LINX linear X-ray sensor data sheet V3 type

SENS-TECH
SENSOR TECHNOLOGIES

1 key features

- array lengths up to 4 m
- 2.5 mm, 1.6 mm, 0.8 mm or 0.4 mm detector pitch
- range of scintillator types
- simultaneous data acquisition and read-out
- 8 steps of gain
- dual energy option with gain settable independently for high and low energy and for each board in the system
- continuous or externally triggered scan
- USB2.0, GIGE or 16 bit output via high speed parallel link to the CPU
- operation by external trigger

2 description

LINX is a linear X-ray sensor, built up of Sens-Tech XDAS DH (Detector Head) and SP (Signal Processing) boards to provide an array of any length. The gain for each DH board can be set separately. Detector pitch is: 2.5 mm, 1.6 mm, 0.8 mm or 0.4 mm. The LINX unit is housed in an aluminium alloy box of modular construction with a stainless steel lid. Lead screening protects the electronics from radiation damage. The unit has a collimator with a carbon fibre window, so that only a narrow X-ray beam can reach the detector, reducing scattered radiation and improving image quality.

X-rays are detected using a scintillator and photodiode array. Gadox, CsI (Tl), CdWO4 and GOS are offered to cover the energy range 30 keV to 1.4 MeV. Bare silicon can be used down to 5keV. Dual energy systems can also be supplied. In this mode, gain for low and high energy channels can be set separately.

The detector is linked to a processor via USB2, PCI-7300A data I/O card, frame-grabber, ethernet or camera link.
Data is output in 16-bit format.

Data acquisition time for a single line can be selected in the range 50 µs to 50 ms subject to the number of detector boards and the maximum read-out rate from the system of 48MB/s.

3 applications

- security inspection
- CT Imaging
- multi-view imaging
- non-destructive testing
- food inspection
- thickness measurement
- foreign particle detection
- bone densitometry
- industrial process control
- mineral sorting
- waste sorting

4 general specification

integration time	10 µs to 50 ms
sub-samples	1, 2 or 4
SNR 0.4 mm (<10pF detector capacitance)	
1.875pC	6,000:1
15pC	17,000:1
60pC	34,000:1
SNR 0.8 mm (<10pF detector capacitance)	
1.875pC	10,000:1
15pC	18,000:1
60pC	34,000:1
SNR 1.6 mm (<30pF detector capacitance)	
1.875pC	8,000:1
15pC	17,500:1
60pC	33,000:1
SNR 2.5 mm (<75pF detector capacitance)	
1.875pC	4,500:1
15pC	14,000:1
60pC	27,500:1
non-linearity	<0.1% over 10 pC
maximum read-out rate	48 MB/s
A/D conversion & output	16 bit
gain adjustment	8 steps, 1.875 pC to 15 pC
data interfaces	USB2, PCI7300A, camera link, giga Ethernet, framegrabber
power supply	12V (9V to 30V), 100mV/p-p ripple. Please consult Sens-Tech for individual system input current requirements and power supply recommendation.
detector pitch	0.4 mm, 0.8 mm, 1.6 mm, 2.5mm
detector active length	50 mm to 4 m
scintillator types	Gadox, GOS, CsI, CdWO4 and Silicon.

5 environmental specification

operating case temperature	+5 to + 60°C
storage temperature	-40 to +70°C
humidity (non-condensing)	
operating	30°C 93%
non-operating	40°C 93%

6 principles of operation

All XDAS DH board have 128 channels. Board width is: 51.2 for 0.4mm pitch; 102.4 mm for 0.8mm & 1.6 mm pitch and 160mm for 2.5mm pitch. 1.6mm and 2.5mm pitch boards can either be single energy with only 64 channels used or dual energy with 64 high energy channels and 64 low energy channels stacked one above the other. For 0.4mm and 0.8 mm pitch boards, these are single energy only. Separate boards need to be used for low and high energy.

Current from the photodiodes is integrated by a custom designed microcircuit containing 128 charge sensitive amplifiers and a multiplexer. User gain settings enable the charge capacity to be set between 1.875 pC and 15 pC. This can be increased by a factor of 4 using the on-board facility for sub-sampling and summation.

User settings to control integration times, gain and number of sub-samples together with information on system configuration are transmitted over the selected interface and stored in non-volatile RAM so that at switch-on, the system is initiated in the last mode saved.

7 data acquisition rate

There are two limiting factors to the scan time, the ADC rate and the data bus rate. ADC conversion rate can be set to 1.5 MS/s or 3.0 MS/s. Normally this will be the determining factor. Using the 3.0 MS/s ADC setting, a single Signal Processing board can convert signals from 128 channels to digital format in 42.7 µs so that for a 10 board system, the conversion time would be 427 µs. For faster scan rates, more Signal Processing boards can be used until the data bus rate becomes the limiting factor.
The maximum data bus rate is 48 MB/s. A single board transmits 258 bytes per scan so that a 10 board system with a scan time of 1 ms would have a data rate of 2.58 MB/s. The maximum rate is 48 MB/s, limiting the scan time to approximately 65 µs for a 10 board system.

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

Integration time **(ms) =** ***pixel width*** **(mm)*/belt speed*** **(m/s)**

Example*: integration time setting for 1.6mm pixel width scanning at 1m/s belt speed shall be 1.6 / 1 = 1.6 ms*

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

3MSps: Tint (minimum) = 1.6µs + (num DH per SP x 42.7µs)
1.5MSps: Tint (minimum) = 3.2µs + (num DH per SP x 85.4µs)

Example*: minimum integration time for a 9 DH board and 1 SP board system shall be 1.6 + 9x42.7 = 386 µs*

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 + 18 x 42.7 = 386 µs*

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:

Data rate (MB/s) = (258 x numSP X numDH per SP) / Tint (us)

Example*: data rate for a system of 2 SP boards and 9 DH boards at 500us integration time shall be (258 x2x9) / 500 = 9.3MB/s. Therefore, host bus speed should be set to 12MHz.*

8 host data interface

Four types are available, providing the following interfaces:

1. Parallel RS485 output using up to 50 metre SCSI cable connecting to:
   - USB2.0 remote converter, adaptor XDAS-USB2
   - GIGE remote convertor, adaptor XDU-INT-SGI
   - PCI7300A card, via an RS485 to TTL convertor, adaptor XDAS-485A-TTL
2. Local USB2.0 output connecting to:
   - Laptop, PC or a single board computer
   - High speed USB2.0 extender using fibre-optic or CAT5 cable
3. Local GIGE output connecting to laptop, PC or a single board computer:
   - UDP protocol
   - 1000 BASE-T Gigabit data rate
   - Fibre convertor.
4. Channel Link / Camera Link:
   - 2.2 Gb/s data rate
   - Interface to Active Silicon AS-PHX-D48CL-PE4 frame grabber

9 evaluation system and software

A software package is supplied (by link) to demonstrate the capability of the unit. This includes integration time and sub-sample setting, gain correction and offset correction. The software includes a data logging facility.
In addition a XAPI is supplied to assist the customer in the development of the required application.
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 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.

10 ordering information

LINX-xyzz-version no (assigned by Sens-Tech).

pitch

x = 1	1.6 mm pitch
x = 2	0.8 mm pitch
x = 8	2.5 mm pitch
x = 6	0.4 mm pitch

scintillator

y = 1	Gadox up to 120 kV
y = 2	CsI(Tl) up to 180 kV
y = 3	CdWO4 up to 320 kV
y = 4	Gadox / CsI (DE)
y = 5	Silicon
y = 6	Gadox / CdWO4 (DE)
y = 7	Silicon / Gadox (DE)
y = 8	ZnSe / Gadox
y = 9	Misc (GOS up to 200kV is available)

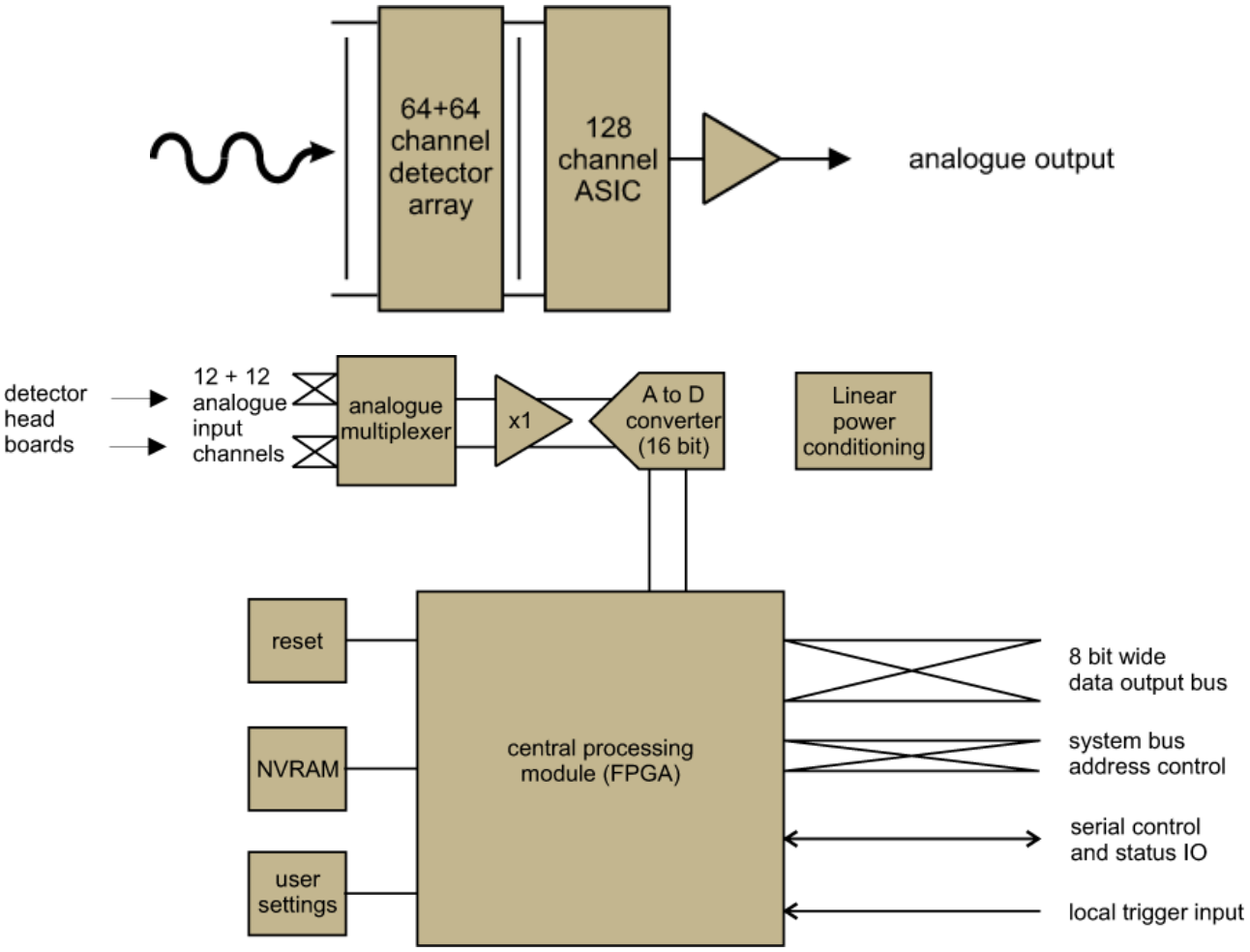
greater thickness can achieve higher levels

active length	(0.4, 0.8 & 1.6 pitch)	(2.5 pitch)
zz = 01	102.4 mm	160 mm
zz = 02	204.8 mm	320 mm
zz = 03	307.2 mm	480 mm
zz = 04	409.6 mm	640 mm
zz = 20	2048 mm	32000 mm

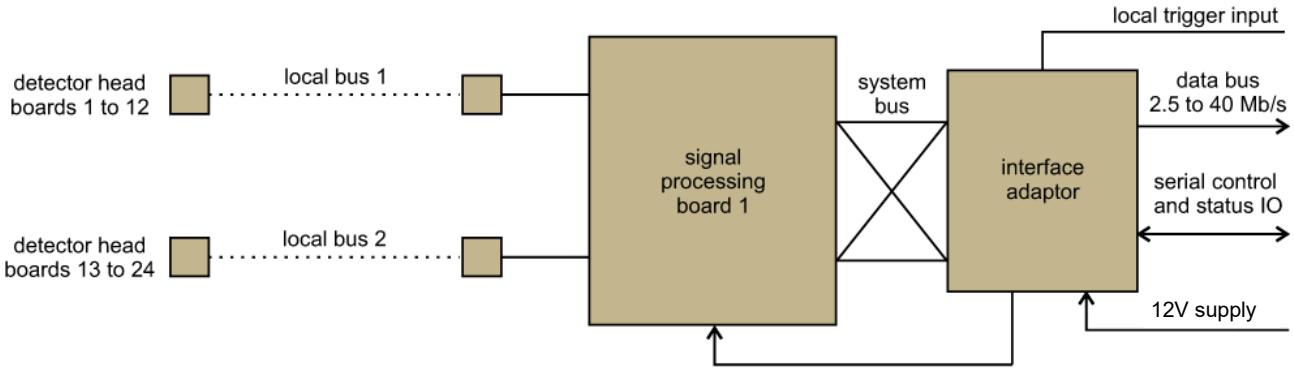
intermediate sizes can also be specified
dual energy (DE) systems can also be supplied.

power supply	XDAS-PSU12	12V / 5A
power cables	LINXPOWERabcde-xx a: 0 = 7W2D connector b: 1 = IP50 rated 2 = IP67 rated c: 1 = flying lead 2 = 4 way DIN (PSU12 type) d: 1 = 10mR per metre e: 2 = screened xx = length in metres	
examples:		
LINXPOWER01112-XX	7W2 IP50 to flying lead	
LINXPOWER01212-XX	7W2 IP50 to 4 way DIN	
LINXPOWER02112-XX	7W2 IP67 to flying lead	
LINXPOWER02212-XX	7W2 IP67 to 4 way DIN	
data cables	CABLE50WSCSI-2/xxM CABLE-USB2-AB-xxM CABLE-CAT6-xxM xx = length is metres	
adaptor units	XDAS-USB2 (see below) XDAS-485A-TTL(see below) XDAS-DFG-TTL (frame grabber) XDU-INT-SGI (SCSI to GIGE)	

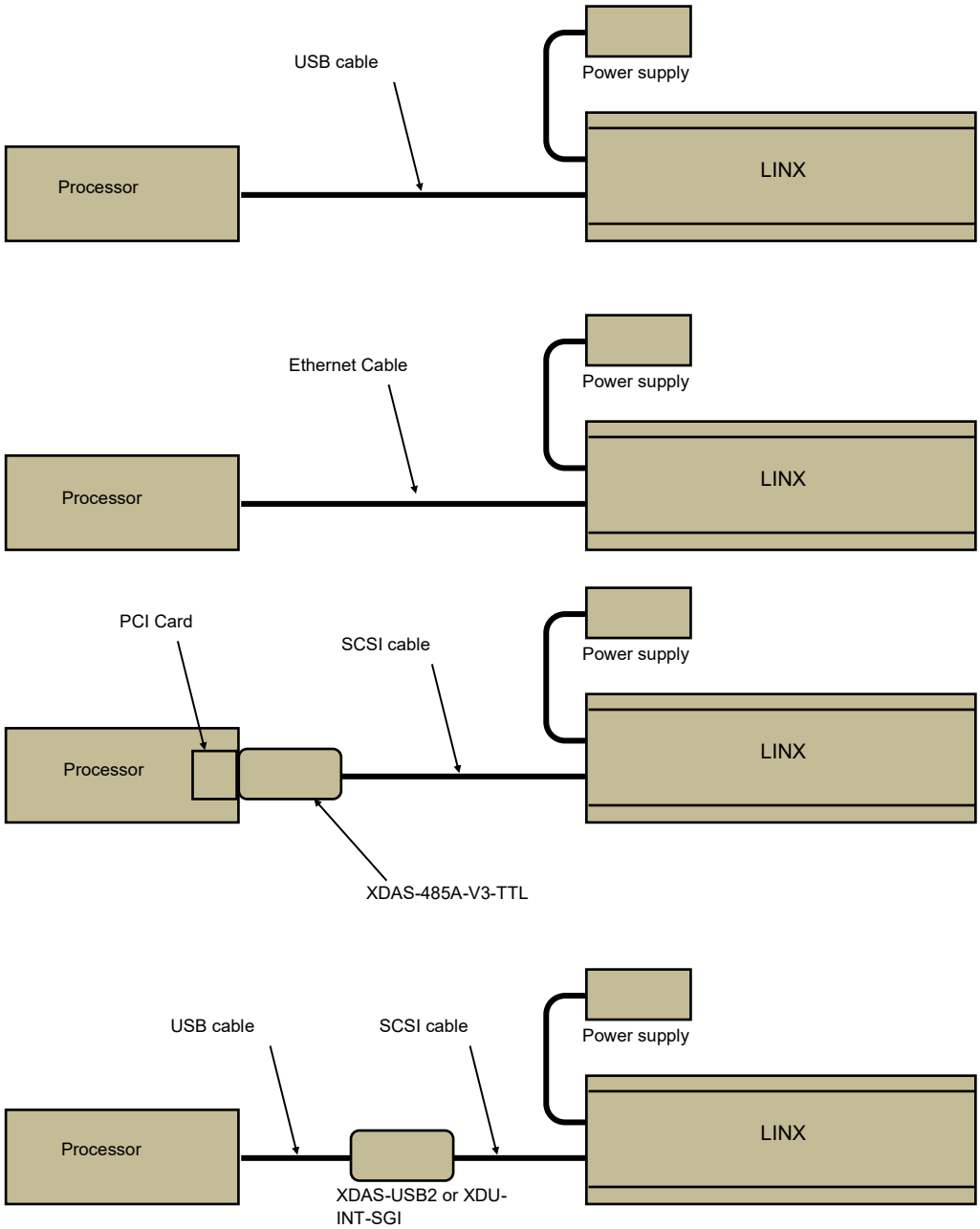
11 internal block diagram



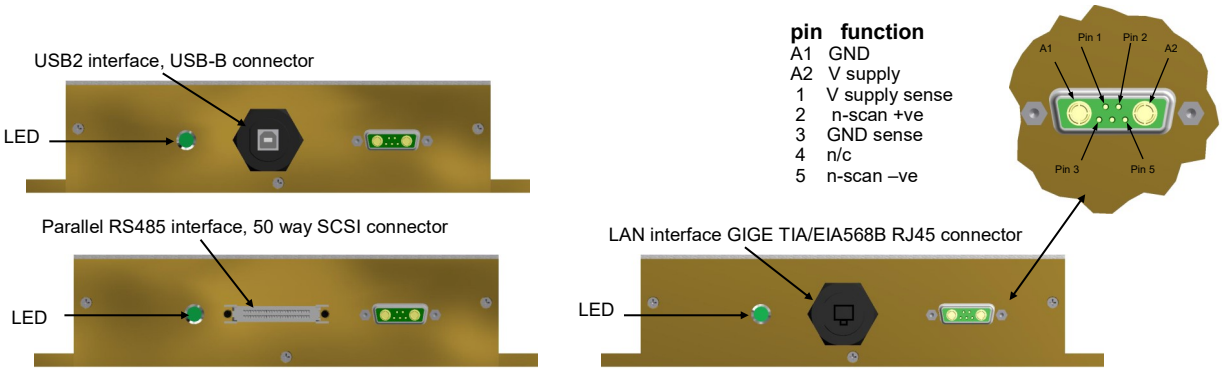
11 internal block diagram continued



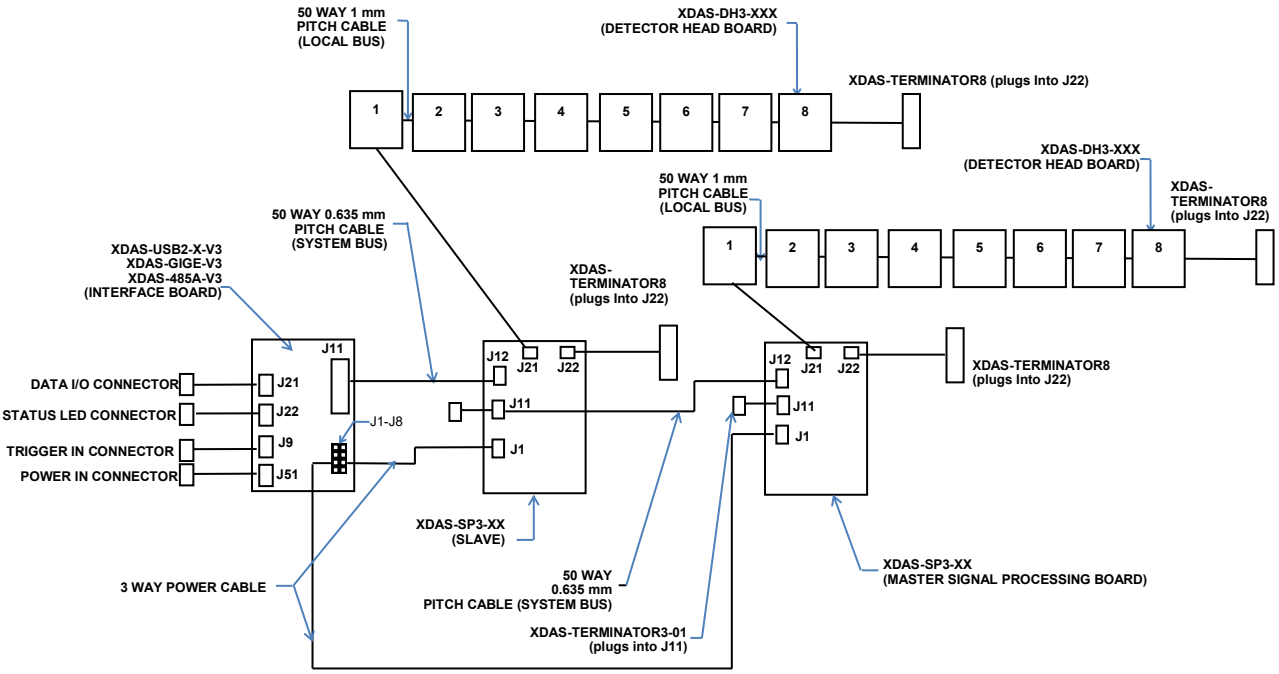
12 system block diagram



13 system connections



14 system configuration



The above diagram shows the arrangement of XDAS boards within the LINX unit. There can be up to 24 Detector Head Boards for each Signal Processing board. These are arranged in 2 detector arms with a maximum of 12 boards per arm. This diagram shows a system built for either local USB2, GIGE or RS485 operation. A system for RS485 can be fitted with a different external interface unit e.g. channel link (camera link).

0.4mm pitch

type of scintillator	thickness	energy range	Signal output per unit energy	decay time constant	comments
Silicon	0.30 mm	5 - 30 keV	highest	1 µs for unbiased diode	direct conversion, no scintillator cost
Gadox (Tb)	0.3 mm	20 - 100 keV	similar to CSI	2 - 3 ms	phosphor strip, no pixellation required to prevent cross-talk

0.8mm pitch

type of scintillator	thickness	energy range	Signal output per unit energy	decay time constant	comments
Silicon	0.30 mm	5 - 30 keV	highest	1 µs 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
CsI	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 µs	pixelated arrays, highest cost material

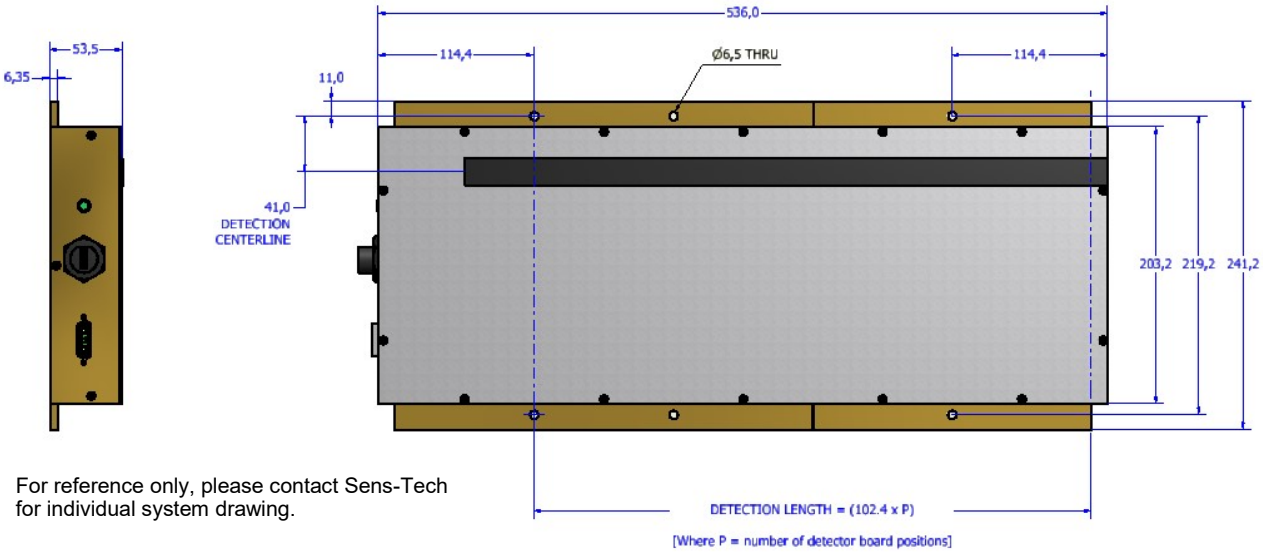
1.6mm pitch

type of scintillator	thickness	energy range	Signal output per unit energy	decay time constant	comments
Silicon	0.15 mm	5 - 30 keV	highest	1 µs 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
CsI	0.4 mm 3 mm 4 mm	40 - 180 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 µs	pixelated arrays, highest cost material
GOS	2.9 mm	80 - 225 keV	50% more than CdWO4 at 160keV	3 µs	pixelated arrays, resistant to radiation damage

15 detectors (2.5mm pitch)

type of scintillator	thickness	energy range	Signal output per unit energy	decay time constant	comments
Silicon	0.15 mm	5 - 30 keV	highest	1 µs 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
CsI	4 mm 10 mm	40 - 180 keV 40 - 320 keV	best light output	2 components, slow decay of secondary component (seconds)	pixelated arrays to reduce crosstalk
CdWO4	2.5 mm 30 mm	80 - 320 keV 80 - 1.4MeV	25% of CSI	20 µs	pixelated arrays, highest cost material
GOS	2.5 mm	80 - 200 keV	50% more than CdWO4 at 160keV	3 µs	pixelated arrays, resistant to radiation damage

16 outline drawings



For reference only, please contact Sens-Tech for individual system drawing.

17 LED status mnemonics

[1] This feature is only available in firmware version 3.0.9 and above.

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

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