

The project summary

Modern X-ray detection based digital imaging techniques would not be possible without the development of multi-channel integrated circuits (IC) used to build detection systems. The dedicated IC attached to an X-ray radiation detector constitutes a hybrid detection module, which is the core of the entire measurement system. The module's parameters are crucial from the acquired image quality point of view. Despite the availability of a wide range of imaging techniques that allow us to discover the fundamental laws of physics and chemistry, scientists still need newer devices to develop the existing state of knowledge. Planned new measuring installations to be used on synchrotron radiation sources are the best example of this, where each next generation requires pushing the existing limits further and further in order to achieve parameters exceeding previously boundaries, such as e.g. operation with high intensity of incident radiation or the ability to precisely determine the place of photon interaction with a radiation detector. This project is part of this development, and its result will be the development of a multi-channel readout IC that meets the requirements for future synchrotron measurement applications.

The scientific goal of this project is to develop a new fast circuit solution operating in the single photon counting mode, dedicated to read-out of a sensors matrix with a high degree of granulation (the single pixel pitch is more than 10 times smaller than the diameter of a human hair), while meeting the requirement for high intensity of incoming pulses at the readout channels' inputs (of the order of several million counts per second per pixel) and potential applications in synchrotron facilities. Thus, the developed solution will be characterized at the single pixel level by ultra-fast processing speed of input pulses by the analog circuitry, implementation of digital blocks responsible not only for counting the number of incident photons, but also indicating the pixel that has collected the most part of the input charge correlated with the photon interaction with a detector - all of them while limiting the level of power dissipation and keeping readout channel noise at the possible low level, as well as ensuring a high degree of system configurability (for example, the possibility of operating adjacent pixels in clusters).

The development of a target solution to the mentioned problem consists of two main parts: theoretical/simulation, and practical/verification. The first part is the search for the optimal architecture of the readout electronics in terms of the requirements described above, which, after modeling, will be verified by simulation at the schematic and post-extraction level. The second part of the project is the implementation of the developed circuitry in a multi-channel specified IC in the selected nanometer CMOS technology, and then measurement verification of the manufactured IC in the developed test environment.