Software Architecture for Remote Monitoring Systems of Surface Contamination by Alpha Radioactive Isotopes

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Abstract. In this paper, we present alpha-radiation monitoring system software. Detector works in accounting mode that adds some extra features. Possible detector applications such as pedestrian radiation portal monitor or portable alpha contamination dosimeter are presented. Detector is based on air ion method. In view of detector works in accounting mode, it shows high selectivity to alpha particles registration. Alpha selection principle is also shown. Control system and software system are considered in detail.

Keywords: Alpha radiation · Control system · Data processing system

1 Introduction

There is an urgent need for searching for alpha contamination sources, for example, at nuclear facilities. Well-known that alpha particle has a very short range in air. Air-ion method for alpha particles registration has been extensively studied. Method allows carrying out remote detecting alpha-particles on distance from a source of the radiation, essentially exceeding run particles in the air. Air ions are transferred to a trace of a particle in working volume of the detector with the help of a specially created air stream (see Figs. 1a, c). A close attention was paid to measuring of the current carried by the moving ions in the air-ion method by MacArthur et al. [1]. Whereas, in this study, detector works in accounting mode that provides sharp selectivity and accuracy of measurements [2, 5]. However, it has been found to be dependent on humidity [3]. Figures 1b, d provide experimental devices based on the detector.

For today, a lot of pedestrian portal monitors are commercially available. (companies Canberra, Mirion etc.). However, they work directly with alpha particles. Scheme of proposed pedestrian portal monitor (displayed in Fig. 1a) and its prototype (see Fig. 1b). Where (1) is a system for airflow directing, (2) – source of an ionizing radiation (α), (3) – doors, (4) – enlarged view of the detector, (5) – charge-sensitive amplifier and pulse shaper, (6) – air ions, (7) – wire netting and filter, (8) – fan, (9) – cathode, (10) – anode, (11) – data processing system, (12) – remote control computer.

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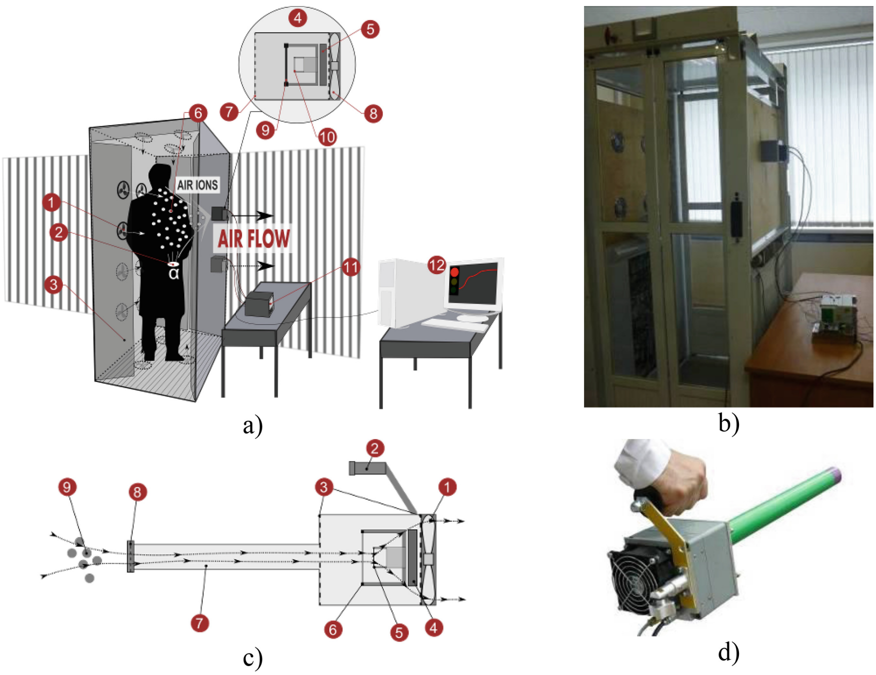


Fig. 1. Potential applications of the detector. Both devices use gas discharge detector. Description of numbered nodes is presented in the main text.

Diagram chart of the portable alpha dosimeter with a tube nozzle and its prototype can be found in Figs. 1c, d. Such nozzle is useful for monitoring places hard to reach. Apart from that, proposed detector can be applied to a wide range of nozzles. As listed in Fig. 1c, (1) – fan; (2) – handle; (3) – wire netting; (4) – amplifier and pulse shaper; (5) – anode; (6) – cathode; (7) – tube nozzle; (8) – filter; (9) – air ions.

1.1 Alpha Particle's Selection Principle

Figure 2 displays the principle of selecting alpha particles. This image suggests that there is a direct relationship between the number of pulses and presence of alpha particles.

Pulse shaper forms pulses acceptable for counter. Notwithstanding the control board can be used as a counter, external counter PIC16F628A was chosen. Unfortunately, the use of the user space counter and kernel module based counter was not successful in this task: not all pulses were accounted. And this counter is connected using serial interface to the control board.

Furthermore, when working in the Linux operating system at a frequency greater than 1 kHz, the number of counted pulses is dependent on duty cycle pulse sequence. At a certain value, it did not produce interrupts or they did not have time to be processed.

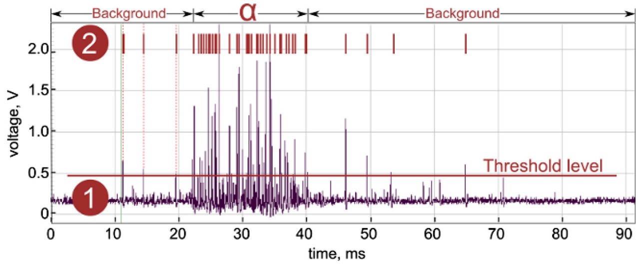


Fig. 2. The principle of alpha particles selecting. For the first stage there is a rejection of low noise pulses (1 – voltage on the discharge wire, 2 – selected pulses); for the second stage there is a detection of the time intervals with high pulse density.

1.2 Software and Hardware Scheme

In this section close attention is paid to the portal monitor control system and control program (see Figs. 3 and 4).

The control system of the portal is built on Atmel ARM9 microcontroller. uLCD panel of the 4D SYSTEMS company was used for data display (marked as “4” on Fig. 4a). This allows to use LCD panel as keyboard. For this device special core module, running under OS Linux, was written. That allows to operatively trigger events from the keyboard (marked as “3” and “5” on Fig. 4a), detector (marked as “8” on Fig. 4a) and counter (marked “9” on Fig. 4a). Using the control system of the portal combination of external computer and web-server interfaces (marked as “7” and “15” on Fig. 4a) is easy getting measurements dates, watching continuously current count and changing settings. When you need to make a backup for the data and settings, you just need to plug in the USB-flash drive (marked as “6” on Fig. 4a). All these options are controlled by standard Linux core modules (marked as “10” on Fig. 4a). The core of the control system program is the main control sub-program (marked as “1” on Fig. 4a) responsible for quality of measurement. That sub-program allows to control for the execution of main modes such as “Calibration” (in this mode device sets an operating voltage).

Control program (can be seen from Fig. 4a, item 1 and Fig. 4b) was made using Tcl/Expect [4]. Extension to the Tcl scripting language Expect, that is a program to automate interactions with programs that expose a text terminal interface.

Fig. 3. External and internal views of the control device.

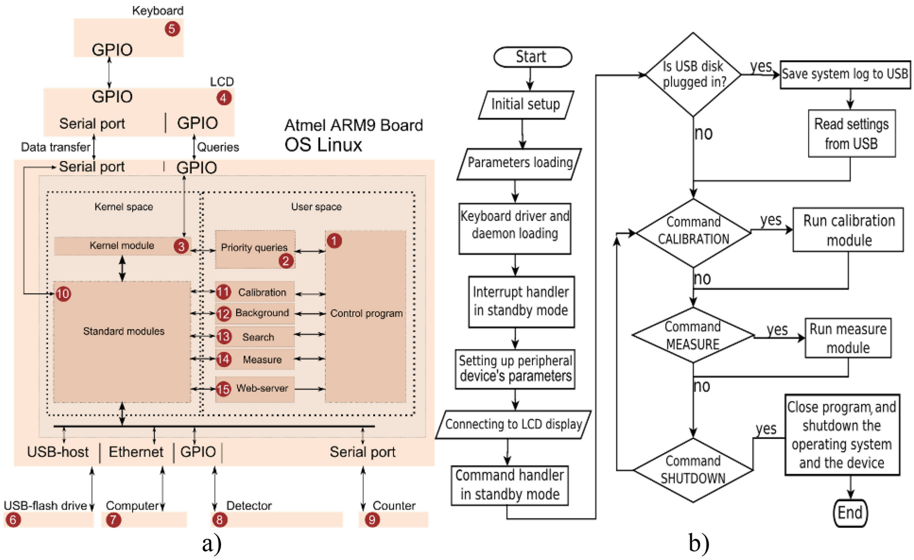


Fig. 4. Block-diagram of the control system of the device (a) and block-diagram of the control program (b). Description of numbered nodes is presented in the main text.

Keyboard software was made using 4DGL (high level graphic oriented language). The screen uLCD acts as an independent system. Hence images are drawn and stored in the display's memory. And it uses serial communication and bus interruptions to communicate to the control board. Little attention has been paid to it. To realize the interruptions, kernel module and corresponding daemon were made (as detailed in Fig. 5a). Figure 5b illustrates proposed transmission protocol for serial communication.

Figure 6 demonstrates the work of the device in calibration (a) and in search (b) modes. For a successful calibration, number of pulses should fall into the specified range certain number of times. As can be seen in Fig. 6a, calibration was successful. During the search mode, the Pu-239 source (760 Bq) was located on the chest. It is evident that number of counts significantly decreases when man leaves portal (see Fig. 6b).

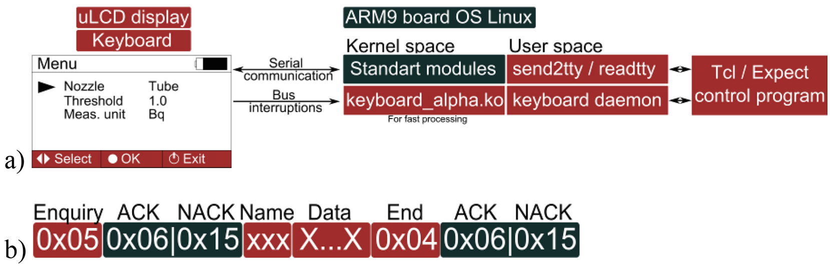
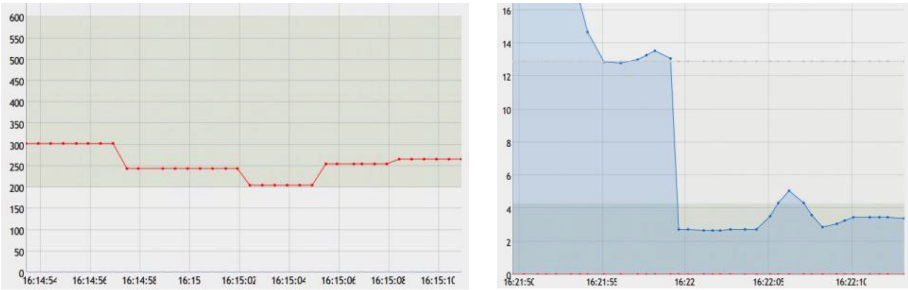


Fig. 5. The communication between control program and uLCD display connected to the keyboard (b). Transmission protocol (b)



a) b)

Fig. 6. Real-time calibration (a) and search (b) (web browser view). It is possible to use it from internet (using virtual private network).

2 Conclusion

This study provides insight into software architecture for remote monitoring systems of surface contamination by alpha radioactive isotopes based on air ion method. In this study, we present also different devices based on this principle. The detector works in accounting mode that is promising because selectivity can be increased. But, on the other hand, it depends on pulse shaper and counter characteristics.

As outlined in the introduction, it may be used at nuclear facilities. It also should be noted that it is economically important due to its relative cheapness because of its simplicity, while it gave satisfactory results.

Using alpha radiation monitoring device based on air ion method introduces some features to hardware and software. For precise counting external counter was used and connected via SPI interface.

Eventually, using multiple detectors and adjusting the fans' position, number, and strength, we can get rid of unwanted pedestrian portal monitor's dead zones.

References

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