

Modular scintillator readout solution for nuclear medical imaging



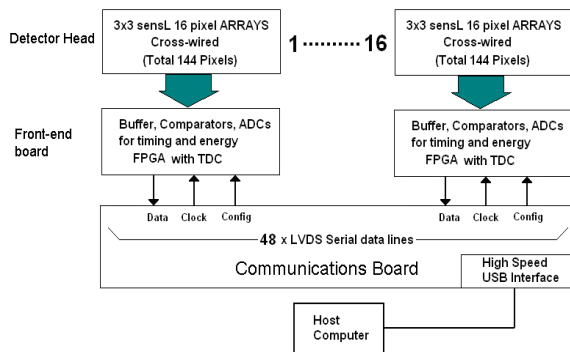
SensL Matrix9 is the first modular, turnkey readout system specifically designed for nuclear medical imaging applications. Building on SensL silicon photomultiplier technology, Matrix9 provides a fully solid-state, four-side scalable detector for the readout of L(Y)SO scintillator arrays. It integrates all the electronics required to localize, time stamp and discriminate scintillation events. Digitized event data comprising time, location and energy are sent to the host system via high speed USB interface. Integrating multiple detector heads, Matrix9 can perform temporal coincidence analysis thereby reducing data rates to and computational load on the host system. Matrix9 is available as a turnkey, fully integrated module or as an OEM sub-system for rapid integration.

System Overview

Matrix9 is a low light imaging system specifically designed for the readout of scintillator matrices in Positron Emission Tomography (PET) scanners. Employing SensL silicon photomultiplier (SPM) technology, the Matrix9 detector head requires low power and operating voltage, is compact, highly robust and offers excellent spatial segmentation and photo response uniformity. Addressing high resolution imagers such as small animal, pre-clinical and mammography PET, Matrix9 is a compelling alternative to multi-anode PMT. A high degree of modularity and compliance with the openPET standard makes Matrix9 a cost effective substitute for PMT in full-body PET systems.

The Matrix9 system architecture is modular and based on three principal sub-systems:

- 1 Detector Head - a 12 x 12 pixel SPM matrix integrated on a four-side scalable daughter board. The detector head is fitted with mechanical mounting points and connects via a 80 way flexible printed circuit cable to the front-end electronics board.
- 2 The Front-end Electronics Board serves to bias the 144 SPM and amplify their signals. Candidate signals are flagged through a programmable threshold discriminator and are digitized, time stamped, buffered and subsequently read out to the Matrix9 Communications board through a high speed serial interface.
- 3 The Matrix9 Communications Board (Matrix9-C) supports up to 16 Matrix9 modules. It provides a common clock, retrieves and buffers event data, performs temporal coincidence analysis for events from different detector heads and interfaces with the host computer through a high speed USB connection.

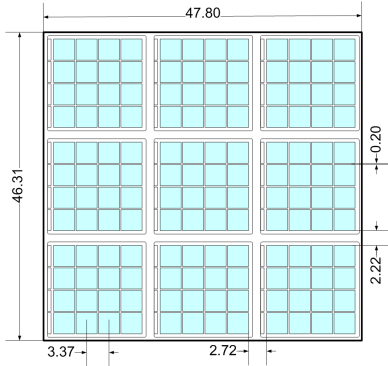


Matrix9 is available in a robust enclosure suitable for easy handling and prototype integration. For OEM integration we offer the detector head and front-end electronics separately without enclosure.

While particularly addressing PET, Matrix9 is designed with sufficient flexibility to satisfy the requirements encountered in a range of scintillator based imaging applications, in particular SPECT and Gamma Cameras.

Matrix9 Characteristics

The dimensions of the Matrix9 detector head are:



Principle detector head characteristics are:

Parameter	Unit	Min	Max
Detector head footprint	mm ²	47.8 x 46.3	
Number SPM pixels		144	
Pixel pitch	mm	3.37	5.89
Pixel sensitive area	mm ²	8.12	
dE/E [FWHM] for LYSO at 511 keV	%	< 17	
Optical response uniformity over all pixels ⁽¹⁾	%	< ±10	

⁽¹⁾ Measured as $\frac{\text{PixelResponse}}{\text{Median(PixelResponse)}}$

Corresponding to a multi-anode PMT uniformity of 1 : 1.2

Basic characteristics of the front-end readout system for the Matrix9 detector head are:

Parameter	Unit	Value
Board size	mm ²	42.5 x 100.0
Enclosure size (including detector head)	mm ³	46.5 x 48.0 x 134.0
Max. cable length to detector head	mm	70
Module power consumption	W	0.7
Signal threshold discriminator resolution	mV	1
Module intrinsic timing resolution	ns	0.5
Event timing resolution	ns	< 3.0
Module interface signal architecture	serial	LVDS
System dead time ⁽¹⁾	µsec	2
Event loss rate at 10kHz / 100kHz rates ⁽³⁾	%	2 / 20
Saturated event rate ⁽³⁾	kHz	500
Readout modes ⁽²⁾		3
Firmware updates via host computer		YES
openPET compliant interface		YES

⁽¹⁾ Time required to process a scintillation event that exceeds signal threshold.

⁽²⁾ The module supports three software selectable readout modes:

- **Single Pixel** - location, time and energy for a single pixel above signal threshold - event size: 8 bytes
- **Full** - location and time of single pixel above signal threshold. Readout of recorded energies for all 144 pixels - event size: 38 bytes
- **Region of Interest** - location, time and energy of single pixel above signal threshold. Energy for each of its 8 neighboring pixels - event size: 24 bytes.

⁽³⁾ Readout in Single Pixel mode.

Communications board characteristics are:

Parameter	Unit	Min	Max
Board size	mm ²	141.0 x 183.0	
Matrix9 detectors supported	mm ³	1	16
USB readout buffer	MB	2	
USB speed	Mbps	20	
Internal clock time resolution	ns	0.5	
Max. cable length to detector head	cm	250	
Power consumption	W	1.0	
Sustainable event rate - Single Pixel mode	kHz	200	
Firmware upgrades via host computer		YES	

Time coincidence analysis: The communications board can match events from different Matrix9 modules in terms of event timing. Dropping events that do not satisfy software a selectable time window constraint are dropped thereby reducing data rates the host computer.

Matrix9 Software

Matrix9 is shipped with a suite of software tools for Windows XP and 7. These include:

- dll drivers, C header files and LabView drivers.
- Fully documented C code examples.
- A GUI based application for visual display of Matrix9 event data and analysis of timing and energy spectra.
- Firmware upload utility.

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