Silicon photomultipliers for determining position of microfluidic radioactive samples

B. Salvador[1]*, D. Escalante[2], L. Fernández[3], A. Corral[3], S. Camacho[2], J.M. Quero[1], A. Luque[1]
[1] Dept. Electronic Engineering, Universidad de Sevilla; [2] Technological Institute of Monterrey, Campus Monterrey; [3] National Accelerators Centre, Universidad de Sevilla
bsalvador@us.es

Abstract—An on-chip sensing circuit for measuring radioactivity in different positions of a microfluidic device through the use of silicon photomultipliers (SiPM) is presented. It is intended for use in a microfluidic platform producing radiopharmaceuticals for PET imaging. The results show that an array of SiPMs can be used to determine the position of a radioactive sample within a microfluidic chip with enough precision to be usable.

Keywords—Microfluidic, photomultipliers, radiation, radiopharmaceuticals.

1 Introduction

In recent years, the concept of dose on demand for the generation of radiopharmaceuticals for the diagnosis and monitoring of diseases has become relevant. PET analysis is usually the most used [1]. Quality controls for PET are based on three factors, activity, half-life and radionuclide purity [2].

The Geiger-Müller tubes [3] [4] have been the most commercially used radiation detectors for many years, given their robustness. Currently, other detectors work through quantum effects and are capable of detecting radiation using the properties of semiconductor materials.

Among these devices are the SiPM, which are capable of generating a Geiger avalanche effect when a photon is detected, thus generating a photocurrent. Also, a photocurrent of greater magnitude is generated when a greater number of photons impacts on the SiPM [5]. The number of impact counts per second (cps) is a measure of radioactivity.

In this paper, sing a SiPM matrix, a system capable of determining the positions where the activity is concentrated using a SiPM matrix has been developed. This measurement can provide information on the progress of the different steps of the radiopharmaceutical synthesis in a microfluidic device.

2 Setup for monitoring

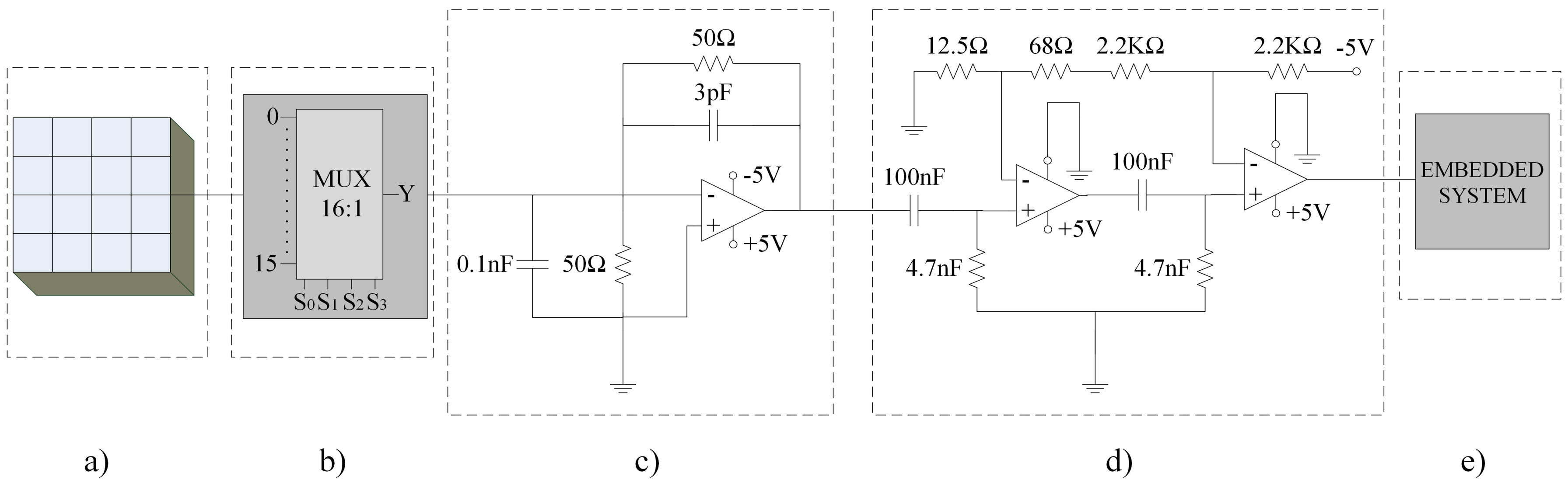

Fig.1. Measurement circuit: a) SiPM Array, b) multiplexer, c) conversion of current to voltage circuit, d) Rail-to-Rail amplifier and e) embedded system

The SiPM used is the sensor ArrayC-30035-16P from SensL. The detection of activity is focused on an area of 256 mm^2, in sectors of 9 mm^2.

- The output will generate a current and it will need a signal coupling to transform it into voltage.
- The sensor is powered at 27 V with positive polarization.
- In order to record the 16 signals by using a multiplexer (Nexperia multiplexer 74HC4067).
- For conversion of current to voltage of the generated photocurrent, an operational amplifier configured in transimpedance mode (TIA OPA656, Texas Instruments) is used.
- The TIA output signal is converted to a digital logic value that can be measured with a simple embedded system. This is done using a Rail-to-Rail amplifier (OPA2354, Texas Instruments).

3 Experimental results

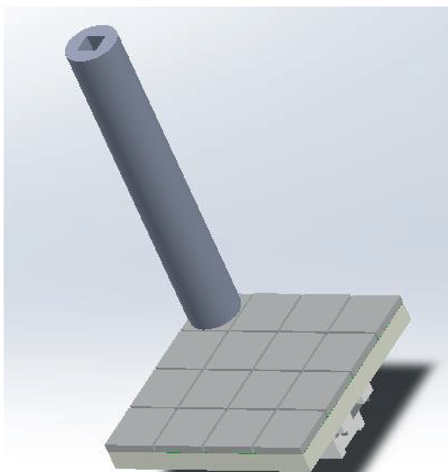

Fig.3. Placing the vial in a corner of the sensor to make the measurement.

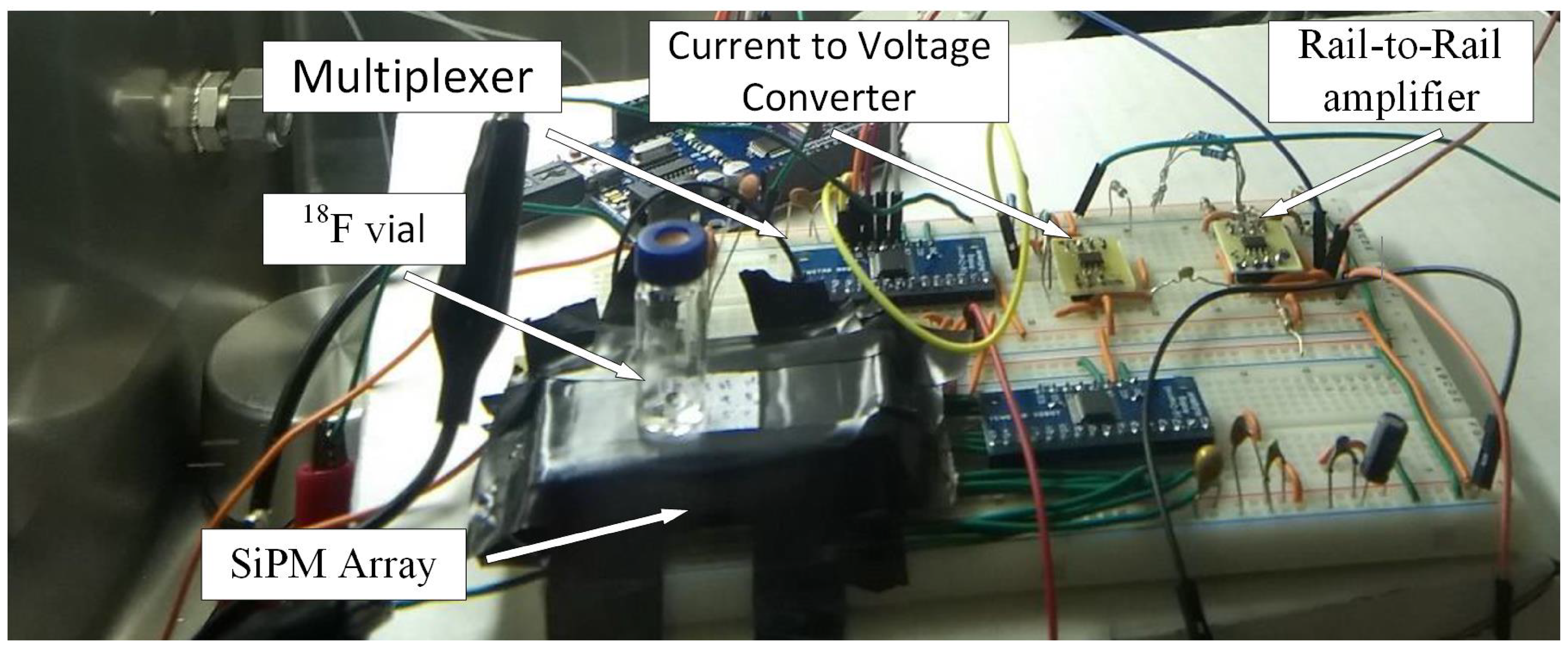

Fig.2. Experimental setup to locate the position of the vial.

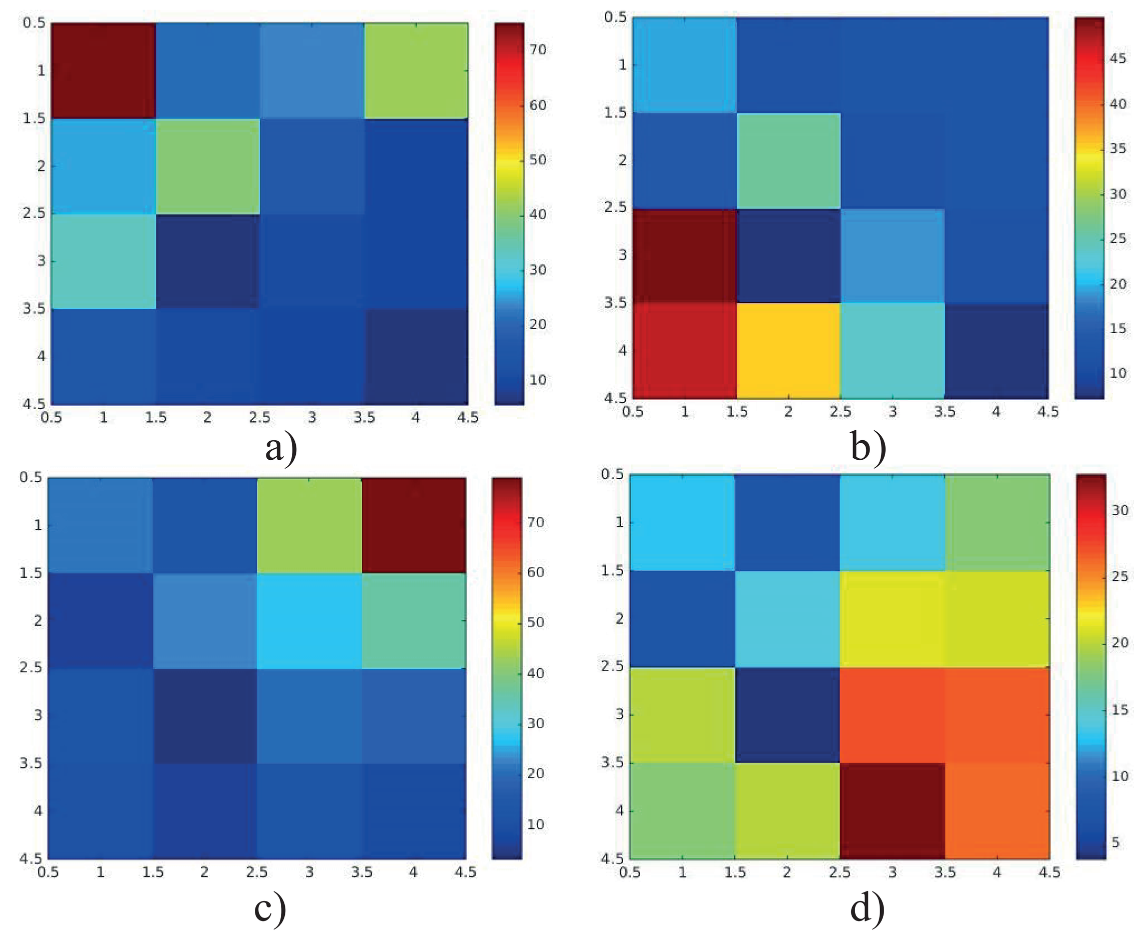

Fig.4. Heat map of the measure: a) pixel 0, b) pixel 3, c) pixel 12 and d) pixel 15.

The test consisted in the use of a vial that was located in different positions:

- Figure 2: Experimental assembly. For this experimental test, the multiplexing of the 16 signals is used to measure the counts per second generated by a vial on a specific pixel for one minute. The vial contains ^{18}F in an approximate volume of 120 µL with an activity of 40.4 MBq.

- Figure 3: The result that was expected for this experiment is that the pixel where the vial is positioned has a greater radiation count than those distant from it. With this test, it was concluded that the sensor is able to differentiate the position of the vial with radioactivity.

Figure 4 : heat map produced by the vial placed in the four corners of the sensor. The cps detected in each sensor allow the differentiation among positions, as intended.

4 Conclusions

In this work, an instrumentation system capable of measuring and positing the radioactivity present in a microfluidic platform has been implemented when it is used for the production of PET radiopharmaceuticals. In addition, each of the instrumentation steps to be followed has been reported to measure radiation by using SiPMs.

The purpose of the development is to monitor the reaction that will happen in a microfluidic PDMS chip. Tests on a real device must be made in order to determine whether this setup is able to correctly identify the position of radioactive samples . Likewise, it is important to perform tests to determine the effect that PDMS will have in the measurements.

5 References

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