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Alpha Contamination Monitoring System in Palm

[1]H. Anu, [2]Betty Martin and [3]R. Amudhu Ramesh Kumar

[1]M.E.(E and C), Sathyabama University, Chennai, India
[2]Professor, E and C, Sathyabama University, Chennai, India
[3]Scientific Officer 'E' grade, IGCAR, Kalpakkam, India

Abstract: Alpha contamination monitoring is essential for the detecting the contamination in hands, cloth and other objects. These contamination monitors are useful in fields like Nuclear Reactors, Fuel fabrication plant, Reprocessing Plants, Active analytical labs, Nuclear Waste Management plants and nuclear waste immobilization plants. Designing and developing a compact Alpha Contamination monitors with self diagnostic feature is the objective of this paper. This paper describes the design, development and calibration of such monitor. The design has been realized using a simulink simulator and electronic system. The verification and validation has been carried out by radioactive source.

Key words: Alpha · Contamination · Immobilation

INTRODUCTION

Alpha particle is highly ionizing and harmful to human. However, previous studies have shown that the detection of such particle in the contaminated area or on contaminated human is achieved by bulky contamination system [1]. Scintillated based techniques are famous for their simple gross counting of alpha particles using Photo Multiplier Tubes (PMT) and associated electronic circuits [2]. The design of the monitor incorporate the features of automatic detection hand or material closer to detection area, HV fail indication, Saturation detection due to light, immediate alarm on contamination and portable design [3]. The design has been tested with simulation based software for their basic functionalities with observed data in the field. The electronic circuits and PCBs are tested for their individual modules and are integrated with main controller for the functionalities. Real radioactive source testing has been carried out with different trials and the indented efficiency of about 25% has been proved and verified. Development of the system has been obtained in four steps

- Development of the system using simulator
- Real time development using electronic circuits and detectors
- Testing of the system with radioactive source
- Testing of the simulator system with test data

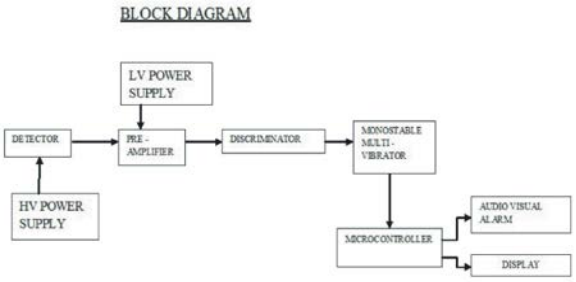

Fig. 1: Compact Alpha Palm Contamination Monitoring System

Block Diagram of Compact Alpha Contamination Monitoring Sysyem in Palm

Flow Chart and Techniques Details

Flow Chart: The indented purpose of the system has been, Alpha particle detection is achieved by scintillation detection, Thin mylar is used to block the light particle and to allow alpha particle to interact with ZnS(Ag). Light in visible spectrum generated though alpha interaction with Zn(Ag) is couple to the Photo multiplier tube, which amplifies the electron based on light input and contributes a current, proportional to the input light. The current output form PMT is converted into pulse using RC circuits. These pulses have been amplified and discriminated from the noises using discriminator (comparator) [3]. The pulses with are converted to uniform size using a mono stable multivibrator. The pulses are

Corresponding Author: H. Anu, M.E.(E and C), Sathyabama University, Chennai, India.

counted in the Micro Controller (MC) and the alarms are generated based on alarm set limits. Prompt alarm generated when count exceeds the alarm limit and not waiting for the count time to complete. HV is bleeded to a suitable low voltage, which is monitored by MC and HV fail alarm is generated promptly. Saturation current of PMT is monitored continuously to generate PMT saturation. Background subtraction of the monitor is an option provided to detect the background periodically and subtract it from gross count such that the net count can be detected [3]. Four button keyboards has been used as Input to the MC to set the HV fail limit, Alarm limit, Background subtraction, counting time, Background counting time, CPM/CPS mode, test mode, date and time as used to set Input to the MC.

Simulation

First Stage Simulation: Signal generator is used instead of alpha reference signal. IR position 'o' means hand is present in the testing element [2]. This position is given to subsystem which gives signal generator output when IR system is in zero position. When IR signal present the subsystem will not allow the output. Flow chart of simulation is given as below

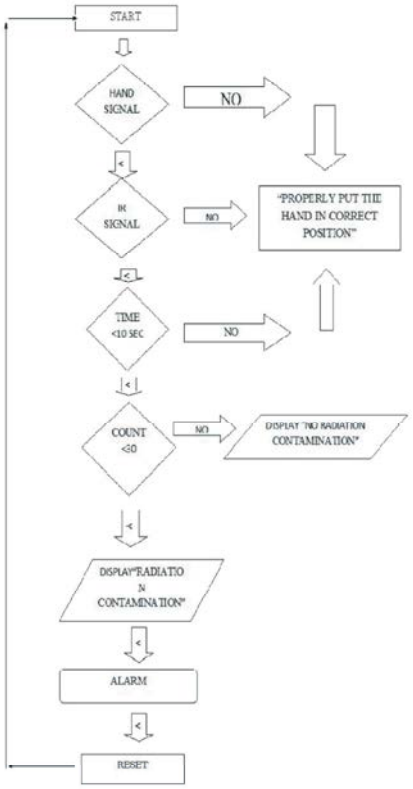

Fig. 2: Flow chart of the simulation

Principle and Operation: This output port is connected to monostable multivibrator through a manual switch1. Multivibrator output port is connected to up counter and the output of up counter is given to 3 displays [4]. One is allowed for counter value. Two individual displays connected to comparators with reference and the output will be either contaminated (or) normal according to the value obtained [3].

While executing run state, reference source value which we are setting for simulation will be displayed.

- If the ref value is below 30 "NO CONTAMINATION" will be displayed in the display.
- If the ref value is set above 30 "CONTAMINATION" will be displayed in the display.

Second Stage Simulation: To show input of IR present there will be no display reading, a separate hand position block with IR signal is connected with logical NOT and hand position is connected with logical OR along with IR signal NOT output through a manual switch 2.

While executing run state it will show no contamination in display [1].

Third Stage Simulation: For test mode, test made output port is connected with manual switch 2 and the output of manual switch 2 is connected to monostable multivibrator to see the output of display [5].

It is used to check the display the value which we set.

Detector Assembly: S.S grill with window of 115 x 180 mm area honey comb mesh is used as the prodetector for the detectors with minimum area of masking the source or object to be checked for contamination [1]. ZnS (Ag) screen covered with aluminized miler has been used as scintilla or detector. Photomultiplier Tube (PMT) of dia 3 inch has been used as photo amplification device, which yield current proposional to the incident alpha radiation [5]. The entire detector setup has been mounted in a MS box. The overall efficiency of the system is expected to be around 25%.

Visual Indication of Contamination Monitoring System:

- Neon lamp to indicate power condition of the instrument.
- 5 mm green LED to indicate count is on, when the instrument is occupied by palm; this LED glows and remains on till counting operation is completed.

- 5mm yellow LED to indicate incomplete operation i.e. when the palm is removed before completion of monitoring period, this led blinks and buzzer sounds on to warn the incomplete operation [3].
- 10 mm dia green LED has been used to indicate clear when the counts are less than the alarm set limit.
- 10 mm dia red LED has been used to indicate palm has been contaminated and required for wash the palm and monitor again.
- 5mm red LED has been used to indicate the saturation condition of the PMT
- Optical interruption of the palm has been detected using IR led transmitter and receiver.
- 8 x 2 alpha numeric LCD display has been used to display alpha counts value, HV value, down counter values, back round values, etc,

Alarm set of the monitor has been accomplished by setting the mode switch and write switch simultaneously for above 10 sec [3]. Then alarm and counts will be displayed and the cursor will be blinking at the most significant digits. By selecting the position and pressing the up key. Like this four digits of the settings can be filled by user.

The pre set time can be set by pressing the mode switch and write switch for 10 sec simultaneously. The counting (preset time) can be set from 00 to 99 secs and this set can be saved in the system permanently until further changes made by user [6].

Testing and Validating: The designed simulation and electronic system has been tested and validated.

Testing by Simulation: The designed simulation of model has been tested for the known frequency with counts, alarm, incomplete operation, clear, high background, HV fail, etc.

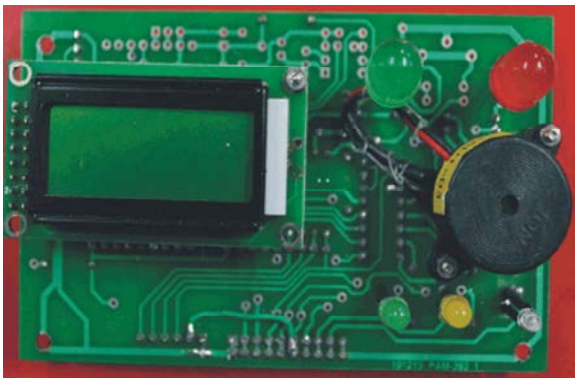

Fig. 3: PCB indicating LCD and other audio visual indicators

Fig. 4: Alarm setting

Fig. 5: Backgrouund mode Enable

Fig. 6: Background Testing

Testing by Radioactive Source: The designed system consisting of electronic, detector and integrated system has been tested with 33 Bq Natural U source.

Detector efficiency has been calculated using the formula

Fig. 7: Clear in Testing

Fig. 8: Contamination indication at the end of source test

Output

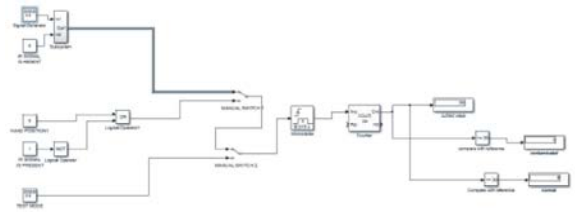

Fig. 9: Contamination

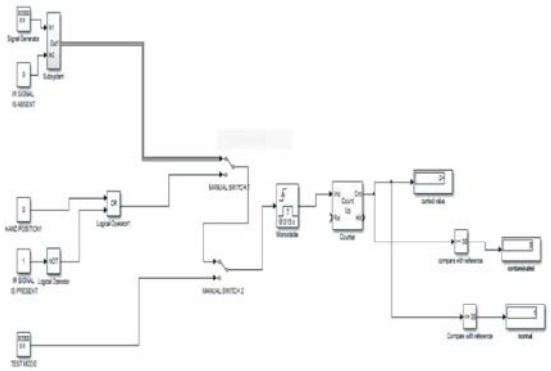

Fig. 10: Before Contamination

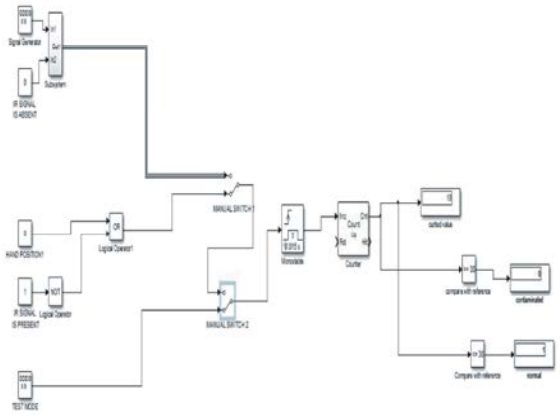

Fig. 11: Test Mode

$$\text{Efficiency} = \frac{\text{Counts per Second}}{\text{Disintegration per sec}}$$

Much iteration of the readings by keeping the source in between IR sensors of the system.

CONCLUSION

It has been proposed to design and develop a compact alpha hand contamination monitor with special features as per industrial requirements. A simulation model has been developed and tested for real time requirements. The simulation model has been tested a validated for the intended purpose. An electronic system has been designed, developed and tested with associated detector. The developed system has been tested with electronic signal and tested with radioactive source. The results are satisfactory and the overall efficiency of the system is in the range of 25 to 30 %. The system has been kept in user area for their usage in IGCAR and the user satisfaction level is good. A user suggestion of making the system operation in battery and mains is considered to implement in the improved version. The wireless communication requirement using Wi-Fi to transmit the current user test contamination is also consider implementing and transmitting the same to the central server

The failure mode analysis of the system of the previous systems have been consider, especially the HV fail, PMT saturation, Background count detection gross counts, etc have been implemented in the system for minimizing the downtime and easy diagnostics of the system.

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