

Modular Scintillator Readout Solution for Nuclear Medicine

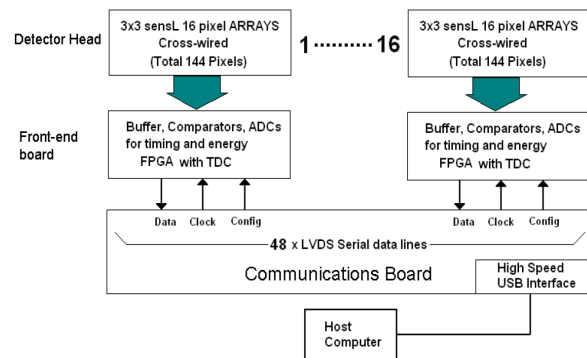
SensL's MatrixSL-9 is the first modular, turnkey readout system specifically designed for nuclear medicine applications. Building on SensL's silicon photomultiplier technology, MatrixSL-9 provides a fully solid-state, four-side scalable detector for the readout of L(Y)SO scintillator arrays. It integrates 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 a high speed USB interface. Integrating multiple detector heads, MatrixSL-9 can perform temporal coincidence analysis thereby reducing data rates and the computational load on the host system. MatrixSL-9 is available as a turnkey, fully integrated module or as an OEM sub-system for rapid integration. The detector head is available in both a square 12 x 12 pixel or a rectangular 4 x 36 pixel arrangement.



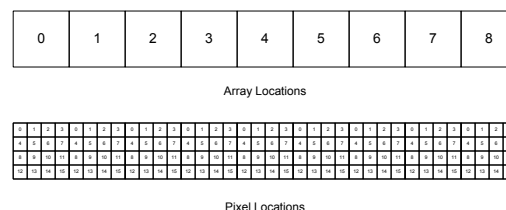
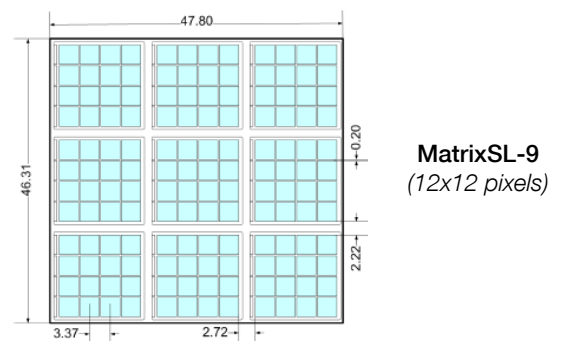
SYSTEM OVERVIEW

MatrixSL-9 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 MatrixSL-9 detector head requires low power and operating voltage, is compact, highly robust and offers excellent spatial segmentation and optical response uniformity. Addressing the needs of high-resolution imagers such as small animal, pre-clinical and mammography PET, the MatrixSL-9 is a compelling alternative to the multi-anode PMT. A high degree of modularity and compliance with the openPET standard makes MatrixSL-9 a cost effective substitute for the PMT in full-body PET systems. The MatrixSL-9 system architecture is based on three principal sub-systems:

1. Detector Head - a 12 x 12 (MatrixSL-9) or 4 x 36 (MatrixSL-9X1) 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 MatrixSL-9 Communications board through a high speed serial interface.
3. The MatrixSL-9 Communications Board (Matrix-EVB-16 - ordered separately) supports up to 16 MatrixSL-9 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.



MATRIXSL-9 DETECTOR CONFIGURATIONS



MatrixSL-9X1
(4 x 36 pixels)

FRONT-END READOUT SYSTEM CHARACTERISTICS

Parameter	Unit	Value
Board size	mm ²	42.5 x 100.0
Enclosure size ⁽¹⁾ (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 ⁽²⁾	µsec	2
Event loss rate @10kHz / 100kHz rates ⁽⁴⁾	%	2 / 20
Saturated event rate ⁽⁴⁾	kHz	500
Readout modes ⁽³⁾		3
Firmware updates via host computer		YES
openPET compliant interface		YES

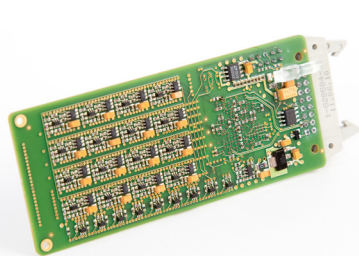
(1) Only applicable to the MatrixSL-9. No enclosure available for the MatrixSL-9X1.

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

(3) 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.

(4) Readout in Single Pixel mode.



Front-end readout board



Back view of the MatrixSL-9 enclosure



Linear MatrixSL-9 detector head

DETECTOR HEAD CHARACTERISTICS

Parameter	Unit	MatrixSL-9		MatrixSL-9X1	
		Min.	Max.	Min.	Max.
Detector head footprint	mm ²	47.8 x 46.3		13.4 x 150 ⁽⁶⁾	
Number of SPM pixels		144			
Pixel pitch	mm	3.37	5.89	3.37	5.89
Pixel sensitive area	mm ²	8.12			
dE/E (FWHM) for LYSO at 511keV	%	< 17			
Optical response uniformity over all pixels ⁽⁵⁾	%	< +/-10			

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

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

(6) Approximate length.

COMMUNICATIONS BOARD CHARACTERISTICS

Parameter	Unit	Min.	Max.
Board size	mm ²	141.0 x 183.0	
MatrixSL-9 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 MatrixSL-9 modules in terms of event timing. Dropping events that do not satisfy a software selectable time window constraint are dropped, thereby reducing data rates the host computer.

MATRIXSL-9 SOFTWARE

MatrixSL-9 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 MatrixSL-9 event data and analysis of timing and energy spectra.
- Firmware upload utility.