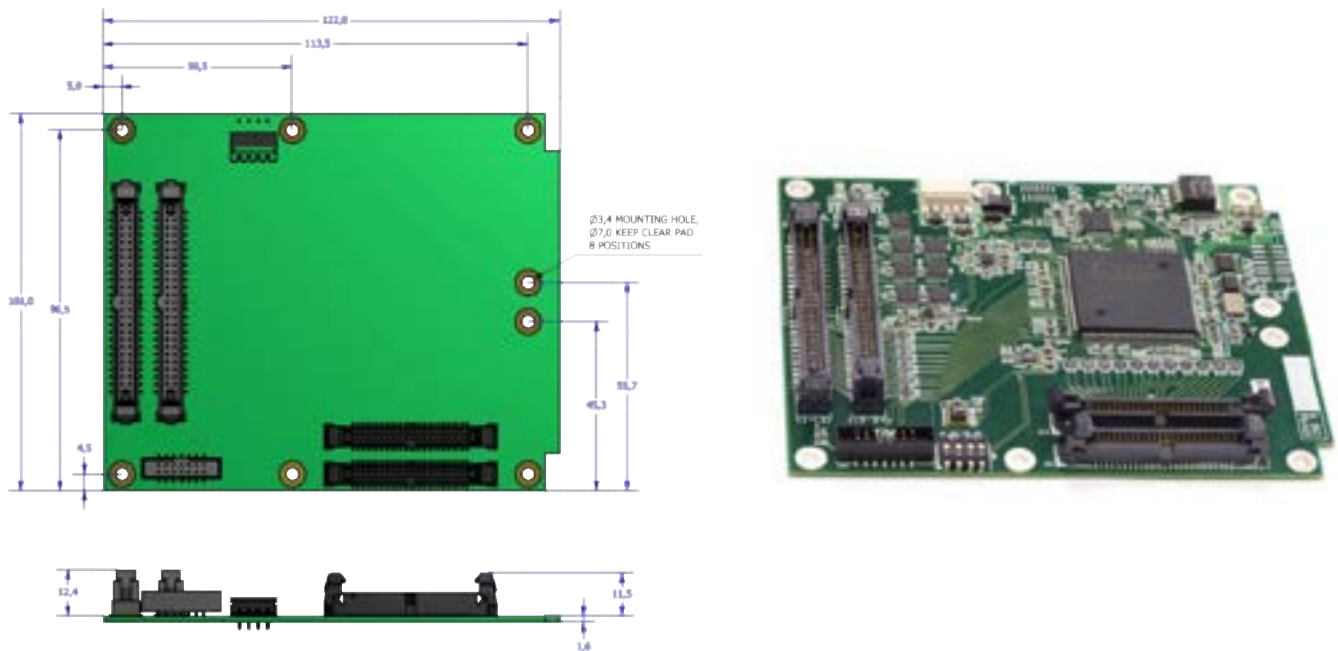
**XDAS-DH3-2x**

### Standard footprint detector head board (mm)



**XDAS-SP3-01**

### Standard footprint signal processing board (mm)





# XDAS-V3 0.8 MM PITCH



## DUAL ENERGY X-RAY DATA ACQUISITION SYSTEM

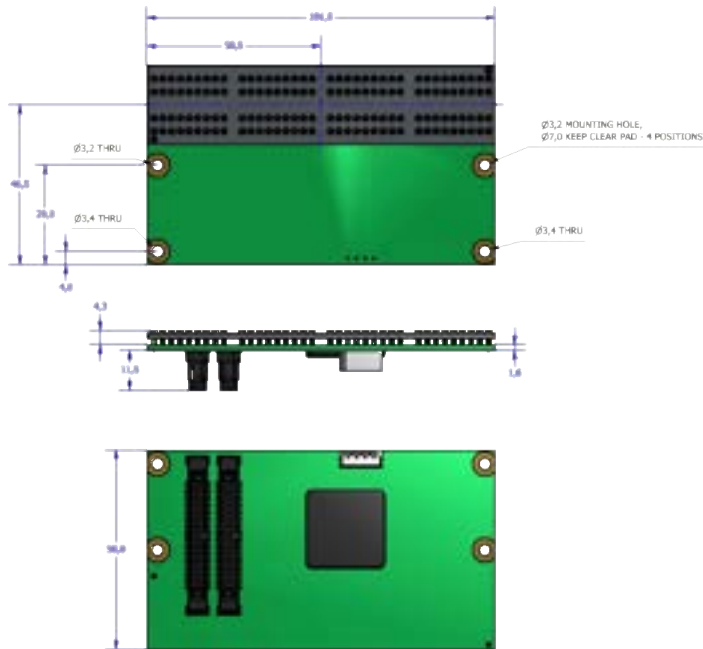
## SENS - TECH

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## OUTLINE DRAWINGS CONTINUED...

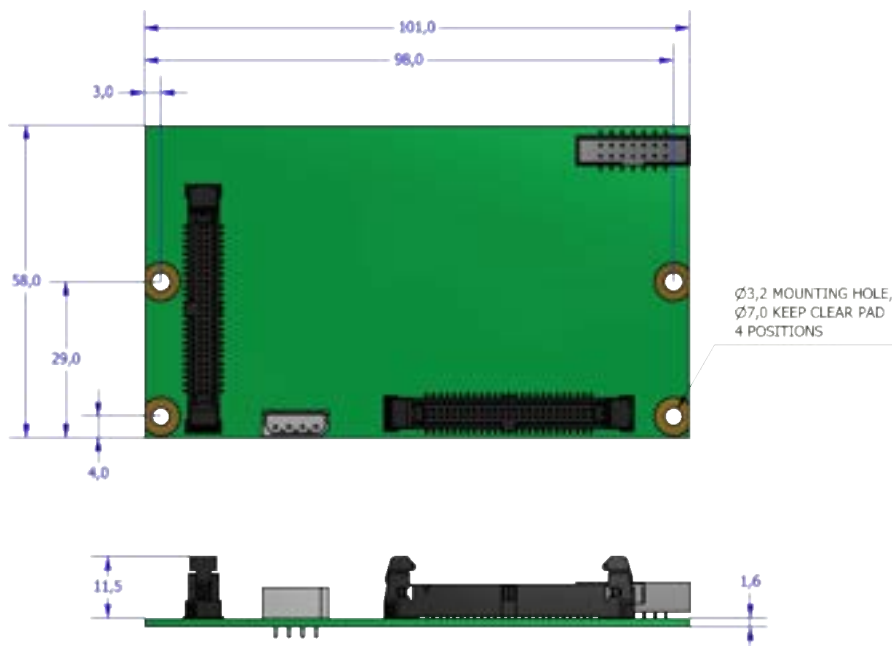
## XDAS-DH3-82x

### Small footprint detector head board (mm)



**XDAS-SP3-801**

### Small footprint signal processing board (mm)



# XDAS-V3 0.8 MM PITCH



DUAL ENERGY X-RAY DATA ACQUISITION SYSTEM

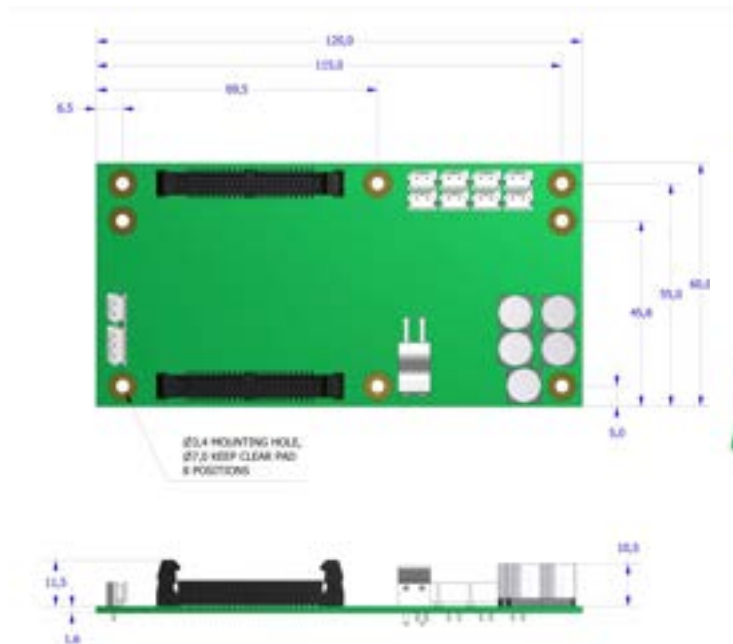
SENS - TECH

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## OUTLINE DRAWINGS CONTINUED...

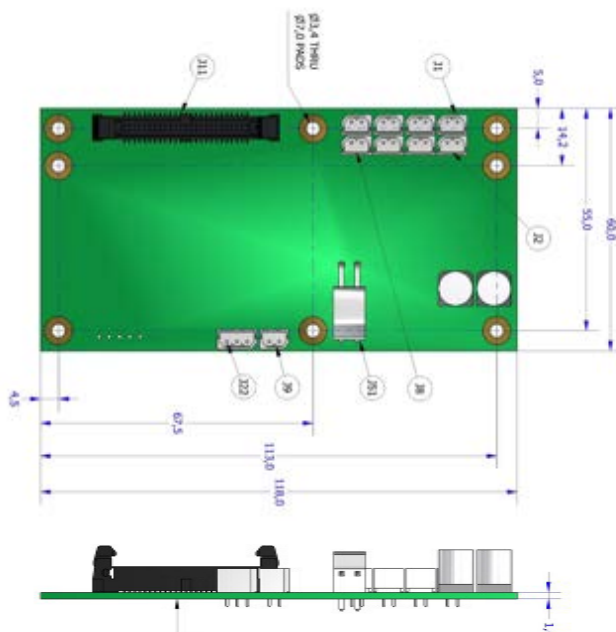
XDAS-485A-V3

Interface board



XDAS-USB2-x-V3

Interface board



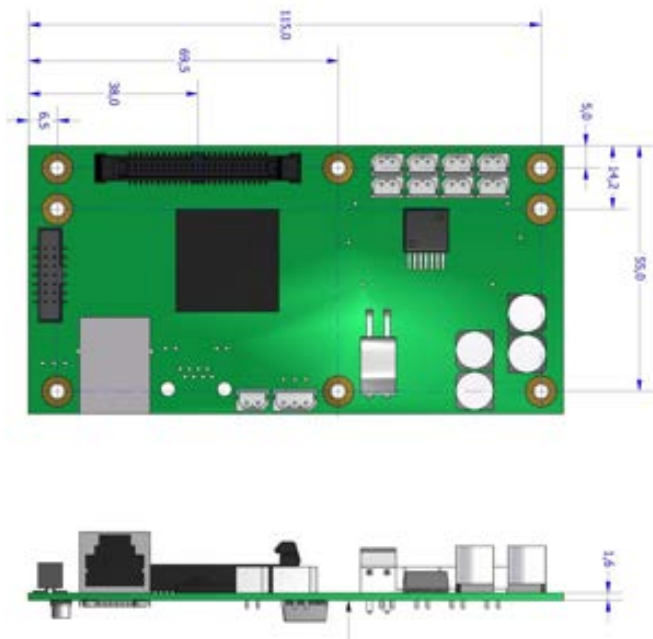
# XDAS-V3 0.8 MM PITCHt

DUAL ENERGY X-RAY DATA ACQUISITION SYSTEM










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## OUTLINE DRAWINGS CONTINUED...

XDAS-GIGE-V3                      Interface board



### LED STATUS MNEMONICS

LED INDICATION	MEANING (USB)	MEANING (GIGE)
 Green	Idle	Idle
 Green (Flashing)	Acquiring data	Acquiring data
 Amber	Data buffer overflow. (Idle)	Connected to 100Mbps link. Not yet supported
 Amber (Flashing)	Data buffer overflow. (Acquiring)	Command received from host
 Red/Green (Alternating)	System under reset	System under reset
 Red [1]	Microcontroller not responding	Device fault. Contact support
 Red [1] (Flashing ~1Hz)	USB endpoint has stalled	Ethernet Link is not connected
 Red [1] (Flashing >4Hz)	Could not enumerate as USB2.0 device	Ethernet link fault
 Off	Power off, un-programmed or other fault	Power off, un-programmed or other fault