[Kim, 3(9): September 2016]
DOI- 10.5281/zenodo.61925

ISSN 2348 – 8034
Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

WI-FI AND USB SERIAL COMMUNICATION FOR RADON COUNTERS

Gyu-Sik Kim
Department of Electrical Engineering, The Univ. of Seoul, Seoul, Korea

ABSTRACT

Radon is a natural, inert, invisible, odorless and chemically inactive radioactive gas emitted from the earth. It 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 this paper, a radon concentration monitoring system is implemented, which uses a PIN diode for detecting the radon particles and a data processing module with Wi-Fi communication capabilities for measurement results transmission and management. Radon measurement results can be sent over Wi-Fi to a central monitoring system.

Keywords: *radon, radon counter, PIN diode, Wi-Fi communication, monitoring system*

I. INTRODUCTION

Radon is a natural, inert, invisible, odorless and chemically inactive radioactive gas emitted from the earth. It is produced by the decay of uranium ore, such as radium, actinium, or thorium. Because it is inert and does not chemically bond to elements, it is released from soil into the atmosphere. Radon is emitted almost everywhere on earth, but some geographical regions have higher concentrations than others. When radon decays, it released alpha particles with energy of 5.5 MeV. 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. It has been reported that the US. Environmental Protection Agency estimates exposure to naturally occurring radon leads to 21,000 lung cancer deaths nationwide each year, making radon the nation's primary environmental health threat and second only to cigarette smoking as a cause of fatal lung 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], it is shown that BJT detectors can be efficiently used for a-particle detection and consequently for radon detection. Moreover, analysis of the performance of detectors under different temperatures has shown that the detector can be efficiently used in a rather wide range of temperatures confirming that the detector can be used both in indoor and outdoor applications. In [7], the system is developed which monitors the radon level, using a PIN diode for detecting the radon particles and a data processing module with Wi-Fi communication capabilities for the transmission and management of measurement results. In [8], 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 this paper, a radon concentration monitoring system is implemented, which uses a PIN diode for detecting the radon particles and a data processing module with Wi-Fi communication capabilities for

DOI- 10.5281/zenodo.61925
Impact Factor- 4.022

measurement results transmission and management. Radon measurement results can be sent over Wi-Fi to a central monitoring system.

II. IMPLEMENTATION OF PIN PHOTO DIODE RADON COUNTER

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 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.

Figure:

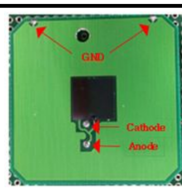	module size	43 x 43 mm
	sensor size	10 x 10 mm

Figure 1. PIN photodiode sensor module

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. The circuit design of power, PWM, buzzer, LCD, switch, and MCU was done. Finally, the PIN photodiode radon counter was implemented as Fig. 2.

Figure:

ISSN 2348 – 8034
Impact Factor- 4.022

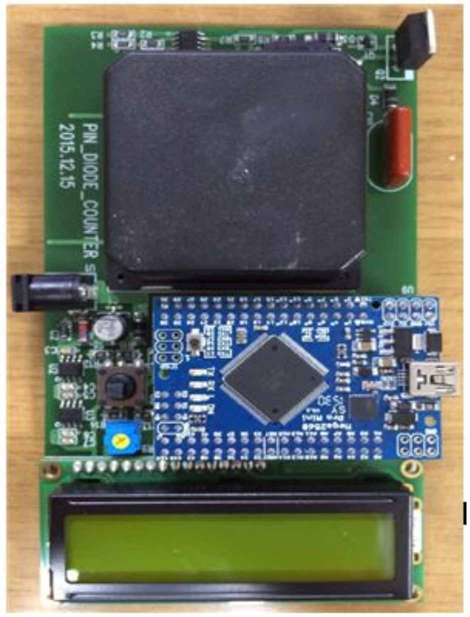

Figure 2. Implemented PIN photodiode radon counter

III. WI-FI AND USB SERIAL COMMUNICATION FOR RADON COUNTERS

Using the implemented PIN photodiode radon counter, the radon level might be measured. This measured radon data sometimes need to be transferred to PC for monitoring and analysis. Fig. 3 shows the schematic diagram of PC to radon counter serial communication using USB. In Fig. 4, the computer screen capture shows Arduino USB serial communication program.

Figure:

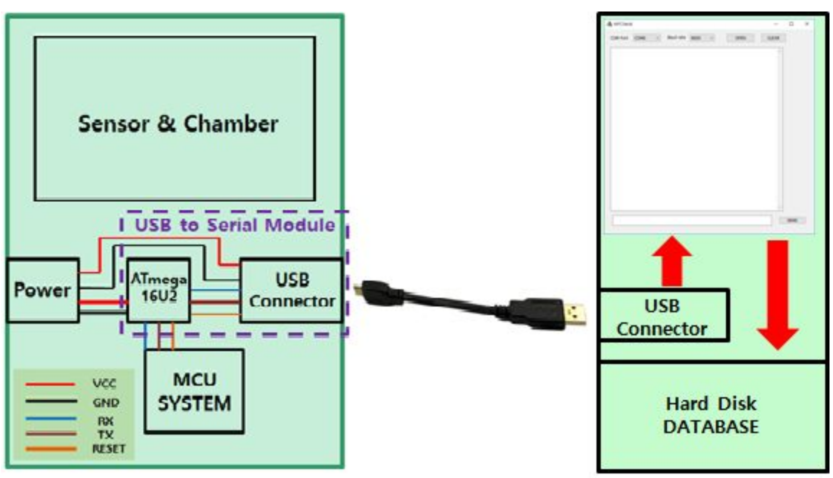

Figure 3. Schematic diagram for USB serial communication

Figure:

ISSN 2348 – 8034
Impact Factor- 4.022

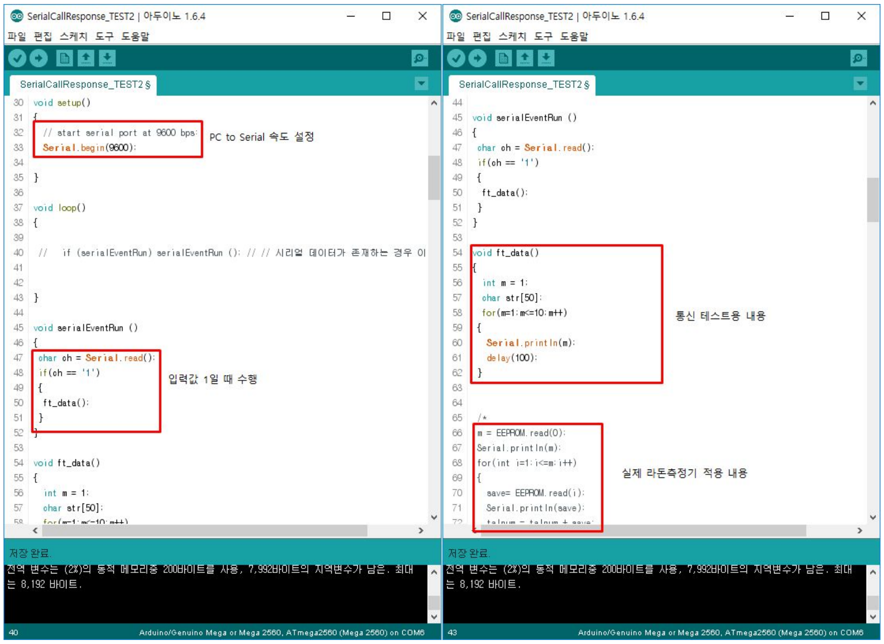

Figure 4. Arduino USB serial communication program

The need for radon level detection over large geographical areas leads to the necessity of wireless connectivity for the measurement device. Wireless sensor networks represent a vast active research area and a large number of applications have been proposed. Radon level measurement results can be sent over Wi-Fi to a computer. Fig. 5 shows the ESP8266-01 Wi-Fi module chosen in this paper. Fig. 6 shows the interface of ESP8266-01 Wi-Fi module to arduino MCU board. Fig. 7 shows Arduino tx to Esp8266 rx pin voltage waveform. Fig. 8 shows the Wi-Fi operation flow chart for radon counter. Fig. 9 shows the radon counter interfaced with Wi-Fi module.

Figure:

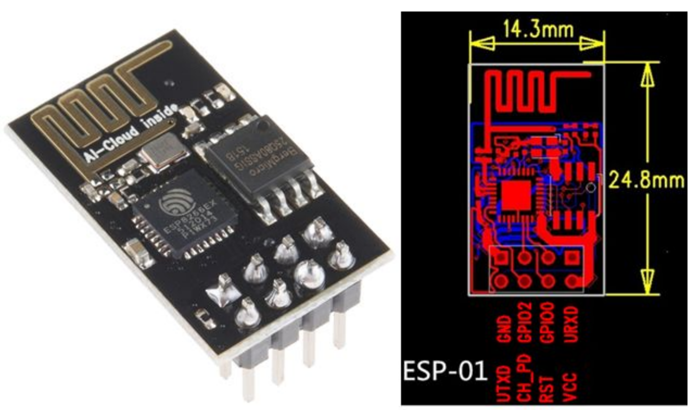

Figure 5. ESP8266-01 Wi-Fi module

Figure:

ISSN 2348 – 8034
Impact Factor- 4.022

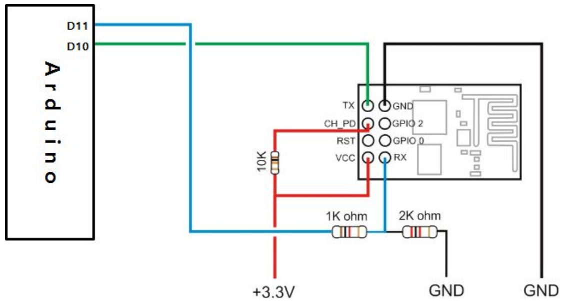

Figure 6. Interface of ESP8266-01 Wi-Fi module to arduino MCU board

Figure:

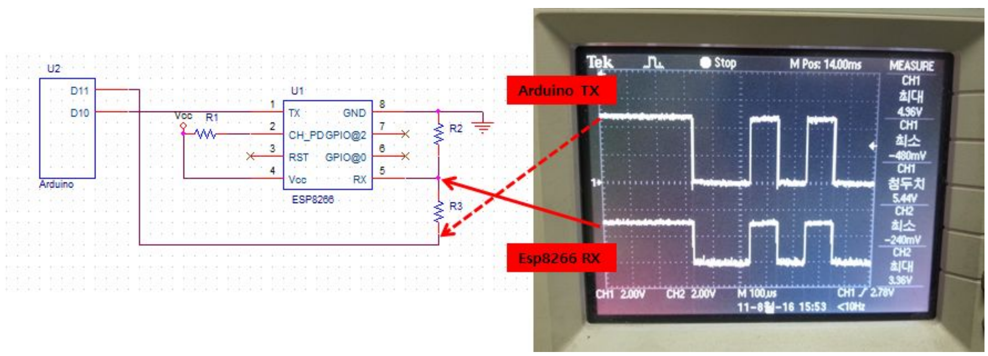

Figure 7. Arduino tx to Esp8266 rx pin voltage waveform

Figure:

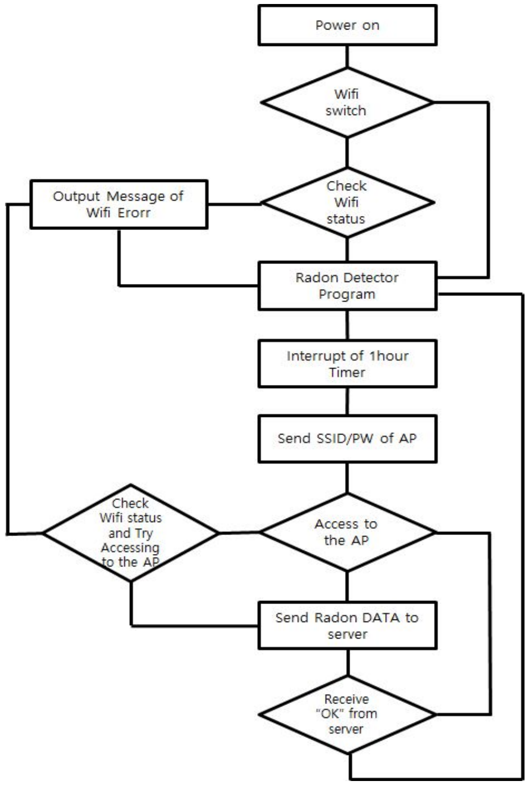

Figure 8. Wi-Fi operation flow chart for radon counter

Figure:

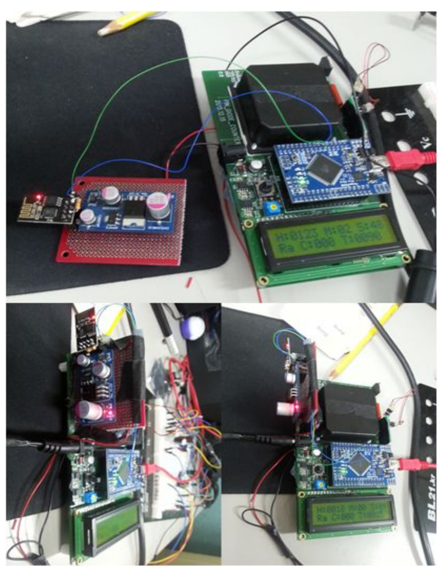

Figure 9. Radon counter interfaced with Wi-Fi module

Figure:

 ISSN 2348 – 8034
Impact Factor- 4.022

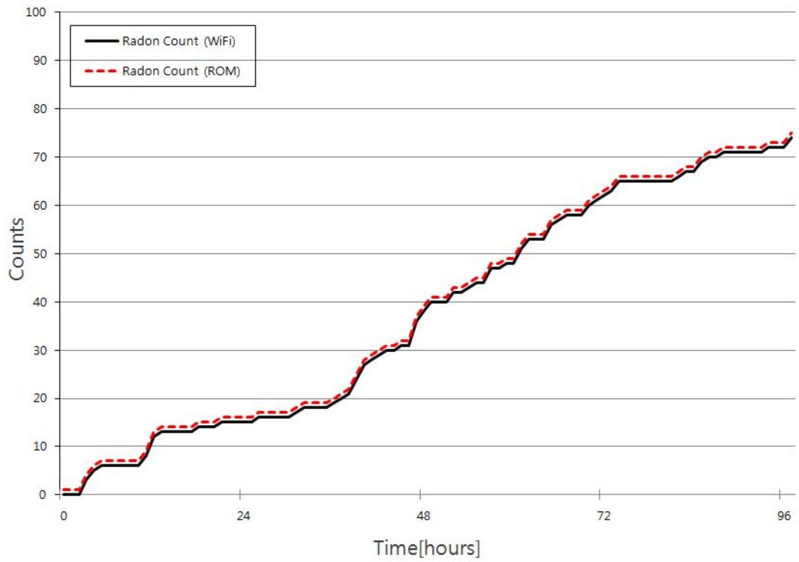

Figure 10. Comparison of measured data with Wi-Fi transferred data

In order to test the Wi-Fi module, the radon level was measured for 96 hours and the measured radon data were stored in ROM of radon counter. Then, they were sent to other PC in remote location using Wi-Fi module. Fig. 10 shows the comparison of the measured radon data with Wi-Fi transferred radon data. It could be easily verified that they were transferred without fail.

IV. CONCLUSION

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. A radon counter using PIN photodiode sensor module is implemented in this paper. The need for radon level detection over large geographical areas leads to the necessity of wireless connectivity for the measurement device. Wireless sensor networks represent a vast active research area and a large number of applications have been proposed. Radon level measurement results can be sent over Wi-Fi to a computer. Through some experimental studies, it could be easily verified that the measured radon data were transferred using Wi-Fi module without fail.

V. ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea governm ent (MSIP) (No. 2016011249).

REFERENCES

1. *Hiroshi Miyake, Keiji Oda and Masami Michijima, "Portable and High-Sensitive Apparatus for Measurement of Environmental Radon Using CR-39 Track Detector," Japanese Journal of Applied Physics, vol.26, No.4, pp.607-610, April, 1987*
2. *Peter J. Diamondis, "Radon gas measurement apparatus having alpha particle-detecting photovoltaic photodiode surrounded by porous pressed metal daughter filer electrically charged as PO-219 Ion*

accelerator," US patent, P.N. 5489780, Feb. 1996

3. *R. H. Griffin, H. Le, D.T. Jack, A. Kochermin and N.G. Tarr, "Radon Monitor using Custom α - detecting MOS IC," in Proceedings of IEEE Sensors 2008, Lecce, Italy, pp.906-909, Oct. 2008.*
4. *Han Soo Kim, Se Hwan Park, Jang Ho-Ha, Dong-Hoon Lee, and Seung Yeon Cho, "Characteristics of a Fabricated PIN Photodiode for a Matching With a CsI(TI) Scintillator," IEEE Trans. Nucl. Sci., vol.57, NO.3, pp. 1382-1385, June, 2010*
5. *R.H. Griffin, A. Kochermin, N.G. Tarr, H.McIntosh, H.Ding, J.Weber and R.Falcomer, "A sensitive, fast-responding passive electrostatic radon monitor," in Proceedings of IEEE Sensors 2011, Limerick, Ireland, Oct., 2011*
6. *V. Tyzhnevyi, G.-F. Dalla Betta, G. Verzellesi, L. Bosisio, G. Batignani, G. Giacomini, A. Picciotto, "BJT detector for a-particle and Radon detection and monitoring," 2011 IEEE Nuclear Science Symposium Conference Record N39-1, pp.1941-1945, 2011.*
7. *S. Folea, M. Hulea, G.Mois, V. Cosma, "Wi-Fi portable solution for distributed radon measurements," Rom. Journ. Phys., vol.58, pp.S126-s139, 2013.*
8. *Ryan H. Griffin and N. Garry Tarr, "Optical image sensors and their application in radon detection," in Proceedings of SPIE, vol.8915, pp.8915C-1~7, Oct., 2013.*
9. *Gyu-Sik Kim, Tae-Gue Oh and Jae-Hak Kim, "Implementation of a PIN photodiode radon counter," Global Journal of Engineering Science and Researches, vol. 3, no.1, pp.58-63, Jan., 2016.*