DIGITAL DETECTOR OF IMPULSES OF A SCINTILLATION COUNTER

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ABSTRACT

This contribution is about the digital signal processing of the signal from a scintillation counter. The digital detection system is implemented in a FPGA device as a part of system form measurement of ionizing radiation.

1 INTRODUCTION

The Scintillation counter is used to measure the energy of ionising radiation. The working principle of the detector is based on interaction between the scintillator and incident radiation, whereat light twinkles are produced. The light twinkles are transformed to a voltage impulse by the photocathode system of the photomultiplier [1]. The height of these impulses is proportional to the energy of the incident ionising radiation [2]. These impulses are produced randomly and their appearance can be described by a Poisson distribution viz. equation 1. Where *p(k)* is probability of coming *k* impulses during the next period. The parameter λ is proportional to the signal frequency and the time interval.

$$p(k) = \frac{e^{-\lambda}}{k!} \cdot \lambda^k \tag{1}$$

where k number of impulses, $k = 0, 1, 2, \ldots\ldots\ldots$
$\lambda = n \cdot T$,
n signal frequency,
T time interval.

The task of the detection system is the creation of a histogram of the heights of incoming impulses. After we obtained this measured histogram we can determine the type of ionising radiation and have conclusions about its activity.

2 DETECTION

We can use two different methods to measure the height of the impulse. These are either using an analog system or a digital system.

2.1 THE ANALOG DETECTION SYSTEM

The analog system consists of a preamplifier, an impulse former and a peak detector. The impulse former is used to shorten the time of an impulse and to remove its d.c. component. The peak detector is used to hold the maximum value of the impulse for a few nanoseconds. The maximum value is converted to digital form and then written to the histogram during this holding time.

2.2 THE DIGITAL DETECTION SYSTEM

In case of a digital system values of the measured signal are converted to digital form by A/D converter immediately after being processed by the preamplifier as in shown in figure 1. The measurement of the height of the impulses is realized by a state machine. The measured height of the impulse is written into RAM memory where is stored for next processing.

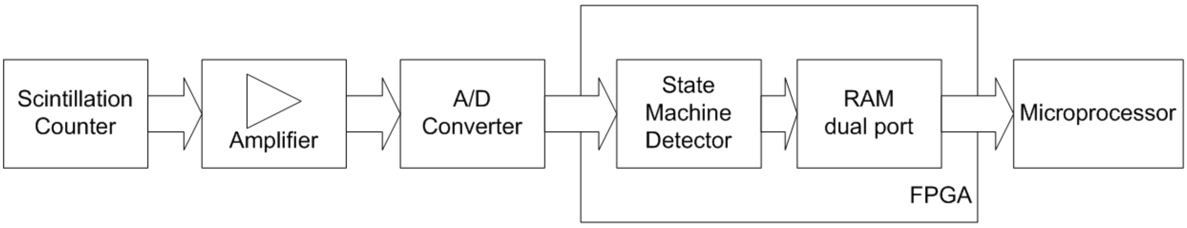

Fig. 1: *Digital Detection System*

3 DIGITAL DETECTION SYSTEM IN FPGA

The state machine is used for the detection of the height of the impulse. The working principle of the state machine is obvious from figure 2 and 3.

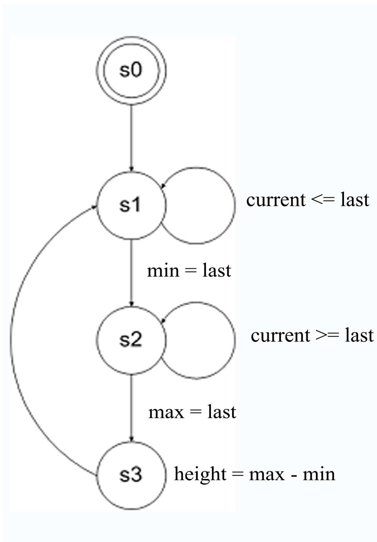

Fig. 2: *State Diagram*

It measures the level of the signal. The state machine detected the minimum of the signal if the current value of the signal is bigger than previous one and if the previous progression was decreasing (state *s1* in figure 1). The state machine detected the maximum of the signal if the current value of the signal is smaller than any previous one and if the previous progression was increasing (state *s2* in figure 1). The height of the impulse is computed by subtraction of the detected minimum value from the detected maximum value. The measured height of the impulse is written into RAM memory if the height of the impulse was bigger than a selected threshold value.

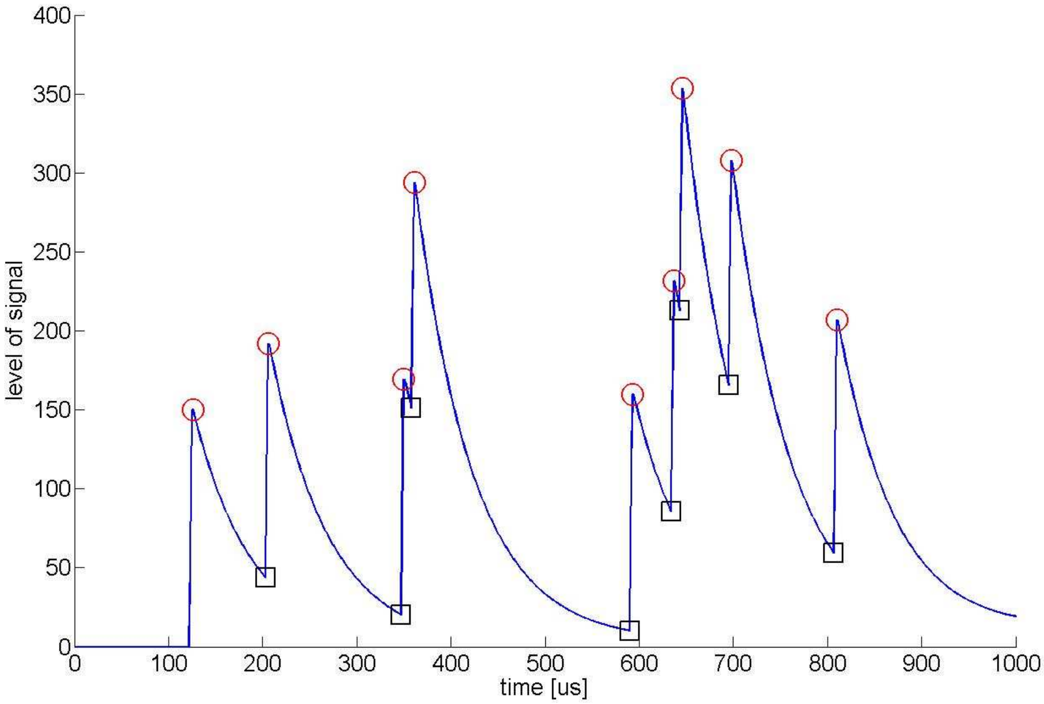

Fig. 3: *Measured Signal*

4 RESULTS AND FUTHER WORK

The described digital detection system including state machine and RAM memory for histogram generation was implemented in an FPGA device. The main advantages of the digital detection in FPGA are that parameters of the detection system can be changed by software and the whole detection system is realized by one chip only. An example of a measured histogram can be seen in figure 4.

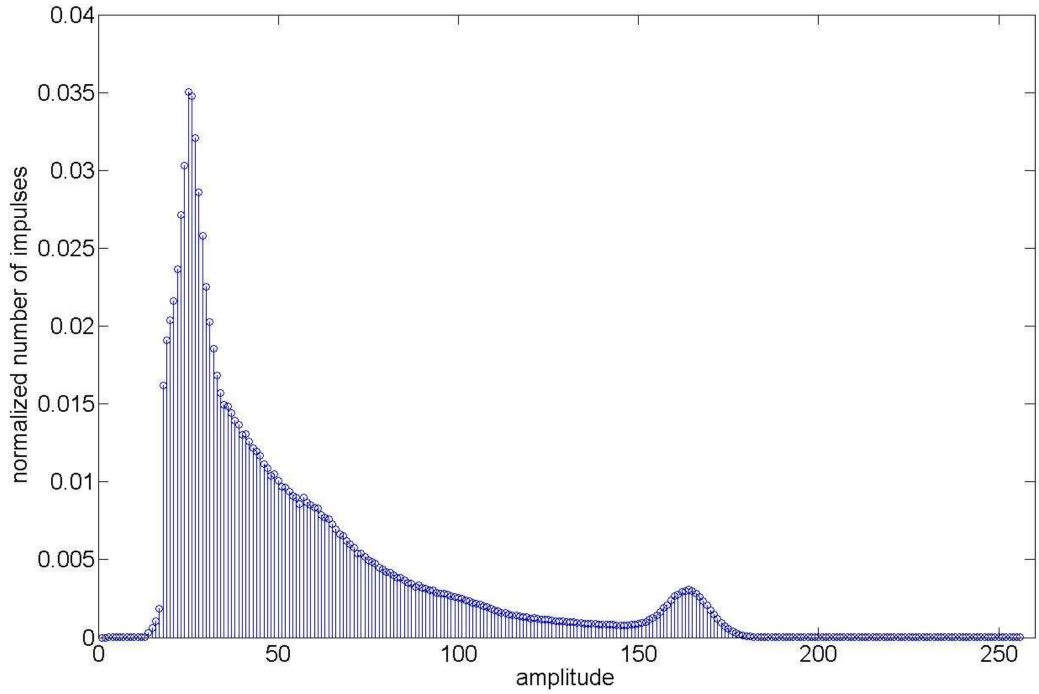

Fig. 4: *Measured Histogram of Amplitudes*

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