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IMPLEMENTATION OF A PIN PHOTODIODE RADON COUNTER

Gyu-Sik Kim[*1] , Tae-Gue Oh[2], Jae-Hak Kim[3]
[*1]Department of Electrical Engineering, The Univ. of Seoul, Seoul, Korea

ABSTRACT

Radon is an invisible, odorless and chemically inactive radioactive gas that is produced by the decay of uranium ore. Various types of equipment and components have been proposed to date for radon detection. In this paper, a radon counter using PIN photodiode radon sensor module is implemented. Through experimental studies, we found that the PIN photodiode sensor module could be used for a radon counter.

Keywords: *radon, radon counter, PIN photodiode sensor .*

I. INTRODUCTION

Radon is an invisible, odorless and chemically inactive radioactive gas that is produced by the decay of uranium ore, such as radium, actinium, or thorium. Because inhaling radon and its radioactive decay products causes irradiation of lung tissue, prolonged exposure to high concentrations of radon significantly increases the risk of developing cancer

Various types of equipment and components have been proposed to date for radon detection. In [1], highly sensitive, electrostatic collection chambers have been developed for low-level radon measurements using CR-39 plastic track detectors. In [2], a radon detector employs an electrically charged pressed, porous metal filter that allows radon gas diffusion, while blocking ambient light, so that it readily traps both attached and unattached Po-214 and Po-2l8 ions, that may be present in gas passing through the filter, the filter being charged positively relative to an unbiased PN junction of a photo diode detector within a detection chamber. In [3], a passive direct-reading radon monitor utilizing a custom α particle detecting MOS integrated circuit and electrostatic radon progeny concentrator has been designed. In [4], a silicon PIN photodiode was designed and fabricated in consideration of low-leakage-current and high-bias-voltage application. In [5], a fast-responding passive radon detector using electrostatic concentration and enhanced readout electronics has been designed. In [6], an electrostatic concentrator constructed by metalizing a plastic funnel is used to focus charged radon progeny onto the exposed surface of an optical image sensor from a webcam. Alpha particles emitted by the collected progeny strike the image sensor, generating sufficient charge to completely saturate one or more pixels. In [7], a radon counter using CCD image sensor module is implemented. They showed that the CCD image sensor module could be used for a radon counter. In [8], a radon concentration monitoring system is developed, which uses the Safety Siren Pro Series 3 Radon Detector for detecting the radon particles and a data processing module with WCDMA communication capabilities for measurement results transmission and management. This solution represents an inexpensive, easy to use, portable Safety Siren Pro Series 3 radon detector and a radon monitoring system which can be used for monitoring the radon level in a specific location or for being a part of a distributed monitoring system.

In this paper, a radon counter using PIN photodiode sensor module is implemented. To demonstrate the practical significance of our results, we present some experimental results.

II. PIN PHOTODIODE SENSOR MODULE

Radon is a radioactive gas that is colorless, odorless, and tasteless and is impossible to detect without the use of sensitive test equipment. Radon is a naturally occurring gas produced by the breakdown of uranium in soil, rock, and water. The EPA presently suggests that corrective action be taken to reduce the radon levels in your home if measured over the long term at 4 pCi/L or greater. Recently a PIN photodiode is more widely used than a conventional PMT, because it requires less bias to operate it and it is very compact. A PIN photodiode sensor module shown in Fig.1 was used for detecting of radon gas in this paper. The LCD display in Fig. 2 shows the level of radon gas in Pico Curies per liter (pCi/L). The display range is 0.0 to 999.9. The radon counter developed in this paper is designed to notify the user of the level of radon gas on either a short-term or long-term basis, and is updated every hour if there is a change in the level of radon gas.

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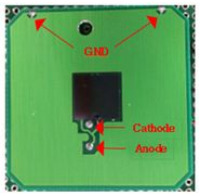	module size	43 x 43 mm
	sensor size	10 x 10 mm

Figure 1. PIN photodiode sensor module

Figure 2. LCD display showing radon concentration data

III. IMPLEMENTATION OF RADON COUNTER USING PIN PHOTODIODE SENSOR

When a radon particle hits the PIN photodiode sensor, the output voltage level of the sensor will be slightly changed. In order to detect this voltage change for MCU, a pulse converting circuit is needed. Fig. 3 shows the pulse converting block diagram. Fig. 4 shows the testing of pulse converting circuit.

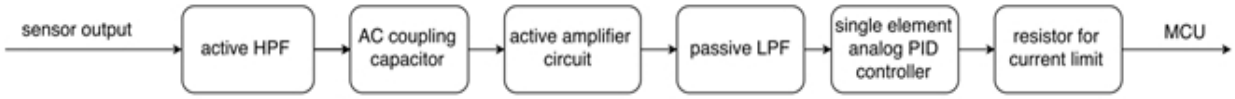

Figure 3. Pulse converting block diagram

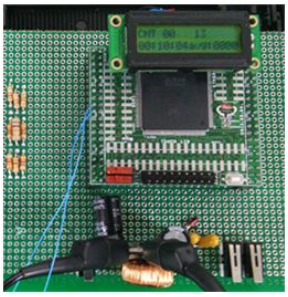

Figure 4. Testing of pulse converting circuit

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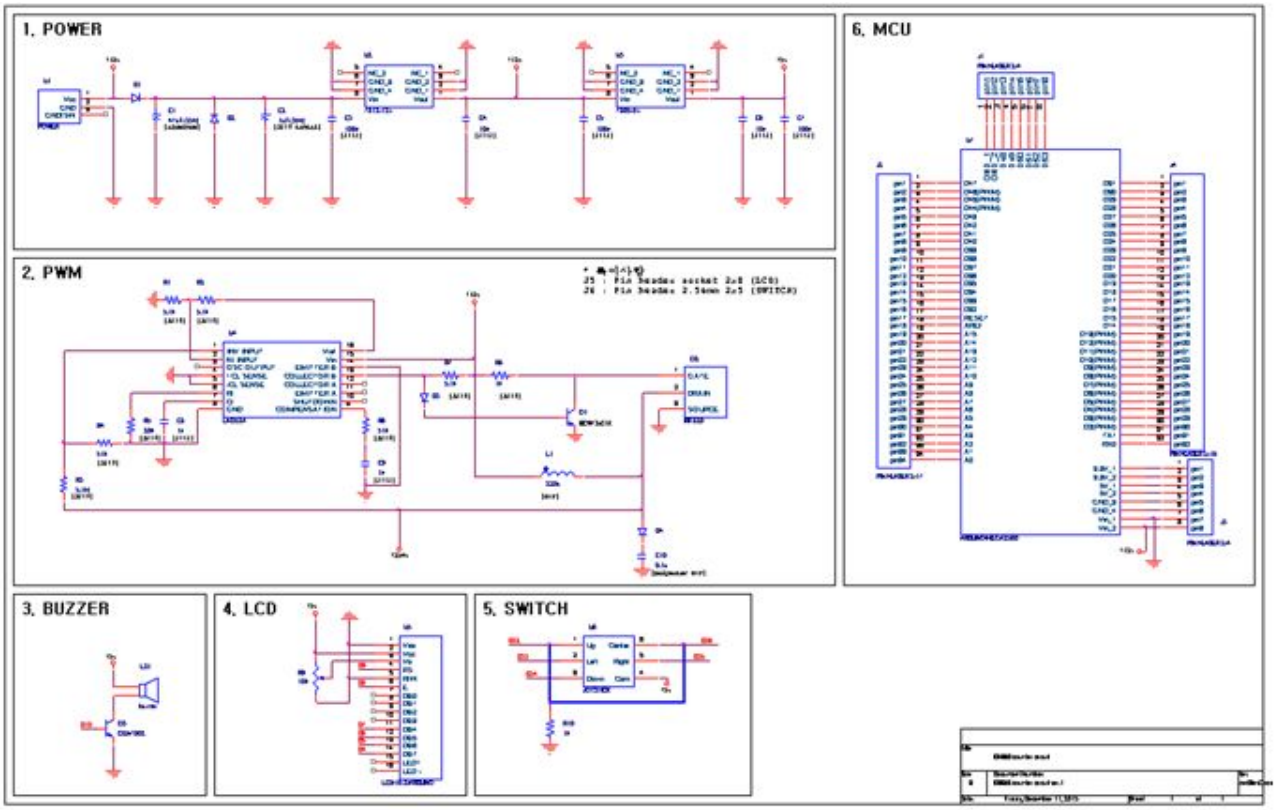

Figure 5. Power, PWM, buzzer, LCD, switch, and MCU circuits

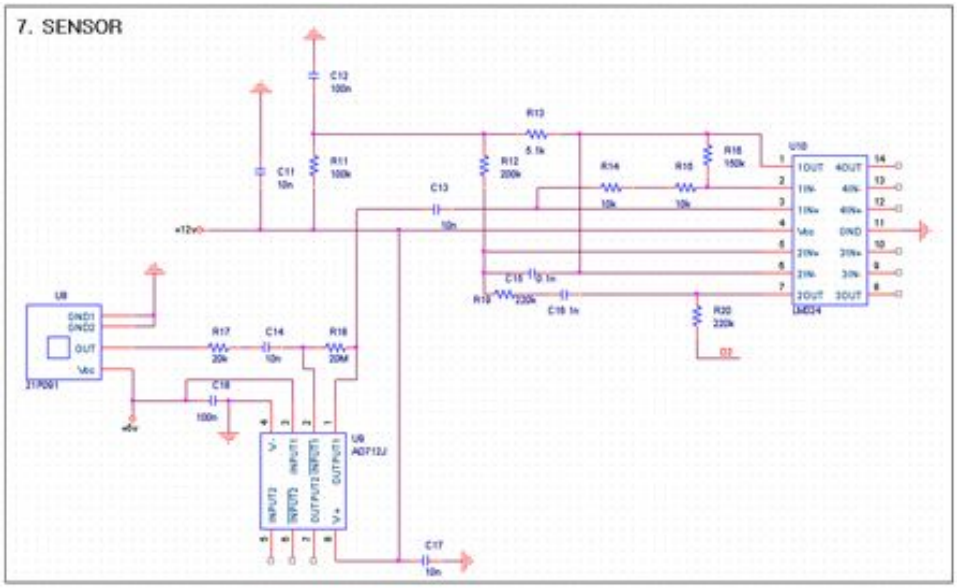

Figure 6. Pulse converting circuit

The circuit design of power, PWM, buzzer, LCD, switch, and MCU is shown in Fig. 5. In Fig. 6, the pulse converting circuit is designed. Based on the circuit in Fig. 5 and Fig. 6, the PIN photodiode radon counter PCB layout is made as shown in Fig. 7. Finally, the PIN photodiode radon counter is implemented as Fig. 8.

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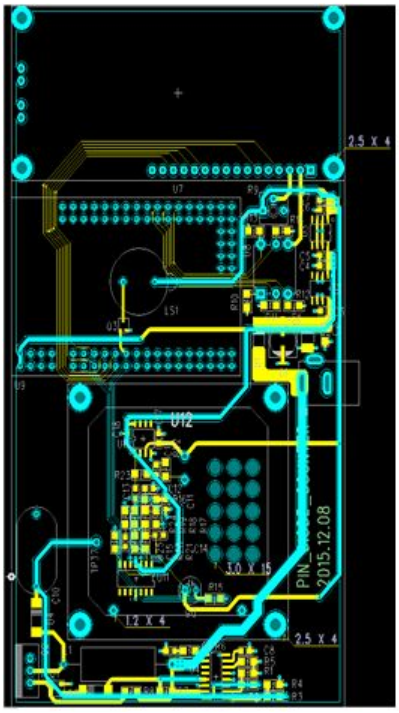
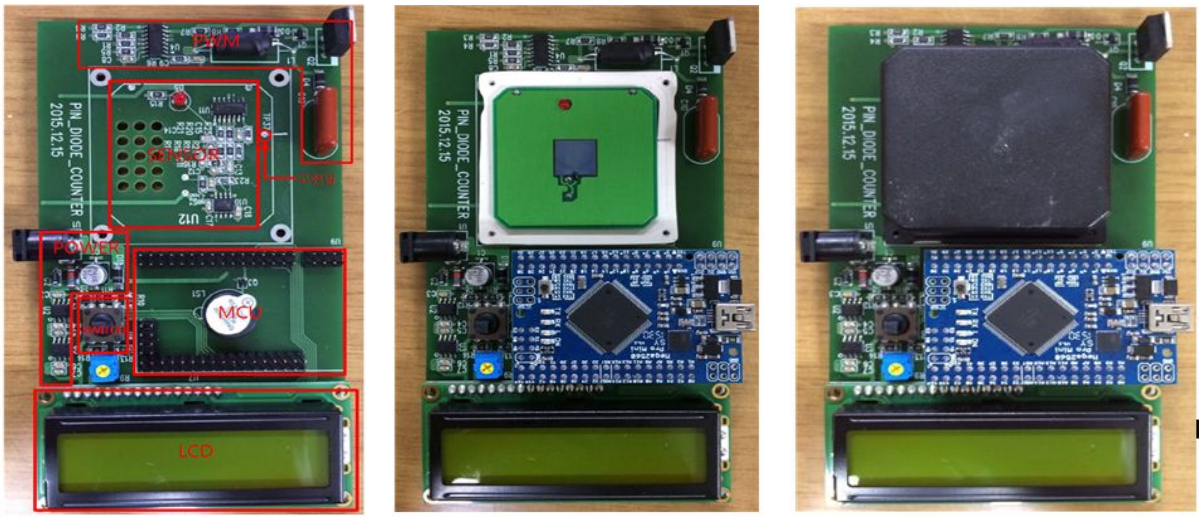


Figure 7. PIN photodiode radon counter PCB layout



(a)assembled LCD display (b)assembled radon sensor and MCU (c)assembled radon chamber

Figure 8. Implemented PIN photodiode radon counter

In order to investigate the performance of the implemented PIN photodiode radon counter, the experimental set-up was made. Radon emitting soil was placed on the shelf. Then, the radon counter was set under the shelf as shown in Fig. 9.

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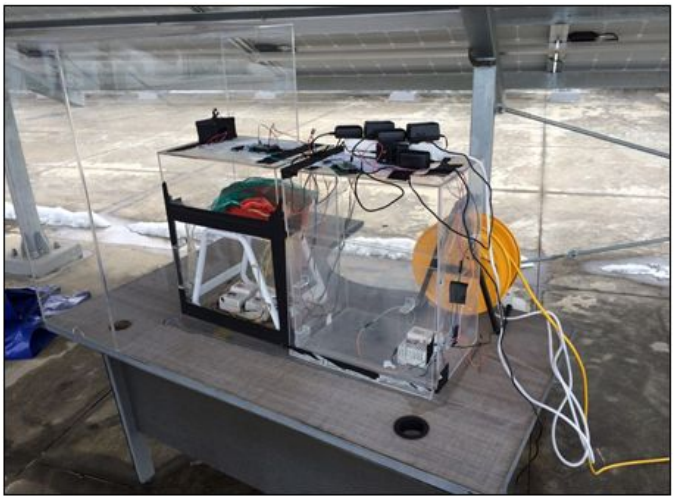

Figure 9. Experimental set-up for performance test

The measurement result using the PIN photodiode radon counter is seen in Fig. 10. It yields a count rate of about 4.38 counts per hour. This corresponds to 15.3pCi/L.

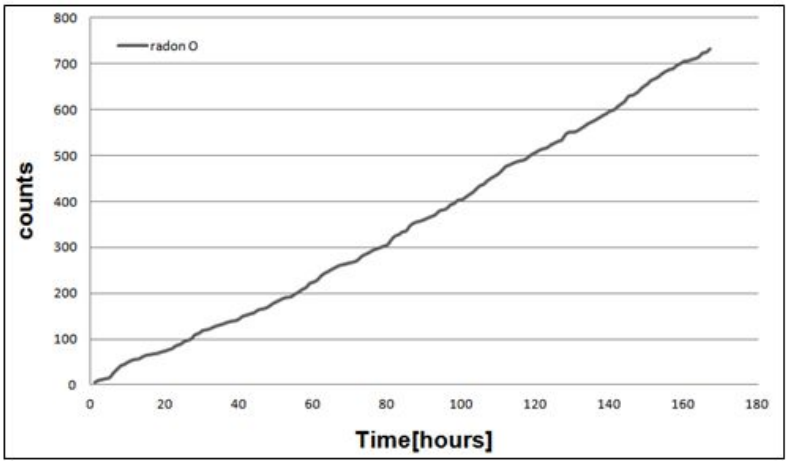

Figure 10. Measurement result showing radon counts per hour

IV. CONCLUSION

A radon counter using PIN photodiode sensor module is implemented. For radon emitting soil, a measured count rate of 4.38 counts per hour was observed. Through experimental studies, we found that the PIN photodiode sensor module could be used for a radon counter. More studies, such as calibration of PIN photodiode sensor module and linear regression analysis should be followed.

V. ACKNOWLEDGEMENTS

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