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Third generation of ArduSiPM All-in-One Detector Technologies: NanoArduSiPM

Expanding on the advancements of ArduSiPM, the first all-in-one scintillator particle detector combining System on Chip (SoC) technology with a SiPM, the LITE SLPD project has developed a next-generation version. The new design delivers better performance and is more compact by reducing external components and microcontroller size. The use of an optimized firmware and of the internal peripherals of the SoC reduces cost and makes upgrades easier. The embedded system does not require an external data acquisition unit since the SoC's internal CPU performs edge computing functions. The firmware features enhanced analysis functions, including an optimized amplitude histogram generator and an improved threshold scan, offering greater accuracy and efficiency compared to previous generations. Additionally, it incorporates data compression algorithms to optimize communications in satellite applications or low-throughput transmission systems such as LoRa.

The third generation, called NanoArduSiPM, is lightweight (7 g) and compact, measuring 42 mm × 36 mm. This is primarily due to the adoption of a new 9 mm × 9 mm processor package, which represents the most significant upgrade from the second generation. It is powered by the Microchip SAMV71, a 320 MHz ARM® Cortex®-M7 processor featuring a 2 MHz DAC/ADC and enhanced memory, which optimizes real-time histogram processing and radiation monitoring. The processor includes a radiation-tolerant version which expands its potential for extreme environments. With the third generation, the digital threshold can be set below 0.5 photons, enabling highly sensitive photon detection. The device measures event rate, arrival time (with 6.6 ns resolution), and the number of detected photons.

NanoArduSiPM maintains low power consumption (just under 1 watt), which can be further optimized using dedicated processor functions in sleep mode. Additionally, its compact design adheres to PocketQube standards, making it well-suited for space applications. While primarily developed as a particle detector, it can be adapted to detect different types of radiation by selecting appropriate scintillators: inorganic crystals for X-ray and gamma or plastic for charged particles.

Beyond particle physics, NanoArduSiPM also serves as a highly sensitive photon detector, enabling a broader range of applications. It is currently being used in collaboration with the Analytical Chemistry Department of Bologna University to study bioluminescence and chemiluminescence. Furthermore, in time-domain optical astronomy, it is being developed to observe optical pulsars and fast transient events since its detection speed is 10^4 times faster than traditional CCDs commonly used.

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