International Journal of Smart Home
Vol. 13, No. 1 (2019), pp.7-14
http://dx.doi.org/10.21742/ijsh.2019.6.1.02

Temperature History System Using the NFC Self-powered Temperature Sensor Tag

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Abstract

This paper presents a next generation temperature history method that provides information on the temperature that is fundamental to the quality and safety of foods and medicines. The next generation temperature history method allows the consumer to easily know the temperature history during transportation using the personal smartphone even if the carrier does not check the tag periodically, even if the reader is not fixed. The proposed next generation temperature history system consists of self-powered temperature sensor, NFC RFID tag, smart phone, PC, and server, and the self-powered temperature sensor serves as battery and temperature measurement. Here, PCs and servers are only needed if data storage and management is required. The performance of the proposed system was confirmed by temperature history experiment with temperature change by placing food packaging box in a closed space.

1. Introduction

Recently, as the interest in IoT has increased, the use of smart RFID tags that combine [1]sensors and RFID tags has been increasing in many fields, and the sense of fulfillment of life safety has emerged as a new age task. Particularly, as people seek quality of life, interest in safety of foods and medicines as well as safety of disasters and crime prevention is increasing. Factors affecting the quality and safety of foods and medicines include temperature, humidity, and oxygen concentration, and temperature history information is very important because temperature plays an important role in foods and medicines as well as in the atmosphere and aquatic ecosystem environment [1] [2] [3] [4] [5].

The current temperature history method uses a transporter to periodically check with a reader during long and short distances distribution, or to read the tag information from a fixed reader, and send the data to the manufacturer or Logistics Company [1],[6]. However, the conventional temperature history method is inconvenient because it cannot sufficiently cover the whole area due to limitations of the installation place of the reader, the installation cost is high, and the transporter periodically checks the tag during the distribution period.

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[1] **Article history:**
Received (January 4, 2019), Review Result (February 6, 2019), Accepted (March 8, 2019)

Print ISSN: 1975-4094 IJSH

To solve these problems, we propose a next generation temperature history method. The proposed method allows the consumer to easily know the temperature history with a personal smartphone without having to install a fixed reader and periodically the transporter checking the tag with the reader. Consumers can increase their sales by increasing the safety and reliability of food and medicines, thus helping to generate economic profit. Especially, the proposed method is absolutely necessary because it is difficult to install the reader in the case of food and medicine for export and the transporter can not check the tag periodically during transportation. In addition, when a problem occurs, it is possible to clarify the responsibility between the production company and the distribution company, thereby reducing the dispute with the customer.

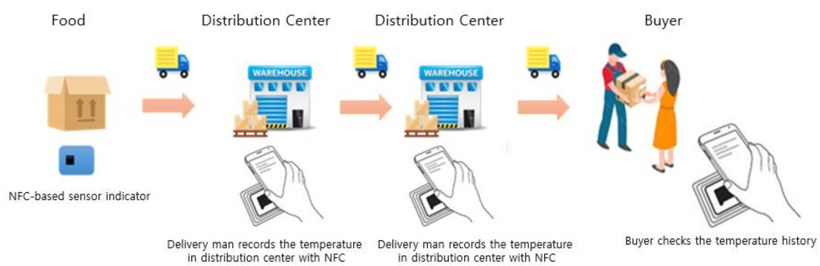
The proposed next generation temperature history system consists of self-powered temperature sensor, NFC RFID tag, smart phone, PC and server, and the self-powered temperature sensor serves as battery and temperature measurement. Here, PCs and servers are only needed if data storage and management is required. In order to verify the performance of the proposed system, a food packaging box is placed in an enclosed space and the temperature history test is performed by changing the temperature.

2. Proposed System

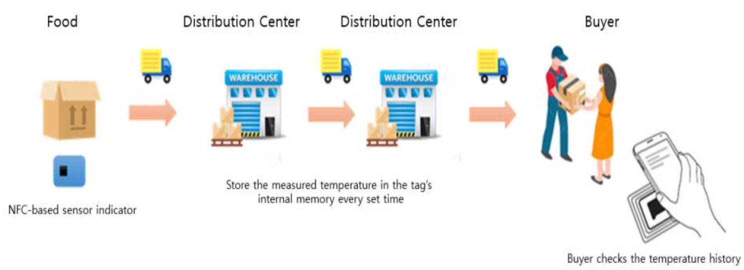
2.1 System Concepts

As shown in Figure. 1 (a), the conventional temperature history method is a technique in which a transponder periodically receives a voltage by putting a smart phone on a sensor tag or checks a temperature history only when a reader is installed in a certain place.

The next-generation temperature history method of Figure 1 (b) does not have a reader installed, but it uses a self-powered temperature sensor to periodically check the temperature



(a) Conventional temperature history method



(b) Next generation temperature history method

Figure 1. Temperature history method.

and store it in the tag memory even if the transporter does not check the temperature during transportation, simply know the temperature history information.

2.2 System Configuration

Figure 2 is a block diagram showing the configuration of a next-generation temperature history system using an NFC RFID tag combined with a self-powered temperature sensor. The system consists of self-powered temperature sensor, NFC RFID Tag, smart phone (HF reader), PC, server. The PC and server are only required if data storage and management is required.

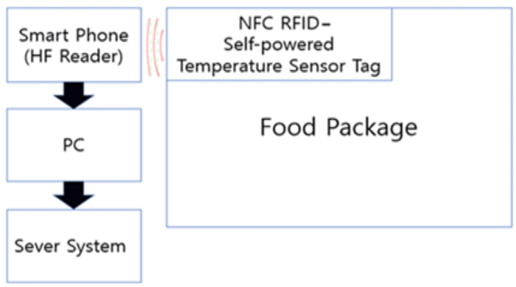


Figure 2. Block diagram of next generation temperature history system.

3. Design of proposed system

3.1 Self-powered Temperature Sensor

Figure 3 displays the photograph of a self-powered temperature sensor product, and Figure 4 shows the characteristics of the voltage change with temperature changes.

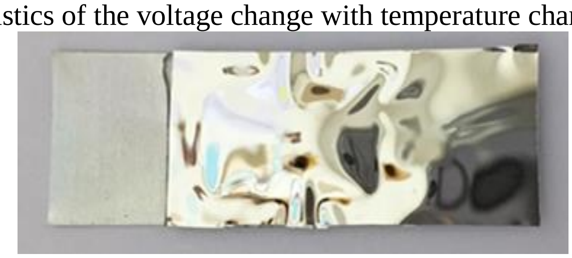


Figure 3. Photograph of the product.

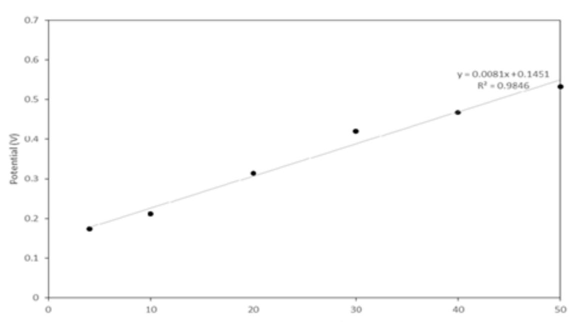


Figure 4. Characteristic graph of voltage change with temperature change.

In Figure 4, the characteristic equation for the voltage change with temperature change is

$$V = 0.0081\,X + 0.1451 \tag{1}$$

where V is the voltage (volt) and X is the temperature (◦C)

3.2 Passive NFC RFID tag fused with self-powered temperature sensor

Figure 5 shows a block diagram of a passive NFC RFID tag combined with a self-powered temperature sensor, and Figure 6 shows a photograph of this. In the picture, the demodulator and modulator use the ASK scheme, the baseband waveform is read from MCU. The MCU uses MSP430F5310, is programmable, and has a built-in general-purpose FRAM for program code or user data storage, such as calibration and measurement data. The power management manages the supply of voltage to the MCU using a three-stage full wave rectifier and a linear regulator. [7] [8] [9] [10]. Energy Harvesting I.C (bq 25570) was used for the voltage boost of the self-powered temperature sensor and storage capacitor (300uF) was used for the driving voltage charging.

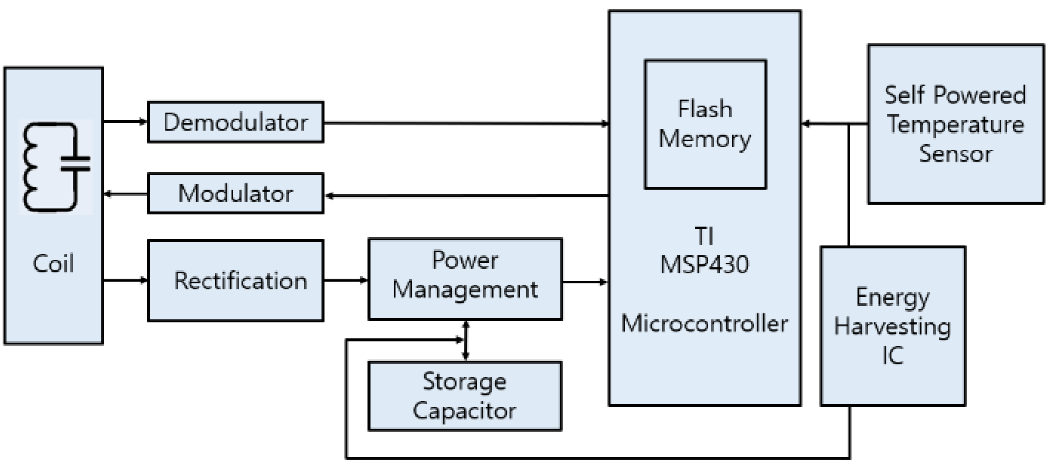


Figure 5. Block diagram of the NFC self-powering temperature sensor tag.

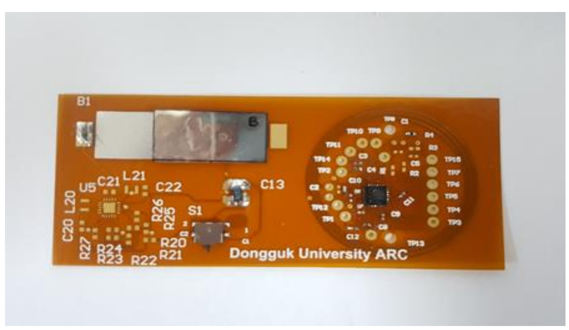


Figure 6. Production photos

3.3 Smartphone app for NFC RFID Tag combined with self-powered temperature sensor

Figure 7 is a signal flow diagram of the app for the temperature history that measures the temperature periodically and stores it in the memory in the tag.

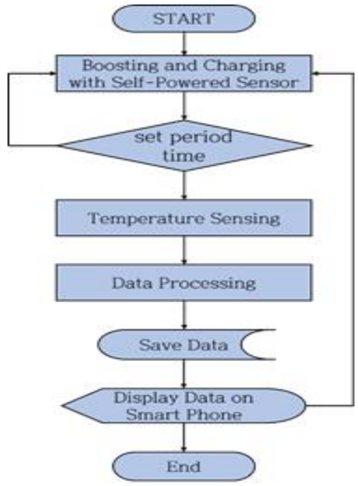


Figure 7. Signal flow for periodic temperature history.

4. Experiment and review

In order to verify the performance of the next generation temperature history system using the passive HF band RFID tag fused with the self-powered type temperature sensor, we experimented with temperature history. Figure 8 shows a photograph of a passive HF band RFID tag fused with a self-generating temperature sensor outside the food packaging box.

First, the food packaging box was put in a closed space, and the temperature was increased every 4 hours at the initial temperature of 0 ° C. After that, it was decreased again after 12 hours and the temperature was changed until 24 hours. Figure 9 is a measurement graph of temperature change. The changed temperature history was confirmed by the developed smartphone app with set time of 4 hours. In the experimental environment condition, the humidity is 50% and the recognition distance is 0.5 cm. As shown in Figure. 9, the changed temperature contents could be confirmed through the developed smartphone app. Figure 10 shows the temperature history monitoring screen confirmed by the smartphone.

Figure 8. Food packaging box with tag attached to NFC temperature sensor.

Figure 9. Measurement graph for temperature change.

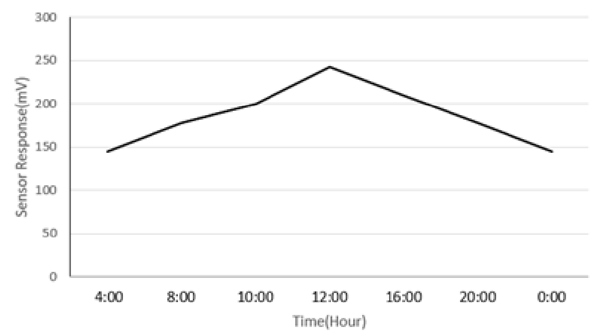


Figure 10. Temperature History Screen.

5. Conclusions

Recently, people's interest in the safety of foods, medicines and so on, while pursuing a high quality of life (QoL), temperature history information that affects the quality and safety of foods and medicines is very important. But the currently used temperature history method uses a fixed installed reader, so it does not cover the entire area because of high installation cost and limitation of installation place. In addition, it is inconvenient for the transporter to periodically check with the reader.

To solve these problems, we propose a next generation temperature history method. The proposed method allows the consumer to easily know the temperature history during distribution of foods and medicines using the personal smartphone. This is because the self-powered sensor can supply the voltage and periodically measure the temperature. The proposed next generation temperature history system consists of self-powered temperature sensor, NFC RFID tag, smart phone, PC and server. Here, PCs and servers are only needed if data storage and management is required. The performance of the proposed system was confirmed by temperature history experiment with temperature change by placing food packaging box in a closed space.

As described above, the proposed method can increase sales by increasing the safety and trust of consumers, producers and distributors about foods and medicines. And reduce the disposal or return of foods and medicines, which will help to create economic benefits.

Acknowledgments

This study was supported by the R&D Convergence Center Support Program of the Ministry of Food, Agriculture, Forestry and Fisheries, Republic of Korea (710013-03).

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