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To cite this article: Hongchang Sun *et al* 2021 *J. Phys.: Conf. Ser.* **2044** 012198

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Development and realization of the electric energy monitoring system for cloud-based intelligent buildings

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Abstract. With the in-depth development of cloud computing technology and the continuous application of various new technologies in the process of modern building construction, the application of embedded technology, communication sensing technology, cloud computing technology and other technologies to create energy-saving building energy monitoring systems has become a research hotspot. This paper first compares and analyzes the network structure of the traditional building energy monitoring system and cloud-based building energy monitoring system, and then focuses on the overall architecture of the system and the design and implementation of the terminal intelligent monitoring unit. On the one hand, the development of building energy monitoring system based on cloud computing realizes cloud processing of building energy monitoring. On the other hand, the control strategy formulated by big data effectively improves the overall energy saving efficiency of the building.

1. Introduction

The employment of cloud computing technology to the construction of modern buildings can enhance the interactivity of the building environment and equipment adjustment, and realize the big data management of the building environment. Smart buildings are part of smart cities, and the energy consumption data collection technology of building equipment is also very mature. The building power monitoring system collects all the energy consumption data of individual buildings in the urban data center, performs overall calculations, and combines smart grid data to perform mining and analysis work, thus achieving the purpose of optimizing the smart grid [1,2].

The application of cloud technology solves the shortcomings of the traditional building electric energy monitoring system with slow control calculation speed and low degree of intelligence [3]. At present, the combination of cloud computing and building power monitoring system is still in its infancy, and there are still some problems, such as the realization of interconnection between different brands. Therefore, the industry association has formulated a "cloud-cloud interconnection" group standard based on various enterprise clouds to address the problem of the inability of interconnection among various home appliance companies, and adopted a unified conversion agreement. All companies open cloud interfaces to provide support for the comprehensive application of cloud technology in building power monitoring systems [4].



2. Comparative analysis of the overall network architecture of the system

2.1. Traditional building power monitoring system network architecture

The traditional building equipment monitoring network mainly has the following characteristics: (1) Only for the operating data of one or several buildings, each network must be equipped with a monitoring network system and each network is disconnected from each other, which increases the investment cost and the difficulty of centralized control [5]. (2) In the traditional construction equipment monitoring network, users can not monitor the running data and fault maintenance progress of the power distribution system in real time, so that the fault time is prolonged, the difficulty of later maintenance is increased and the efficiency is reduced [6]. (3) The traditional construction equipment monitoring network is difficult to expand its functions, the software reusability is poor, the resources can not be shared, and a lot of human and material resources are wasted [7]. The traditional building power monitoring system network architecture is shown in figure 1.

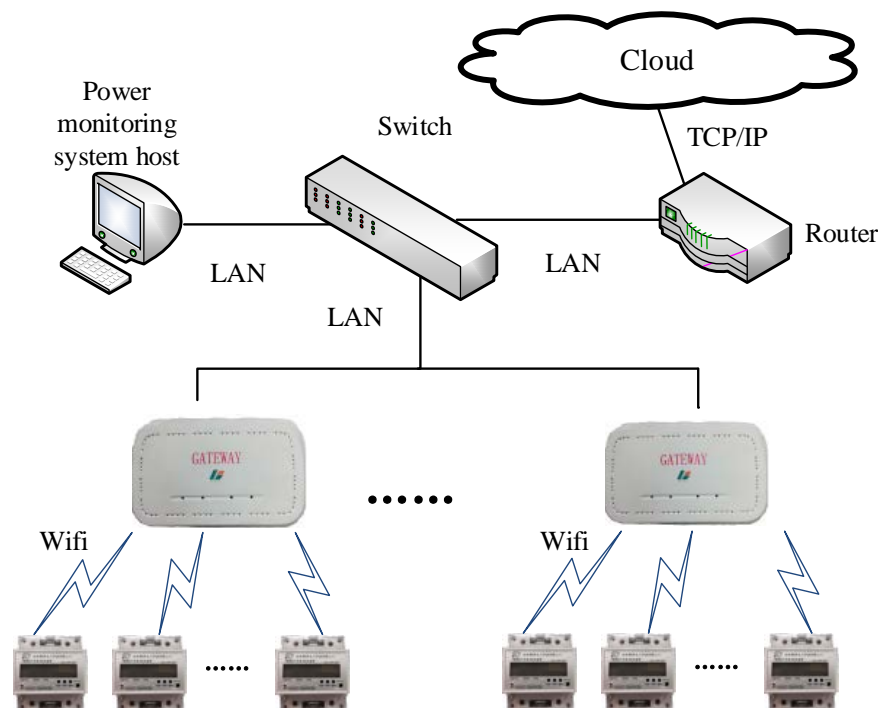


Figure 1. The traditional building power monitoring system network architecture.

2.2. The network architecture of the multi-path building power monitoring system based on cloud computing

Figure 2 shows the network architecture of the multi-path building power monitoring system based on cloud computing, which contains three levels: core layer, aggregation layer and edge layer. And it is a distributed network topology [8]. Cloud technology can transmit various information data recorded daily by massive construction equipment to the cloud platform, and then it performs distributed processing of big data to mine the potential information of the data, thus realizing the real-time monitoring of construction data and video to improve work efficiency and service quality, and reduce investment costs [9].

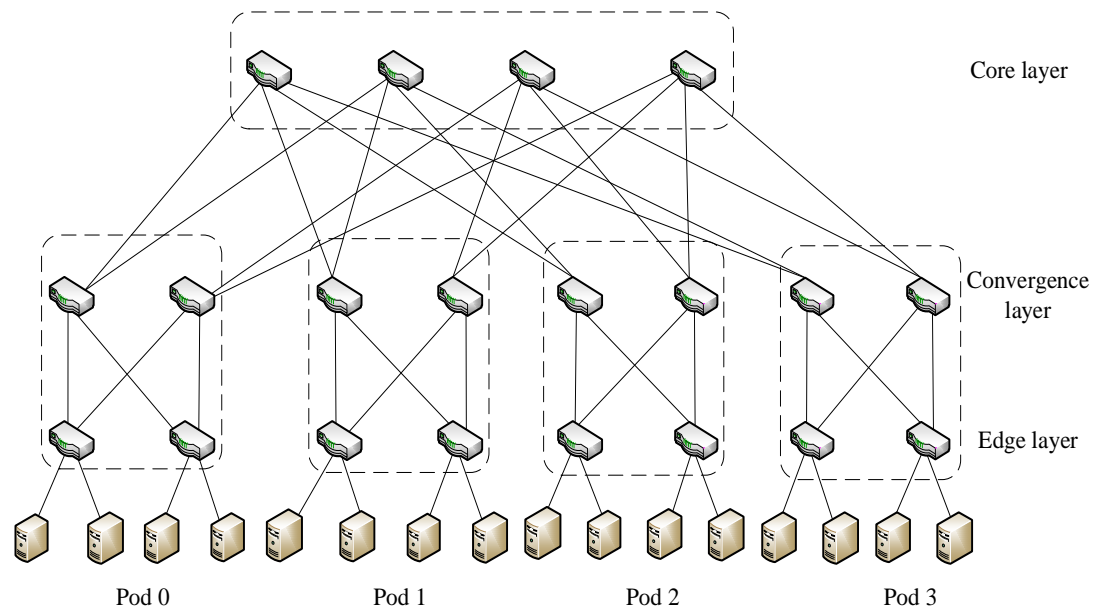


Figure 2. The network architecture of the multi-path building power monitoring system based on cloud computing.

Applying the cloud technology in the field of building power monitoring can simplify the operation and maintenance of the entire power monitoring system, and improve the network structure and capabilities of building power monitoring. Specifically, constructing a flat system topology can improve the ability of local switching and nearby processing in the intelligent building network; Adding the self-organizing network function can effectively improve the usability and scalability of the system; Utilizing big data architecture of the distributed storage and parallel computing and mining the big data can quickly realize the calculation of building energy monitoring global information, and improve energy efficiency by comparing and analyzing the operating performance of building electromechanical equipment. Under the current trend of interconnection of everything and services to the cloud, the high level of professional technology of cloud service companies is used to achieve the purpose of optimized operation, energy saving and emission reduction.

3. The overall architecture of the building power monitoring system based on cloud computing

The application architecture of the building power monitoring system based on cloud computing technology effectively expands the application design dimension, and incorporates building common data into the power monitoring system from the perspective of individuals to the perspective of buildings. The utilization of cloud technology combines big data technology, relying on the urban data center, to feed back building localized information, services, and data to the owner. Enterprise-level applications focus on enterprise data management and resource sharing within the industry, including billing management, security management, resource management, fault-tolerant management and other services, which are unified into the application infrastructure. The basic architecture is shown in figure 3.

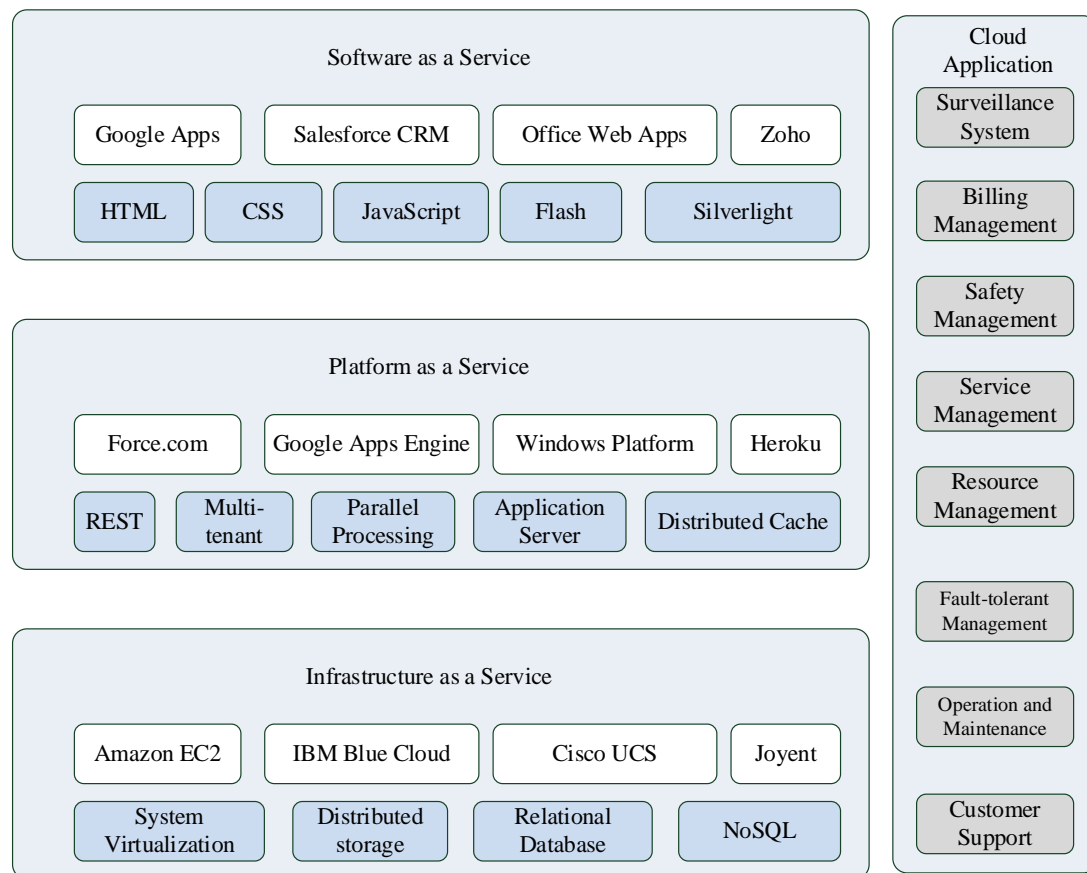


Figure 3. The architecture of the building power monitoring system based on cloud computing.

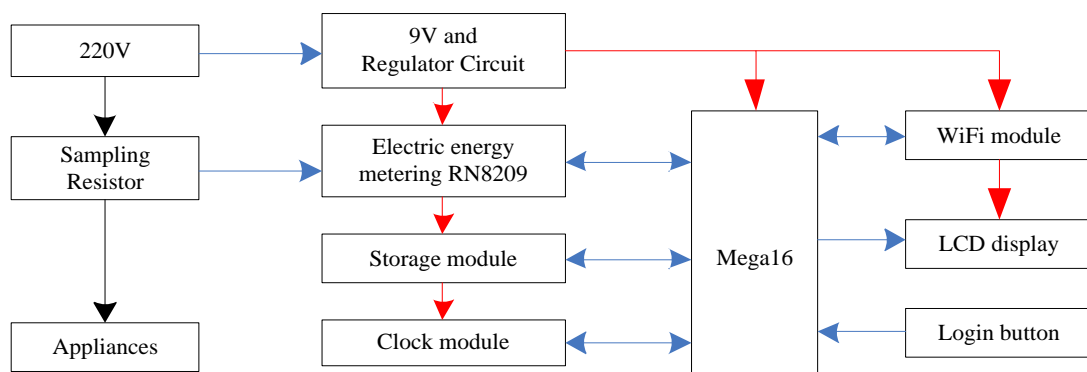


Figure 4. system chart of Intelligent power monitoring unit.

4. Realization of building electric energy monitoring system

4.1. Design of Intelligent Electric Energy Monitoring Unit

As an important part of the building intelligent power system, the intelligent electric energy monitoring unit realizes the measurement of the electric quantity, current, voltage, power and so on in the room, and displays it through LCD. Traditional electric meters mostly use transformers to measure

voltage, current and power, which have disadvantages such as low measurement accuracy and large size. The smart meter employs the new power metering chip RN8209 to achieve data measurement. And this chip supports the standard of IEC62053-22:2003 and communicates with the host through the SPI interface.

The intelligent electric energy monitoring unit is mainly composed of a power supply module, a metering module, an MCU module, a WiFi wireless module, an LCD display module, a storage module, and a clock module. The system block diagram is shown in figure 4. The red arrow in the figure indicates the direction of current supply, the blue arrow indicates the direction of information flow, and the black arrow indicates the direction of 220V current.

(1) Energy metering module

The chip of RN8209 is utilized as the energy metering module, which has the functions of measuring voltage, current, electricity, power, etc. The metering chip samples the load AC voltage signal and load current signal, and after internal processing, it outputs the power value, voltage effective value, current effective value and electricity consumption information through SPI communication. The measuring circuit of RN8209 is shown in figure 5.

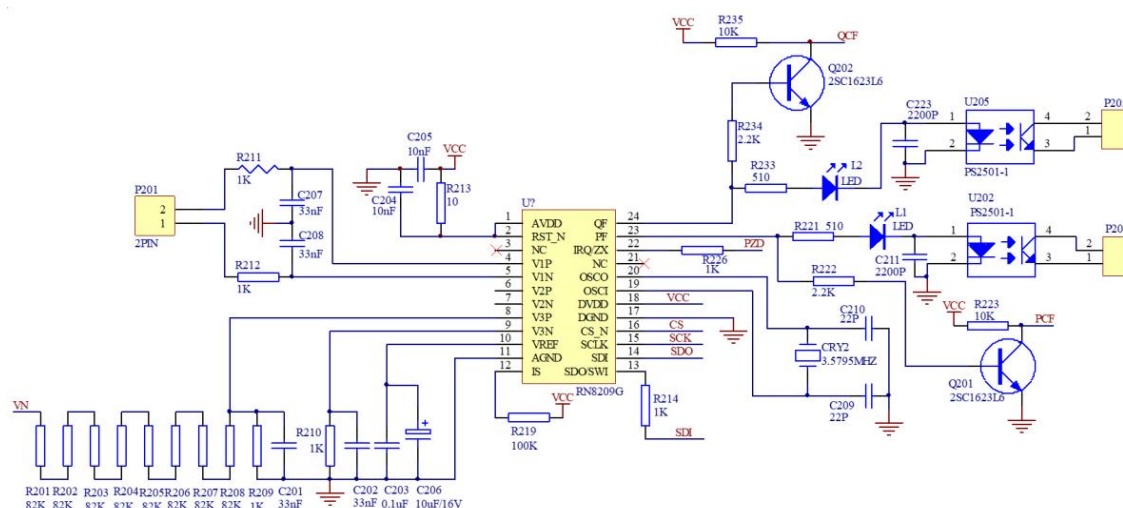


Figure 5. RN8209 peripheral circuit diagram.

When the current is collected, the input terminal of the live wire passes through 0.56 micro-ohm manganese, resulting in a slight voltage drop. The two ends of the manganese are connected to the positive and negative analog pins of the current channel A through a 1K resistor. Through the chip internal processing using the completely differential input mode, the 24-bit effective current value can be read from the register, and the current value can be obtained through data processing.

The voltage acquisition is also achieved by the differential input mode. The neutral line passes through a 496K resistor. In order to reduce the power, multiple resistors are connected in series. The voltage obtained by the 1K resistor is input to the positive analog input pin of the voltage channel and the negative analog pin of the circuit channel is connected to the ground by the 1K resistor. After the chip is processed internally, the 24-bit voltage effective value is read from the register, and the voltage value can be obtained through data processing.

Current channel B obtains the current on the neutral line through a current transformer, and compares it with the current value collected by current A channel. If it is different, it means there is a phenomenon of electricity theft. Both the active power and reactive power can be obtained by reading the register.

(2) LCD display module

The information display part of the intelligent power monitoring unit uses the ht1621 segment code driver chip to drive the LCD display, which can display information such as voltage, current, power, accumulated power consumption and time, etc. The display part of the circuit is shown in figure 6.

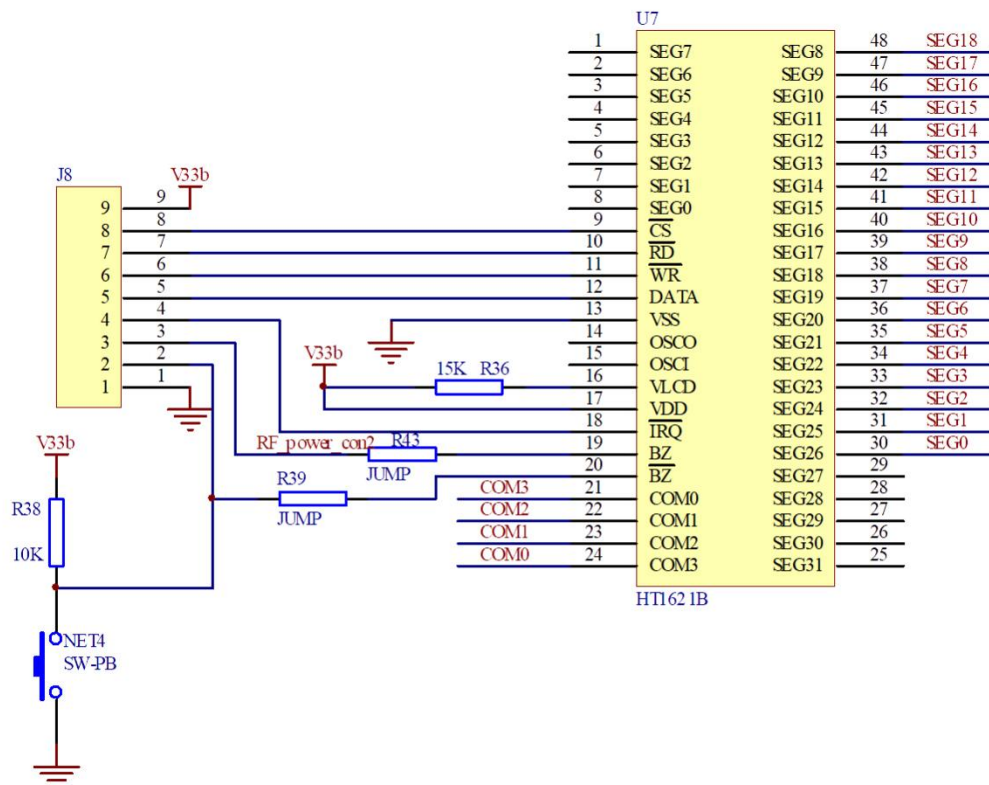
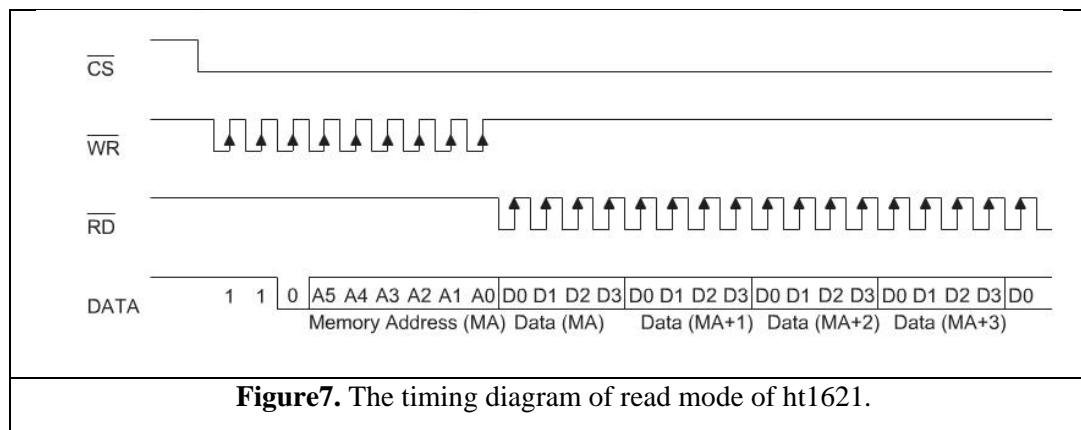


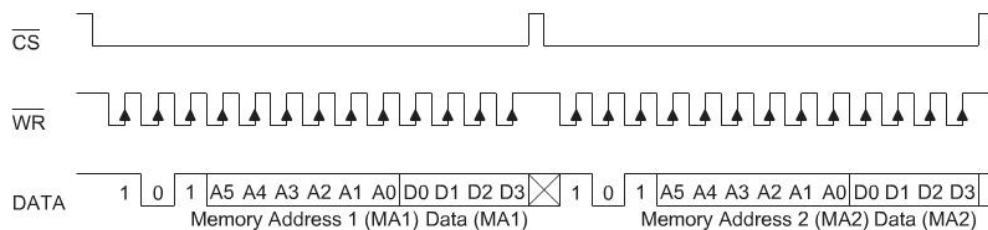
Figure6. Display part of the circuit diagram.

The four pins of ht1621 are used as excuse pins to connect to the single-chip microcomputer. /CS is used as the chip selection input pin, and the input and output are valid when set low; /RD and /WR are used as read and write pulse input pins; DATA is used as data input and output pin. When /RD is a falling edge signal, information is output to the DATA pin; when /RD is a rising edge signal, information is read from the DATA pin. When the /WR pin is a rising edge signal, the data command is written into ht1621. The timing diagram of read and write mode of ht1621 is shown in figure 7 and 8.

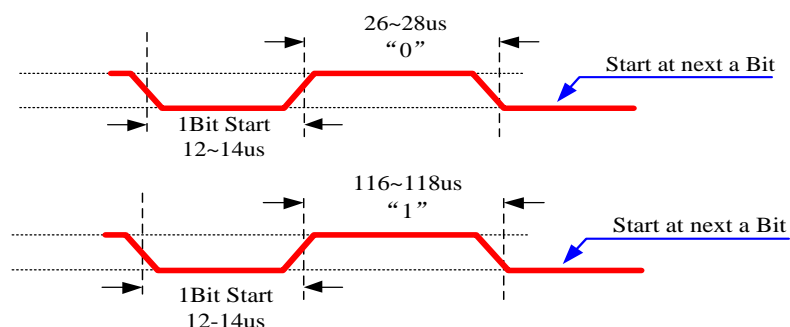


4.2. Control output mode of intelligent electric energy monitoring unit

The intelligent power monitoring unit owns the wireless control function. The system uploads real-time building data to the data center. The data center analyzes the change trend, judges the possible overshoot in advance, then develops a control strategy and sends it to the end host of the building. The terminal host of building parses the command and sends it to the intelligent power monitoring unit. The latter realizes the linkage of the electrical equipment in two ways according to the control command: wireless module and infrared module.



Taking the temperature and humidity collection command of the intelligent electric energy monitoring unit as an example. The length of the command is 8 bits: the first three bits are addresses, the last three bits distinguish temperature and humidity, 011 represents a temperature command, and 101 represents a humidity command. The signals '0' and '1' are both composed of low and high levels, and the signals '0' and '1' are distinguished by the duty cycle of the high level, as shown in figure 9.



During data measurement, because the sensor is susceptible to the influence of external temperature and humidity, the humidity measurement data is nonlinear, and the temperature is linear due to the good energy gap material. The intelligent power monitoring unit will correct the initial data, and hence obtain the modified formula as follows:

$$T = -40 + 0.01M \quad (1)$$

$$RH_L = (-4 + 0.0405N - 2.8 \times 10^{-6} N^2) \% \quad (2)$$

$$RH_T = RH_L + (T - 25)(0.01 + 0.00008N) \% \quad (3)$$

5. Conclusion

This article describes the design of a new generation of building power monitoring system from the perspective of cloud technology application. According to the comparison and analysis of the network structure of the traditional building power monitoring system and the cloud computing based building power monitoring system, the paper focuses on the overall system design and implementation of the architecture and terminal intelligent monitoring unit. Looking forward to the future, with the in-depth application of cloud computing and big data technology in the field of building energy consumption, cloud platform providers will provide services required by individual customers of smart buildings in the form of service packaging and computing power rental, thereby fundamentally solving the current lack of efficient energy monitoring and energy-saving control strategies for smart buildings.

Acknowledgments

This research has been supported by the Key Research and Development Program of Shandong Province (2016GGX103031), the Science and Technology Program of the Ministry of Housing and Urban-Rural Development of China (2020-K-083), the Science and Technology Program of Housing and Urban-Rural Development of Shandong Province (2020-K3-10).

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