IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 2, February 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

A Study on a Wi-Fi System for Radon Monitoring

Jae-Hak Kim[1] , Sung-Ha Yun[2] and Gyu-Sik Kim[3*]

[1,2,3] Department of Electrical and Computer Eng., University of Seoul,
Seoul, 130-743, Korea
* Corresponding author : Gyu-Sik Kim (gskim318@uos.ac.kr)

Abstract
Radon is a natural, inert, invisible, odorless and chemically inactive radioactive gas emitted from the earth. Because inhaling radon and its radioactive-decay products causes irradiation of lung tissue, the radon data obtained from houses and workplaces need to be transferred using Wi-Fi and the Internet to a database on a radon-monitoring server system. To do this, the ESP8266 Wi-Fi module was used. Through some experimental studies, we showed that the data transmission using these Wi-Fi modules was very successful.
Keywords: *Radon, Wi-Fi, Database, Radon Monitoring, ESP8266*

1. 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. 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.
There is also much research regarding the measurement of radon concentration in soil gas, water, and indoor air. In [5], results are presented of a preliminary study of radon concentration in soil gas. For the study, AlphaGuard equipment was used to obtain samples from 64 locations within 13 urban areas in Bulgaria from 2008 to 2012. In [6], measurements were taken in Transylvania, in Northwest Romania, of radon concentration in water and indoor air. The measurements were taken using a LUK-VR system for radon gas measurements, a Lucas cell for water, and CR-39 track detectors for indoor air. In [7], they presented the study of the multiple linear regression model for the estimation and prediction of the time series of radon and thoron progeny concentrations in atmosphere.
For our experiments, we used a radon counter with a PIN photodiode radon-sensor module [8]. These radon counters were used to measure the radon concentration of indoor air in houses and workplaces. A radon monitoring and alarm system was also used. The radon concentration data obtained from houses and workplaces was transferred using Wi-Fi and the Internet to a database on a radon-monitoring server system (Fig. 1).

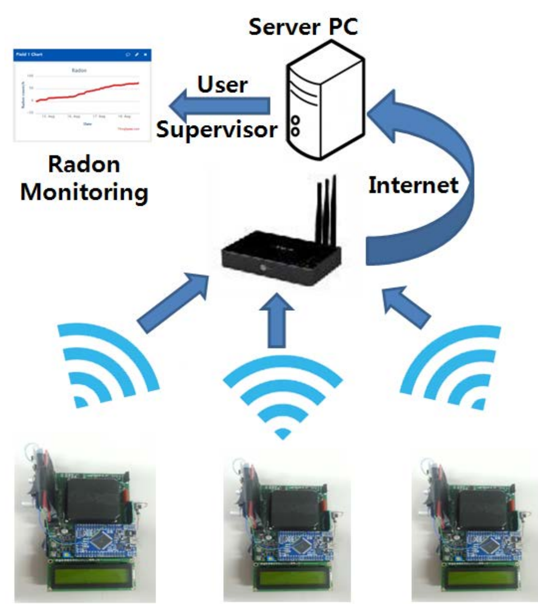


Fig. 1 Concept of Wi-Fi based radon monitoring

2. Wi-Fi based radon monitoring system

The ESP8266 Wi-Fi module is a self-contained system-on-chip (SOC) with integrated TCP/IP protocol stacks that can give any microcontroller access to a Wi-Fi network [9]. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions to another application processor. Each ESP8266 module comes pre-programmed with AT Command Set firmware, meaning the module can be hooked up to an Arduino device with about the same Wi-Fi ability as a Wi-Fi shield. The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community of users. This module has powerful enough on-board processing and storage capability to allow it to be integrated with the sensors and other application-specific devices through its general-purpose input/outputs (GPIOs), with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry. The front-end module is designed to occupy minimal PCB space. The ESP8266 Wi-Fi module is shown in Fig. 2.

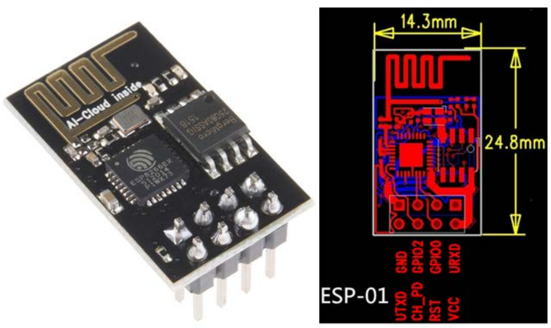
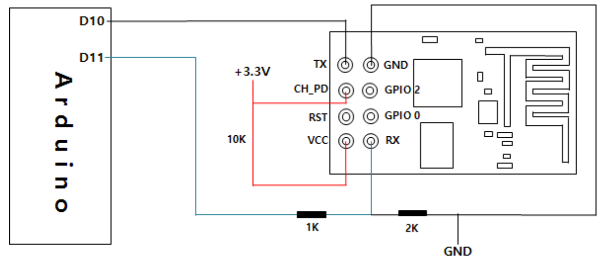
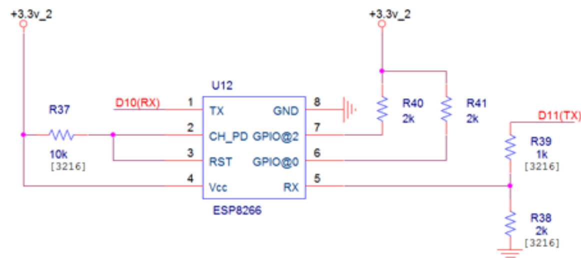


Fig. 2 ESP8266 Wi-Fi module

The logic connections between the Arduino and the ESP8266 are very simple: the ESP Rx connects to the Arduino Tx, and the ESP Tx connects to the Arduino Rx; however, the ESP8266 runs off 3.3V, while Arduino pins run off 5V. Before connecting them, it is necessary to provide a way to reconcile these voltages, or the ESP might be damaged. In order to adjust the voltage between the Tx/Rx pins, a simple resistor circuit was used as shown in Fig. 3. Either Access Point (AP) mode or Station mode (for the ESP8266) was chosen by the command of Arduino MCU. Station mode is the default-operating mode for the ESP8266 adapter. In this mode, the ESP8266 adapter operates as a client that connects to a Wi-Fi access point. This mode is used to connect a Wi-Fi adapter to a wireless network. In AP mode, the adapter acts as an access point enabling other Wi-Fi adapters to connect to it; therefore, the adapter can be used to create one’s own wireless network. In Station mode, the ESP8266 Wi-Fi module receives the measured radon-concentration data from the radon counter’s MCU using serial communication. It then sends the data to the radon monitoring server system over the Internet. The ESP8266 Wi-Fi module connected to the implemented radon counter is shown in Fig. 4.



(a)



(b)

Fig. 3 Interface of the ESP8266 Wi-Fi module to Arduino MCU

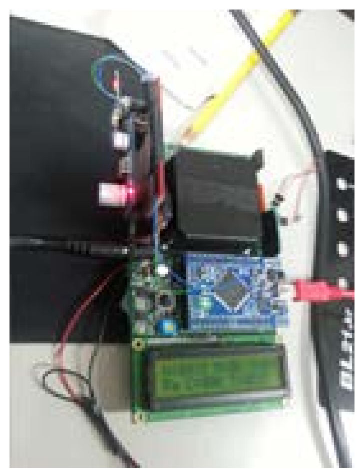


Fig. 4 ESP8266 Wi-Fi module connected to the implemented radon counter

3. Experimental Results

In Fig. 5, we show how a new service set identifier (SSID) and password were assigned to a Wi-Fi router so that the radon counter could be connected to a Wi-Fi router using a smartphone. First, the ESP8266 was converted to AP mode. The ESP8266 SSID and password were then set to new values using the smartphone’s Wi-Fi. After using the smartphone’s web browser to access the ESP8266 web server (address 192.168.4.1), the Wi-Fi router’s SSID and password were reset from the smartphone screen. Once all of these initialization processes were complete, the

ESP8266 should be converted to Station mode from AP mode. Then, the radon counter could connect to the Wi-Fi router using the router's SSID and the password stored in the ESP8266's flash memory. After that, the measured radon-concentration data was transferred to the server.

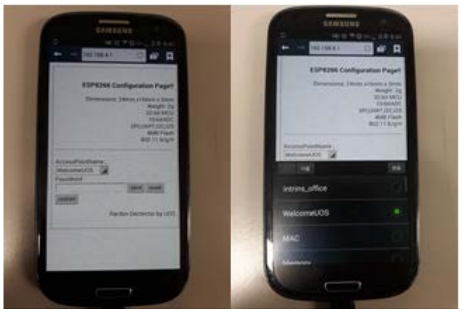


Fig. 5. Assigning of new SSID and password to a Wi-Fi router

Fig. 6 Communication test between Wi-Fi module and MCU

Fig. 6 shows the Wi-Fi operation test using a serial communication. At first, the ESP8266's serial communication speed is set to be 115000bps. Because that of the MCU Arduino is set to be 9600bps, the ESP8266 should be set to be 9600bps using a firmware update in order to be compatible with Arduino. The PC serial monitor was used to confirm the operation of the Wi-Fi operation.

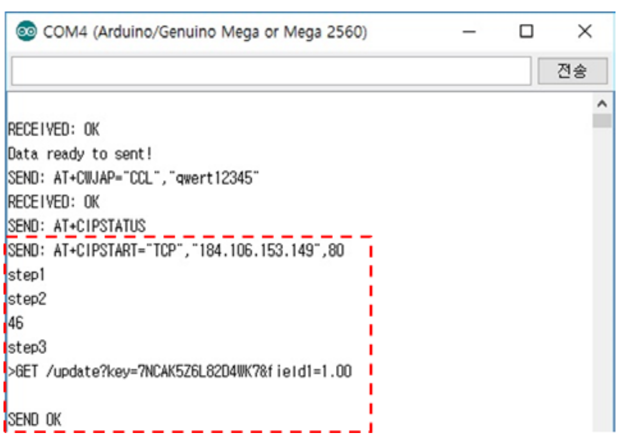


Fig. 7 Verification of server data transmission success using serial monitor

Fig. 7 shows the verification of server data transmission success using serial monitor. The dashed box in Fig. 7 shows that the server IP address was 184.106.153.149 and the port was connected to 80. The data of 1.00 was sent and the message of "SEND OK" would be displayed if the data transmission was successful.

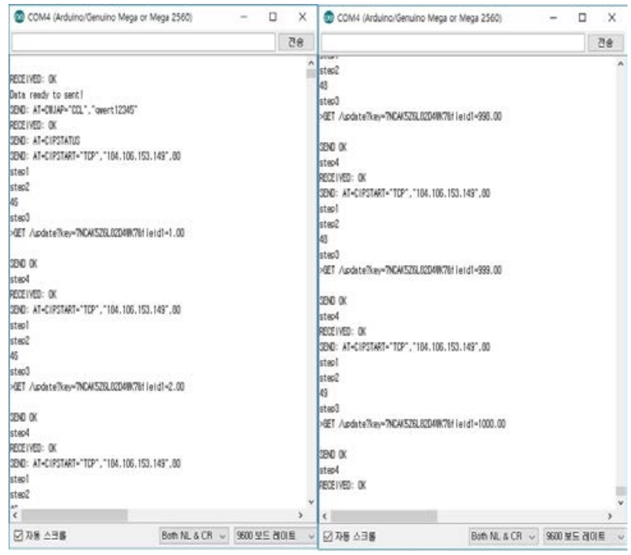


Fig. 8 Verification of Wi-Fi data transmission success using serial monitor

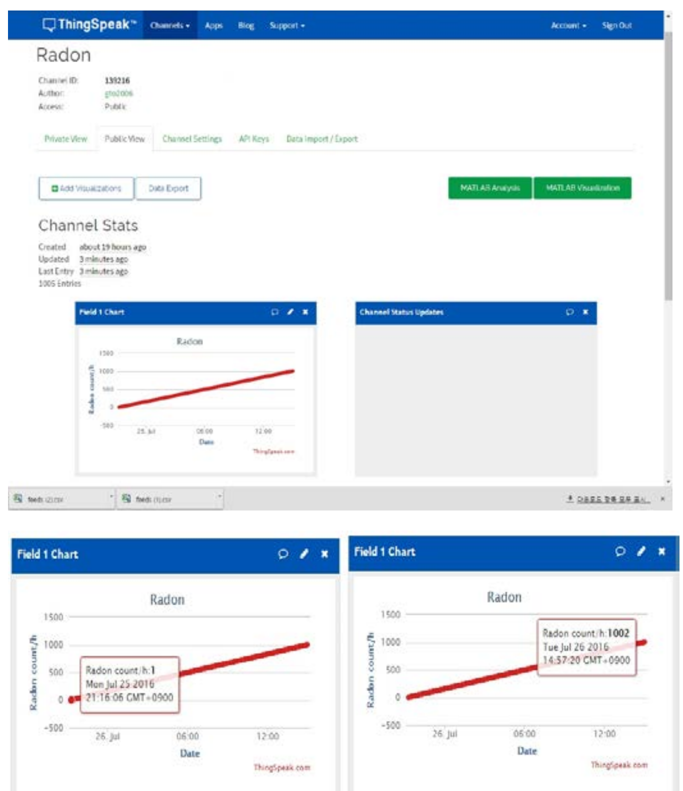


Fig. 9 Transmission test of a Wi-Fi system with an interval of 1 min. for 1000 times

Fig. 8 shows the verification of Wi-Fi data transmission success using serial monitor. Fig. 9 shows the transmission test of a Wi-Fi system with an interval of 1 min. for 1000 times. As the experimental result, all of the data transmission was successful and the transmission error rate was 0%.

4. Conclusions

Because inhaling radon and its radioactive-decay products causes irradiation of lung tissue, prolonged exposure to a high concentration of radon significantly increases the risk of developing cancer. So, the radon concentration data obtained from houses and workplaces need to be transferred using Wi-Fi and the Internet to a database on a radon-monitoring server system. To do this, the ESP8266 Wi-Fi module was used. Through some experimental studies, we showed that the data transmission using these Wi-Fi modules was very successful.

Acknowledgments

This work was supported by the Korea Ministry of Environment (MOE) as ‘‘the Environmental Health Action Program.’’ This work was also supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (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, April, 1987, pp.607-610

[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, Oct., 2008, pp.906-909

[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, June, 2010, pp. 1382-1385

[5] Bistra Kunovska, Kremena Ivanova, Zdenka Stojanovska, Daniel Vuchkov, and Nadia Zaneva, “Measurements of radon concentration in soil gas of urban areas, Bulgaria,” Rom. Journ. Phys., Vol.58, Supplement, 2013, pp.s172-s179

[6] D.C. Nita, M. Moldovan, T. Sferle, V.D. Ona, and B.D. Burghele, “Radon concentrations in water and indoor air in north-west regions of Romania,” Rom. Journ. Phys., Vol.58, Supplement, 2013, pp.s196-s201

[7] E. Simion, I. Mihalcea, V. Cuculeanu, F. Simion, “Estimation and prediction of the outdoor ^{222}Rn and ^{220}Rn progeny concentrations using meteorological variables,” Rom. Journ. Phys., Vol.58, Supplement, 2013, pp.s262-s272

[8] 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, Jan., 2016, pp.58-63

[9] http://rancidbacon.com/files/kiwicon8/ESP8266_WiFi_Module_Quick_Start_Guide_v_1.0.4.pdf

Jae-Hak Kim was born in Korea, in 1991. He received the B.S. degree in 2016 from the Dept. of Electrical and Computer Eng., University of Seoul, Korea. He is a graduate student in the Dept. of Electrical and Computer Eng., University of Seoul, Korea.

Sung-Ha Yun was born in Korea, in 1976. He received the B.S. degree in 2000 from the Dept. of Electronic Eng., University of Dankook, Korea. He received the M.S. degree in 2011 from the Dept. of Electrical and Computer Eng., University of Seoul, Korea. He is a Ph.D. student of the Dept. of Electrical and Computer Eng., University of Seoul, Korea. He works for LG Electronics Co. Ltd.

Gyu-Sik Kim was born in Korea, in 1958. He received the B.S. degree in 1981 from the Dept. of Electronics Eng., Seoul National University, Korea. He received the M.S. degree in 1983 and the Ph.D. degree in 1990 from the Dept. of Control and Instrumentation Eng., Seoul National University, Korea. He is working as Professor in the Dept. of Electrical and Computer Eng., University of Seoul, Korea.