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WIRELESS Temperature Monitoring System for Blood Bank using Zigbee

Lau Jye Hui[a], Fauzan Khairi Che Harun[a*], Yusmeeraz Yusof[a], Norlaili Mat Safri[a]

[a]*Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

*Corresponding author: fauzan@fke.utm.my

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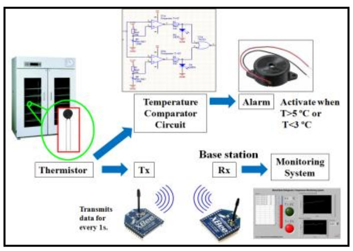
Graphical abstract



Abstract

A wireless temperature monitoring system has been designed and fabricated for the monitoring of blood bank temperature. The protection of blood is done by labeling of blood components and stored at refrigerator temperature of 4ºC. Therefore, it is important to monitor the temperature of blood bank to ensure the blood is stored properly to avoid the shortage of blood supply. This study involve both hardware and software implementation. A circuitry is produced and is placed at the blood bank which involves thermistor, ZigBee as transmitter and a buzzer as alarm. The temperature data is transmitted for every one second to the base station. As for the monitoring system, it will display the temperature data as well as time that received by another ZigBee at the base station. By using LabVIEW, the monitoring system was published to the internet by creating a website which can reduce the work load without involvement of labour. The integration of both software and hardware is done, where activation of the alarm and indicators for both circuit and monitoring system happen simultaneously based on the temperature condition of the blood bank.

Keywords: Temperature monitoring system; ZigBee; LabVIEW; internet; alarm

Abstrak

Satu suhu wayarles sistem pemantauan telah direka dan difabrikasi untuk memantau suhu bank darah. Perlindungan darah yang dibuat menggunakan pelabelan komponen darah dan disimpan pada suhu 4 ºC. Oleh itu, adalah penting untuk memantau suhu bank darah untuk memastikan darah disimpan dengan betul untuk mengelakkan kekurangan bekalan darah. Kajian ini melibatkan kedua-dua perkakasan dan pelaksanaan perisian. Litar dihasilkan dan diletakkan di bank darah yang melibatkan termistor, ZigBee sebagai pemancar dan penggera. Data suhu dihantar pada setiap satu saat ke stesen pangkalan. Seperti untuk sistem pemantauan, data suhu akan dipaparkan serta masa yang diterima oleh satu lagi ZigBee di stesen pangkalan. Dengan menggunakan LabVIEW, sistem pemantauan telah diterbitkan ke internet dengan mewujudkan satu laman web yang boleh mengurangkan beban kerja tanpa penglibatan buruh. Integrasi kedua-dua perisian dan perkakasan dilakukan, di mana pengaktifan penggera dan petunjuk untuk kedua-dua litar dan sistem pemantauan berlaku secara serentak berdasarkan keadaan suhu bank darah.

Kata kunci: Suhu sistem pemantauan; ZigBee; LabVIEW; internet; penggera

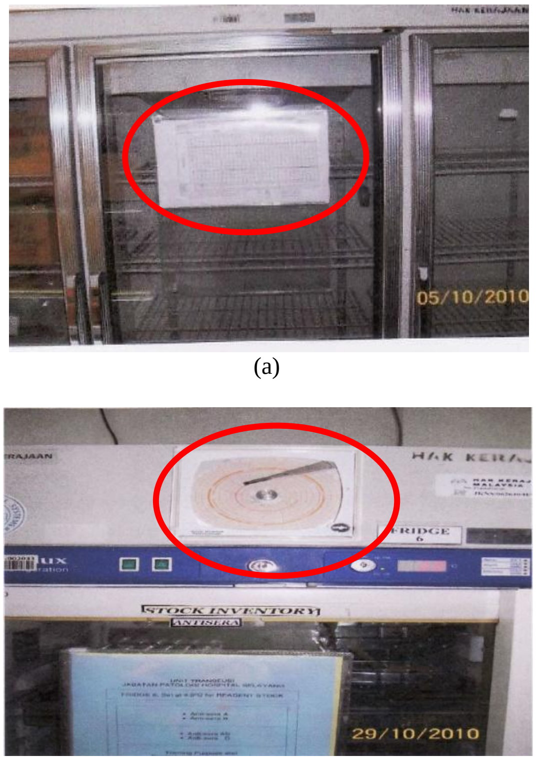
■1.0 INTRODUCTION

Blood bank acts as a laboratory center that has the responsibility in collecting and storing the blood safely for research and medical purposes. The collected blood is used in hospital especially the emergency treatment for the patients. According to American Association of Blood Bank (AABB), 23 million units of blood components were transfused in 2008 to save lives of cancer patients, trauma victims and organ transplant recipients. The association also says that the demand for blood transfusion will increase in future due to aging population and advances in medical treatments.

In order to fulfill the increasing demand of blood transfusion, the blood bank needs to ensure the continuously available safe blood supply to help injured or sick patients. The protection of blood is made by labeling of blood components and stored them at refrigerator temperature of 4°C.[1] Therefore, it is important to monitor the temperature of blood bank to ensure the blood is stored properly to avoid the shortage of blood supply.

■2.0 PROBLEM STATEMENT

It was found that most of the hospitals in Malaysia monitor the temperature of the blood bank manually. The current method that they are using is to record the temperature of the blood bank in table or graph by the staff for every 30 minutes. The table and graph are used to present the temperature data of the blood bank manually from the refrigerator as indicated in Figure 1. Besides the monitoring of the blood bank temperature done manually, the absent of alarm system to alert the staff in the case where the temperature of the blood bank goes higher or lower than the cooling performance of 4±1 ºC is also important to be addressed.



(a)

(b)

Figure 1 Blood bank temperature monitoring: monitored manually by recording down the data in table or graph.

■3.0 RELATED RESEARCH

In 1984, Robert E. Dawley had stated out the problem of manually monitoring the temperature of blood bank. The experimental evidence had showed that the optimum temperature for the stored blood is 4ºC.[2] In order to ensure that the blood bank is functioning well, the Red Cross is required to check on the blood bank temperature system carefully and frequently. All these manual tests had to be performed manually which was subjected to error and labor intensive.[2]

Many studies had been conducted on the issue of autonomous temperature monitoring technology. This is because by using the automated method, the need of time consuming manual checking can be eliminated.[3] However, the wireless technology was not that advanced where in 2004, the temperature data were sent by using the RF communication which faces the problem of high battery power consumption.

Later, the ZigBee protocol is being introduced to the IT and electronic industries. Its technology is based on the IEEE 802.15.4 standard and operates at 2.4GHz frequency with the maximum data rate of 250 kilo bytes and allows the indoor communication range up to 30m.[4]

The ZigBee module is famous as it supports the unique needs of low-cost, low-power, wireless sensor network (WSN).[5] WSN is a small sized wireless network that is capable in sensing, collecting and processing the data by communicating with others sensor nodes. The scattered sensor nodes that are placed in a sensor field will collect the data and route data back via RF channel.[4] Due to this advantage, ZigBee module has successfully attracts other industries in implementing high-end applications such as national security application, biomedical applications, seismic monitoring and more.

In 2010, Ramli Said had conducted his study on the topic of “Logger Temperature Controller”. In his study, he stated out the problem of monitoring temperature of blood bank manually and produced a wired designation of temperature logger that suited the LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench) software.

However, there are several shortcomings for the mode of short distance wired data. The problems exist such as poor expansibility, short transmission range and instable system.[6] Therefore, the ZigBee communication mode is said to be more suitable for short distance communication due to its strengthens of less complicated wire and flexible networking.

LabVIEW of National Instruments, USA is a graphical programming environment based on the concept of data flow programming.[7] Another advantage for LabVIEW is that it can be connected to internet conveniently for automatic data acquisition and real-time remote monitoring.[6]

■4.0 METHODOLOGY

The hardware implementation and software programming of the project is discussed here. Figure 2 shows the block diagram of the temperature monitoring system.

As shown in Figure 2, the thermistor is placed inside the refrigerator. The thermistor is connected to a comparator circuit and it will determine the activation of the alarm. The alarm will be activated if the temperature of the blood bank is greater than 5 ºC or lower than 3 ºC .On the other hand, the same thermistor will also be connected to the ZigBee (transmitter) that will send the temperature data for every 1 second. At the base station, another ZigBee is placed and acts as a receiver that will receive the data from the refrigerator. The data will then be displayed in the monitoring system.

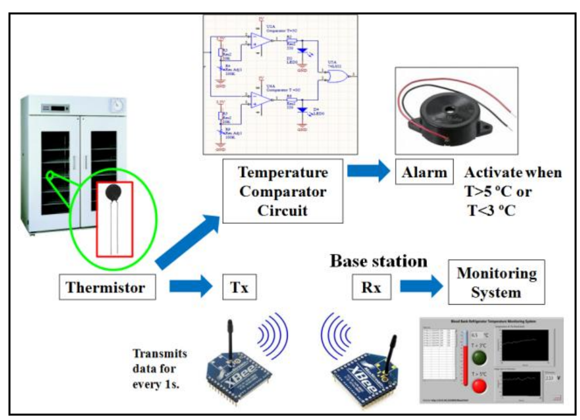


Figure 2 Block diagram of temperature monitoring system

4.1 Methodology and Approach

Figure 3 shows the flow which consists of hardware design, software implementation and LabVIEW interface design.

At the beginning, work was done to achieve better understanding about temperature logger and Zigbee module. After that, type and model of components are determined and followed by schematic circuit design. After accomplishing the hardware part, the software part was designed to interface with the LabVIEW. Lastly, both software and hardware were integrated and tests were conducted on the system functionality and its accuracy.

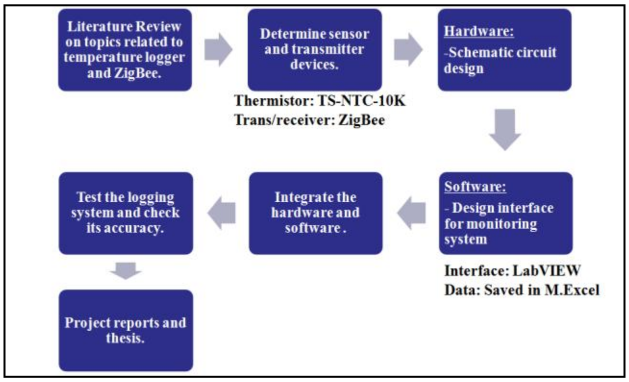


Figure 3 Study's flow chart

■5.0 RESULTS AND DISCUSSION

The temperature monitoring system was divided into two configurations, which were hardware part and software part.

5.1 Hardware Part

The schematic diagram of the circuit is designed using the Altium designer. Most of the components can be found in the library of Altium Designer. The assignment pins for each component are shown in the schematic which is important when building the circuit on board. The complete schematic diagram of temperature monitoring is shown in Figure 4.

As shown in Figure 4, the thermistor is connected parallel with a 20 kΩ resistor, and connects to the ADC input of ZigBee. The temperature data are then be sent by the ZigBee to the base station for every 1 second.

At the same time, the thermistor is connected to the comparator circuit to determine whether the temperature of the blood bank fulfill the conditions of T > 5 ºC or T < 3 ºC. If the condition of T > 5 ºC is fulfilled, the red LED will be turned on; while if the condition of T < 3 ºC is fulfilled, the green LED will be turned on. The alarm will then be activated if either one of the condition is fulfilled.

A set of voltage regulator is needed as well in the circuit because the power supply for ZigBee is 3.3 V. Therefore, at first, the voltage is regulated from 9 V battery to 5 V supply through LM7805, and after that further regulated to 3.3 V through LM 1117 before it is supplied to ZigBee. Figure 5 shows the circuitry of the designed device.

5.2 Software Part

The LabVIEW interface is designed for monitoring purpose. A ZigBee is placed at the base station as receiver and the temperature data are display in the monitoring system.

Due to the received data at the base station is voltage value of the thermistor, a convertion matrix was needed. Experiments were conducted to obtain the relationship between temperature and thermistor voltage (Figure 6). The equation that was obtained from the plotted data is $T = -5.6v^2 - 0.6v + 31$, and is applied in the built system. From figure 6, it is obvious that a linear relationship between temperature and voltage lies within the temperature of 0 ºC to 10 ºC. Even-though for a NTC type thermistor, the output response graph is non-linear, it is only true for a broad range, i.e. from -100 ºC to 400 ºC (Figure 7). For small window size, i.e. from 0 ºC to 10 ºC the relationship is close to linear system as shown in Figure 7 (right).

Lastly, the overall interface of the monitoring system was designed as shown in Figure 8.

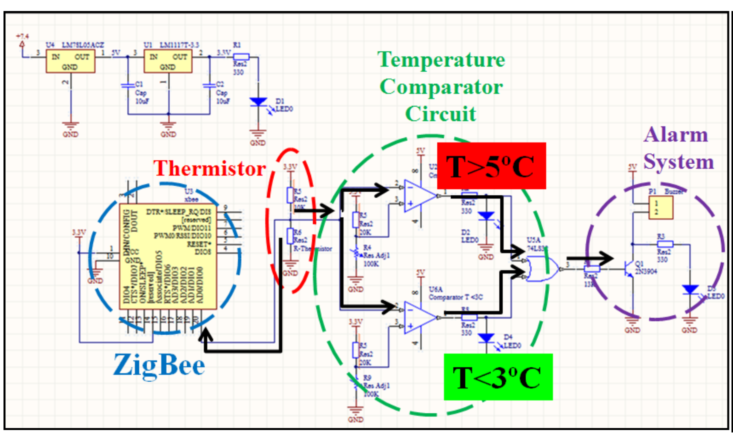


Figure 4 Full schematic design for temperature monitoring system

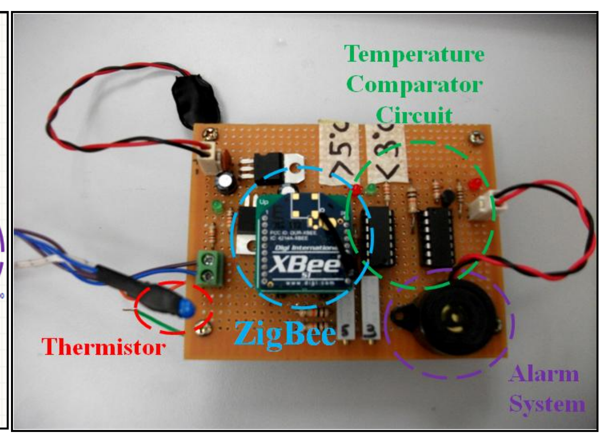


Figure 5 The circuitry of the study

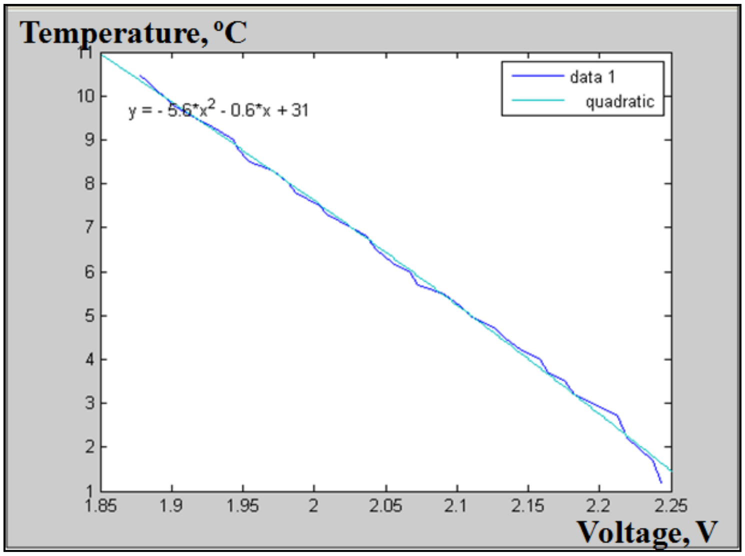


Figure 6 Graph of temperature vs. voltage for the thermistor

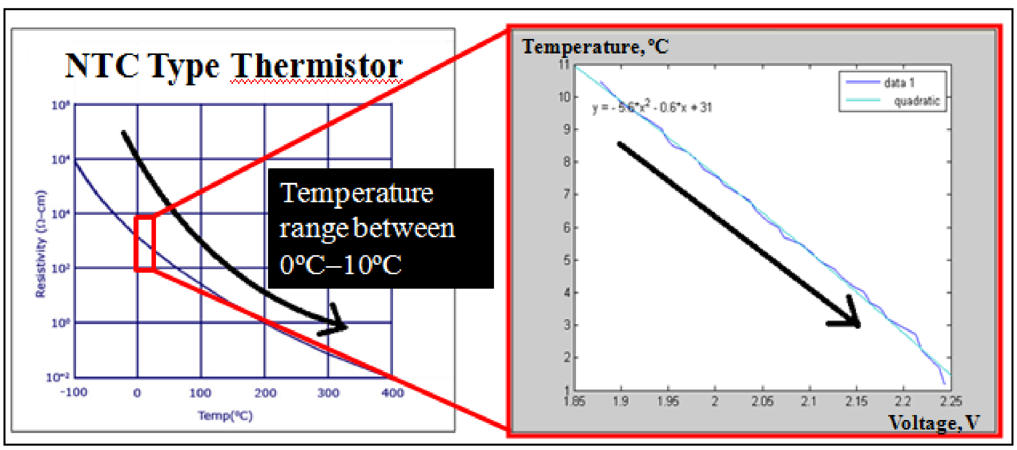


Figure 7 Linear range obtained for the thermistor

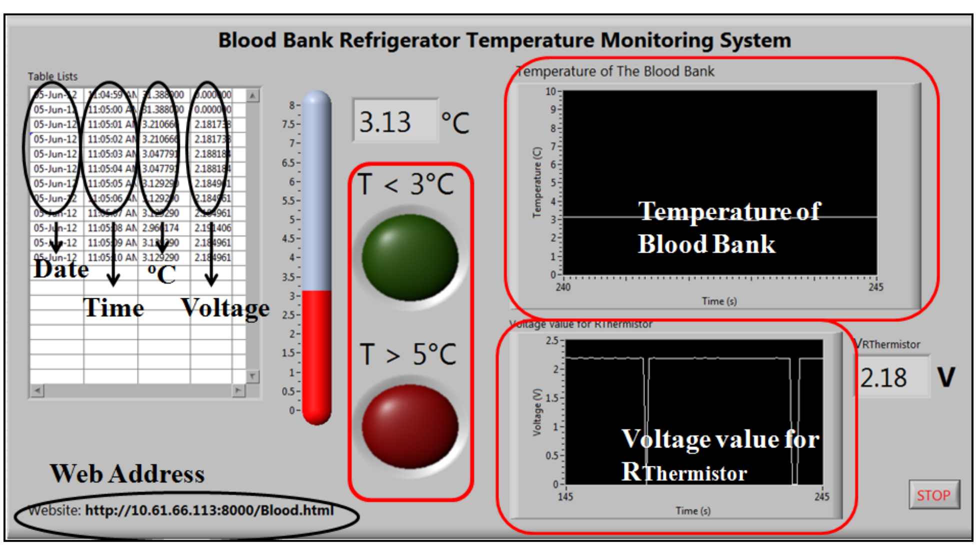


Figure 8 LabVIEW interface for the monitoring system

5.3 System Integration

Three experiments were conducted to test the logging system. Table 1 shows the expected outcomes of the experiment. In the first case where the temperature is less than 3 ºC, only green LED and alarm are on. In the second case where the temperature is within 3 ºC to 5 ºC, none of them is on. Lastly, in the third case where the temperature is more than 5 ºC, only red LED and alarm are on. The result for each case is shown in figure 9.

In Figure 9(a), when the temperature dropped to 2.64 ºC, both green LEDs at LabVIEW and comparator were on, and the alarm was activated. Next, in Figure 9(b), when the temperature rose to 4.5 ºC, the green and red LEDs at LabVIEW and comparator were off, and the alarm was deactivated. In Figure 9(c), when the temperature rose to 5.52 ºC, both red LEDs at LabVIEW and comparator were on, and the alarm was activated.

Besides that, the temperature monitoring system can also be seen through the website that had been created as shown in Figure 10.

Table 1 Expected Outcomes of the Experiment

CASES	GREEN LED	RED LED	ALARM
T<3ºC	ON	OFF	ON
3ºC<T<5ºC	OFF	OFF	OFF
T>5ºC	OFF	ON	ON

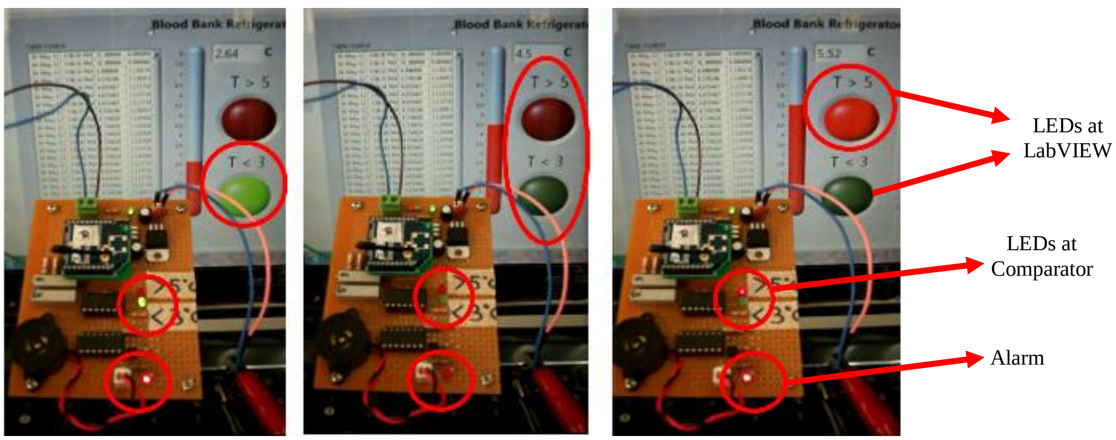


Figure 9(a) Case 1, T<3ºC **Figure 9(b)** Case 2, 3ºC<T<5 **Figure 9(a)** Case 3, T<5ºC

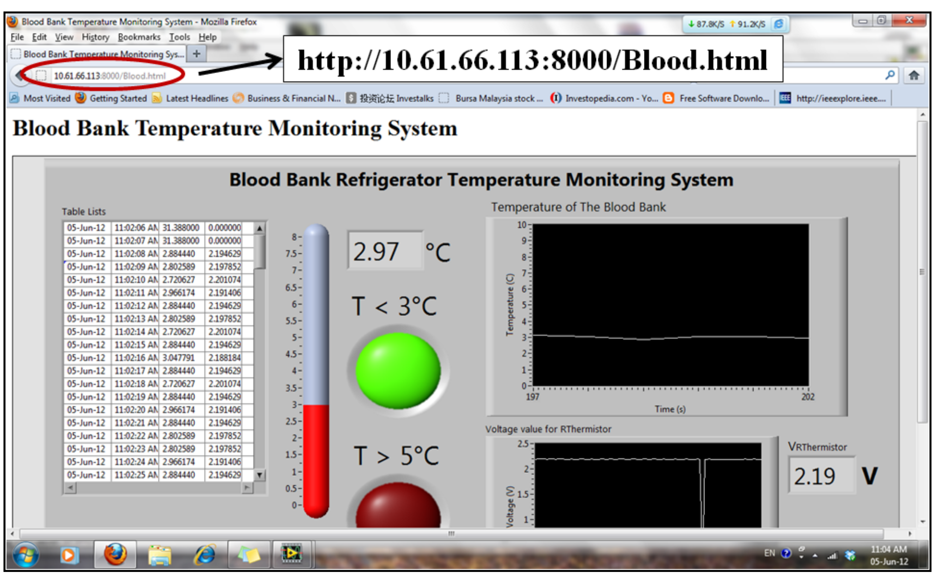


Figure 10 Web-based monitoring system

■6.0 CONCLUSION

In summary, the designed system is able to transmit temperature data of the blood bank for every one second to the base station. The received temperature data then are displayed in the LabVIEW based real-time monitoring system. The developed LabVIEW based real-time monitoring system can also be viewed ubiquitously through the internet and become the web-based monitoring system. The developed system also is equipped with an alarm system, both in the hardware and software parts.

■7.0 FUTURE IMPROVEMENT

There are some improvements that can be implemented. The blood bank monitoring system can be more functional by using sensor that can detect humidity as well, as humidity also is important factor that affect blood quality. A controller could be introduced where if temperature is out of range, then it could control the cooling system to restore the temperature into the required range. And lastly, the base station should be able to receive and display parallel data in the monitoring system as input could be from multiple refrigerators.

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