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Factors Influencing the Accuracy and Precision of NFC-Based Temperature Monitoring Device

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Abstract

Near-field communication (NFC) is a short-distance wireless data transmission technology with potential for wearable sensors. Xu et al. (2020) developed a battery-free smart textile patch with an NFC antenna and a temperature sensor (STP-NFC) [1]. To address potential issues with the testing protocol that could affect the accuracy and precision of temperature measurement from the STP-NFC, a validation experiment was conducted at a fixed room temperature of 20 °C. This was done using a commercial IR imager to compare the results with the STP-NFC results. Results showed excellent accuracy with an average temperature of 21.50 °C and a difference of only 0.36 °C from an IR imager's reading. The STP-NFC also had excellent precision with a small standard deviation of 0.83. Optimal performance was achieved with a 6 mm distance, a 150-second time interval, and a 4-second scanning duration for each scan. Additionally, the gage repeatability and reproducibility (R&R) study has been conducted to assess the STP-NFC measurement system's consistency, and the STP-NFC's reproducibility has been demonstrated. These results have implications for developing reliable wearable medical monitoring devices using NFC technology.

Keywords: Near Field Communication; Wearable Sensors and Devices; Validation Experiment; Optimal Procedure; Repeatability and Reproducibility

1 Introduction

Peter T. Lewis introduced the Internet of Things (IoT) in the 1980s. It refers to the wireless connection of operators and objects to optimise remote control and management [2]. As the IoT advances, more items are being tagged for identification, automation, monitoring, and control [3].

NFC is a promising IoT technology that has recently received significant attention for its potential use in point-of-care (POC) devices. It is a wireless data transmission method used for short distances, with a range of up to 20 centimetres and typically 10 centimetres [4]. The NFC system comprises two parts: a transmitter and a receiver. When an NFC-enabled device is brought close to an NFC tag, the tag's antenna picks up the signal from the device and responds with its data.

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The NFC antenna can be placed on various materials, including textile materials, making it an ideal transmission method for wearable sensors. Fig. 1(a) shows the structure of a typical NFC system [5].

Equipped with NFC functionality, Xu et al. (2020) have developed an STP temperature sensor (STP-NFC) consisting of a temperature sensor chip and textile coils, shown in Fig. 1(b). In the STP-NFC, the embroidered conductive coil connected to the NFC chip is both an antenna and an energy harvester. An embroidered coil is connected to an NXP NTAG NFC chip, which powers an MCU chip and a temperature sensor array using harvested energy. A smartphone with NFC can power the STP-NFC system [1]. The STP-NFC can be attached to the human body using medical tape, and the data can be easily read using a mobile phone app. Due to its small size, flexibility, and ease of use, it has the potential to be developed into a POC device for medical health care. By enabling real-time temperature tracking in various medical applications, such as patient monitoring [6], vaccine storage [7], and medication tracking [8], NFC facilitates precise and efficient temperature management, significantly leading to improved patient care and safety [9]. Meanwhile, since it utilises embroidery methods, STP-NFC can be produced in wearable and adaptable forms. Compared to traditional sensors with their drawbacks of complexity, low sensitivity, limited lifespan, and lack of compatibility with the human body, flexible sensors for wearable health monitoring have become crucial and make STP-NFC even more promising [10].

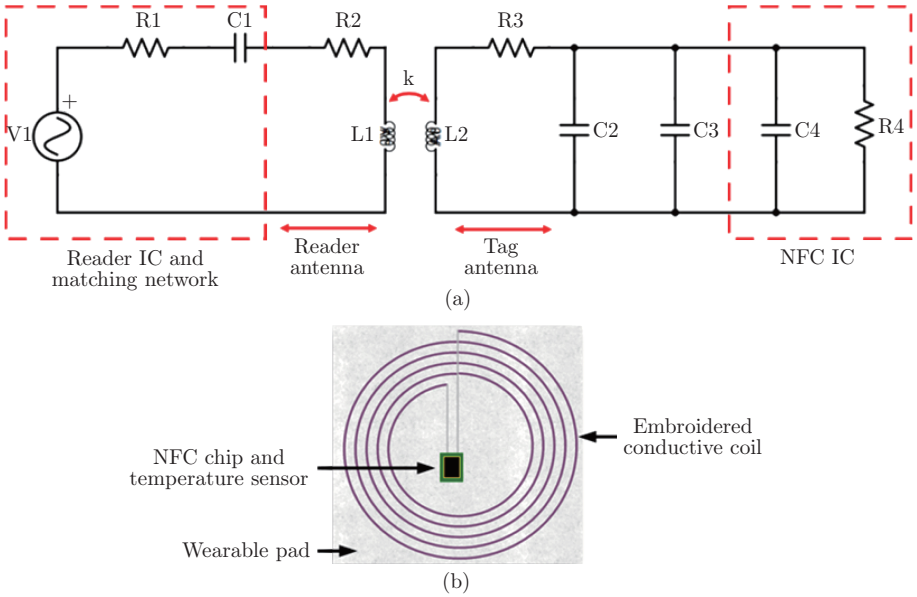

Fig. 1: (a) Structure of NFC system [5] (b) Structure of the STP-NFC

However, the accuracy and precision of temperature measurement obtained from the STP-NFC have not yet been validated, which may be influenced by various testing protocols, such as the distance between the mobile phone and the STP-NFC, the time interval between measurements, and the duration of contact during each measurement. These factors could potentially affect the performance of the temperature measurement process, yet their effects have not been confirmed.

Meanwhile, the repeatability and reproducibility of the STP-NFC have not yet been analysed. Repeatability presents the variations caused by the device, and it can be measured when a single operator repeatedly measures the same object using the same procedure under consistent conditions. On the other hand, reproducibility refers to variations caused by the measurement system,