Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22-23, 2025

Performance Evaluation of Wireless Communication for Aerial Radiation Detection Using a Multi-Channel Detector Mounted on a Drone

Sang Hun Shin[a*], Hee Kwon Ku[a], Min Beom Heo[a], Jae Wook Kim[a], Hyun Jin Boo[b] and Byung Gi Park[b]
[a]*FNC Technology Co., Ltd., 13, Heungdeok 1-ro, Giheung-gu, Yongin-si, Gyeonggi-do, Korea*
[b]*SoonChunHyang University, 22, Soonchunhyang-ro, Asan-si, Chungcheongnam-do, Korea*
[*]*Corresponding author:ssh9431@fnctech.com*

***Keywords :** Multi-channel monitoring system, Drone, Wireless Communication, Data transmission rate, Aerial radiation

1. Introduction

In the event of a nuclear facility accident, a rapid and effective response requires the establishment of an early monitoring system and the operation of a stepwise surveillance system. A comprehensive environmental radiation survey using various exploration platforms is essential, and altitude-based aerial radiation measurements using drones enable early response to nuclear accidents occurring in neighboring countries[1-3].

Emergency aerial radiation monitoring requires quick spatial analysis of affected areas and a precise measurement technique based on radionuclide identification and radiation concentration variations rather than dose rate alone. With the rapid growth of the global unmanned aerial vehicle (UAV) industry and government support policies, the utilization of UAVs has expanded across various fields. In the nuclear industry, the integration of advanced information and communication technology (ICT) has increased the necessity of utilizing drones for radiation measurement. In particular, aerial radiological surveys have become increasingly important for rapidly assessing radiation levels in inaccessible or widely contaminated areas.

This study developed a drone-mountable multi-channel radiation detection system using compact spectrometry for large-scale aerial radiation measurements. The system integrates a Global Positioning System (GPS) module for accurate location tracking and supports various wireless communication methods, including LTE, to evaluate real-time data transmission performance The study compares these methods under different conditions to identify the most effective approach for reliable aerial radiation monitoring.

2. Methods and Results

2.1 Multi-Channel Radiation Detector

To analyze radiation concentration and radionuclide identification, this study used a semiconductor-based cadmium zinc telluride (CZT) detector combined with a small multi-channel analyzer (MCA). Four CZT detectors were employed to construct a multi-channel monitoring system, enabling simultaneous multi-point radiation detection. The CZT radiation detector offers excellent energy resolution despite its small size and operates at room temperature, allowing it to measure radiation intensity while identifying radionuclides simultaneously.

The CZT sensor crystal used in this study has a volume of approximately 500 mm³, with a full width at half maximum (FWHM) of 9.9±0.5 keV at 662 keV, making it suitable for radionuclide identification.

2.2 Drone System

The drone used in this study is designed to carry a radiation detection system while maintaining stable flight performance and supporting sufficient payload capacity. It incorporates a GPS module for precise positioning, a wireless communication system for real-time data transmission, and remote control capabilities for aerial monitoring

Drones can be utilized to quickly measure radiation levels over large areas and predict the dispersion of radioactive contamination during a nuclear accident. To ensure stable data transmission, this study evaluated the performance of different wireless communication methods (USB, LTE, and Zigbee) through experiments conducted at a distance of 10 m.

2.3 Wireless Communication Performance Evaluation

To evaluate the performance of different wireless communication methods, an outdoor experiment was conducted using a drone equipped with a multi-channel radiation detector. The general characteristics of each communication method are summarized in Table I.

Table I: Comparison of communication methods

	Data Transmission Rate	Range	Features
USB(Wired)	Up to 10 Gbps	Limited (Cable length, ~few m)	High speed, low latency, stable connection
Zigbee	Up to 250	Short	Low power,

	kbps	(~10–100 m)	mesh networking, suitable for IoT
LTE	Up to 100 Mbps	Wide (Nationwide)	Long-range, moderate latency, high mobility

Figure 1 shows a comparative analysis of the energy spectra measured using different wireless communication methods for a Co-60 radioisotope. The USB method displayed the most stable data transmission with sharp and distinct peaks at 1.17 MeV (396 channel) and 1.33 MeV (450 channel), reflecting excellent energy resolution and zero data loss.

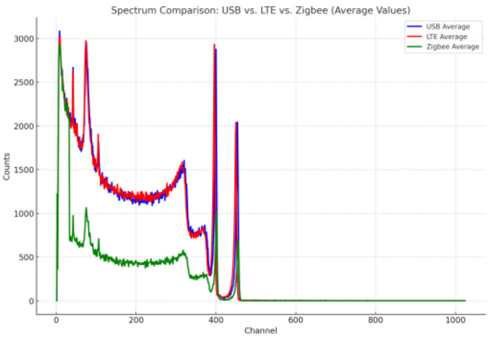

Fig. 1. Comparison of Energy Spectra Using USB, Zigbee, and LTE Communication Methods.

Compared to the USB baseline, the LTE communication method maintained approximately 98% of the peak intensity at both energy levels, indicating minimal data loss and stable transmission quality. In contrast, the Zigbee communication method retained about 75% of the peak intensity, reflecting a significant reduction in data quality and measurement accuracy.

At a distance of approximately 10 m, the data transmission rate for Zigbee dropped below 80%, further degrading energy resolution and reducing measurement reliability. Conversely, both USB and LTE maintained transmission rates above 95%, ensuring accurate and consistent energy spectrum measurements.

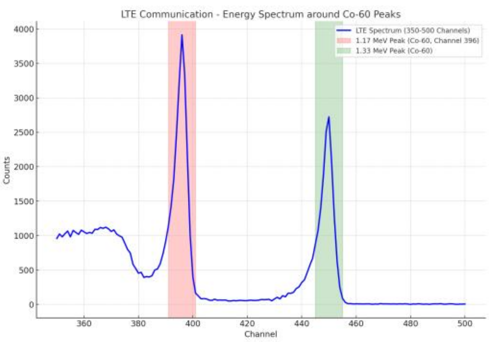

Fig. 2. Measured energy spectrum of Co-60 peaks for LTE communication method

Figure 2 is an enlarged view of the 1.17 MeV and 1.33 MeV energy regions of the Co-60 energy spectrum measured using the LTE communication method shown in Figure 1. This figure demonstrates that LTE enables precise measurements without data loss while maintaining high energy resolution.

3. Conclusions

In this study, a multi-channel radiation detection system was developed for drone-based aerial radiation monitoring. Prior to evaluating real-time measurement capabilities, a comprehensive assessment of wireless communication performance was conducted, focusing on USB, LTE, and Zigbee methods.

All methods maintained stable transmission rates at short distances, but noticeable differences in data transmission stability emerged as the distance increased. LTE consistently demonstrated reliable performance with minimal data loss, while Zigbee exhibited significant transmission degradation.

Based on the results, LTE proved to be the most suitable option for stable and reliable aerial radiation data transmission across varying distances. In emergencies requiring drone deployment in place of personnel, LTE communication provides dependable long-range data transmission.

Future work will focus on optimizing communication protocols, enhancing data transmission efficiency, and minimizing data loss, thereby improving the practicality of drone-based aerial radiation monitoring systems for early response to nuclear accidents.

Acknowledgments

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT). (No.2020M2D2A2062538)

REFERENCES

[1] IAEA, Generic procedures for monitoring in a nuclear or radiological emergency IAEA-TECDOC1092, p.220, 1999.

[2] Y Sanada, T Sugita, Y Nishizawa, A Kondo and T Torii, The aerial radiation monitoring in Japan after the Fukushima Daiichi nuclear power plant accident, Progress in Nuclear Science and Technology 4, p.76, 2014.

[3] Y Sanada and T Torii, Aerial radiation monitoring around the Fukushima Dai-ichi nuclear powerplant using an unmanned helicopter, J. Env. Rad. 139, p.294, 2015.