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COMBUSTIBLE GAS MONITOR SYSTEM OF BUILDING BASED ON CAN BUS AND ZIGBEE TECHNOLOGY

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Abstract. *Considering the complexity of building environment and the inconvenience of wiring, a gas pipe leakage monitoring system of building was proposed based on CAN bus and Zigbee technology. In order to improve the working hours of terminal nodes and robustness of Zigbee network, dormancy and awakening rotation mechanism were adopted for Zigbee terminal nodes and spare nodes were added for Zigbee backbone nodes, which can keep the system better adapting the complex building environment. The experimental results show that the system can detect gas leakage with high resolution, and can effectively meet testing demand of the intelligent building.*
Keywords: Wireless sensor networks, Zigbee, CAN bus, Intelligent building

1. **Introduction.** Intelligent building is a new kind of building which is produced by the mutual penetration and combination of architecture technology and information technology. Its main function is being safe, convenient, efficient, and energy saving. Gas pipeline is the main facility of building to transport energy. However, monitoring the gas leakage timely is an important aspect directly related to intelligence of building [1]. At present, most of existing instrument detecting combustible gas leakage is cable instrument. The laid wires of instrument directly limit use of the testing instrument, which not only cannot find leakage point in time, but also increase the probability of the accident [2]. Although the Zigbee wireless network has many characteristics, such as low power consumption, self-organization and self-healing, the wall obstruction can also affect the transmission quality. CAN bus has advantages of high communication rate, long transmission distance, simple structure, low cost, strong anti-jamming capability.

In order to solve problems of the pipeline in gas detection, this paper makes full use of Zigbee wireless network technology and CAN bus technology in terms of their respective advantages. We design a combustible gas monitor system based on CAN bus and Zigbee technology; differing from general combination of Zigbee and CAN bus, we adopt dormancy and awakening rotation mechanism for Zigbee terminal nodes and add spare nodes for Zigbee coordinator nodes and routing nodes to improve the working hours of terminal nodes and robustness of system, which can not only effectively realize the distributed real-time monitoring, also adapt to the complex building environment.

2. **General Design of System.** The overall structure of block diagram is shown in Figure 1. Outlet of gas pipeline on each floor is randomly provided with a number of terminal sensor nodes, which can support bidirectional data communication between

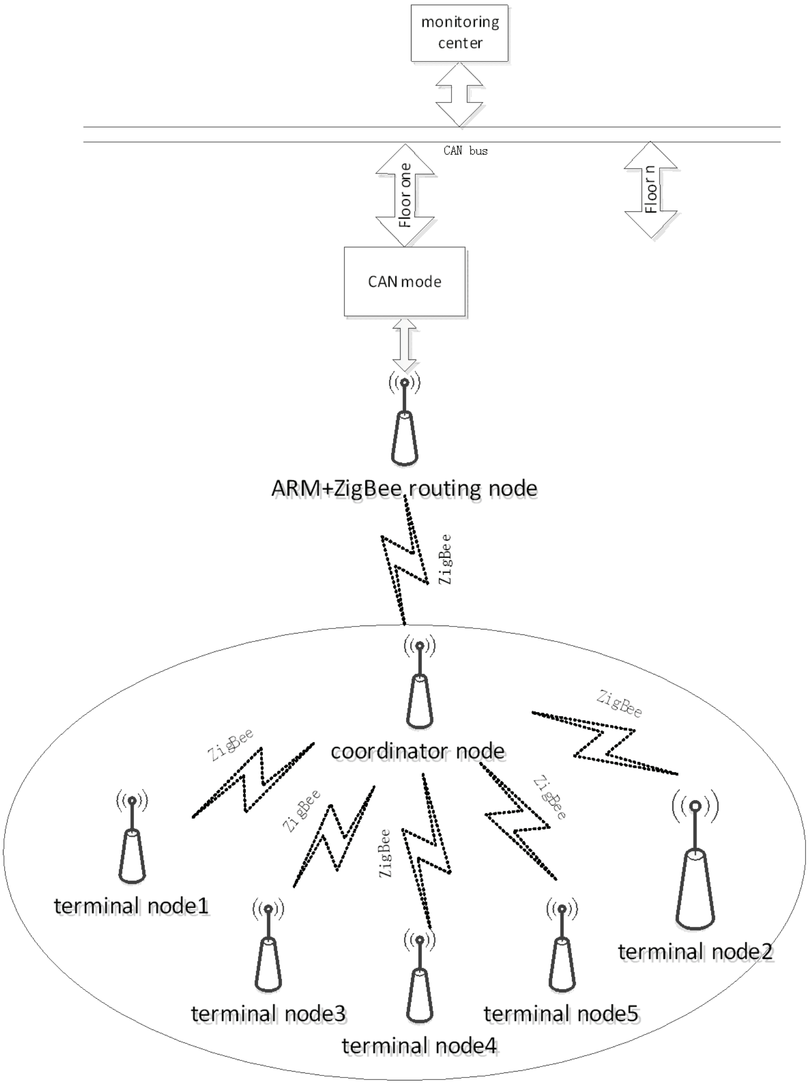

Figure 1. System overall structure diagram

Zigbee network and coordinator. Each terminal node is responsible for the leakage of combustible gas to be monitored. It can transfer collected data information timely to coordinator nodes, communicate with routing nodes through Zigbee network. The routing nodes deployed on aperture of every floor is responsible for collecting terminal nodes information. Considering influence of wall, we add spare nodes for Zigbee routing nodes and coordinate nodes to improve robustness of network. Routing node can send data to CAN nodes, and the CAN nodes can transmit them to monitoring center for the real-time acquisition and monitoring.

3. The Hardware Design of System.

3.1. The hardware design of gas terminal data acquisition module.

The hardware design of gas terminal data acquisition module is mainly composed of power supply module, main chip CC2430 and gas sensor module. Consider the developed Z-Stack protocol Stack. It can only need to add a small amount of peripheral circuit and accomplish data collection and transmission, which can reduce power consumption of nodes [6,8]. The chip has better ability of anti-interference and sensitivity of antenna to send and receive, in terms of performance, and it is very suitable for building in such a complex environment.

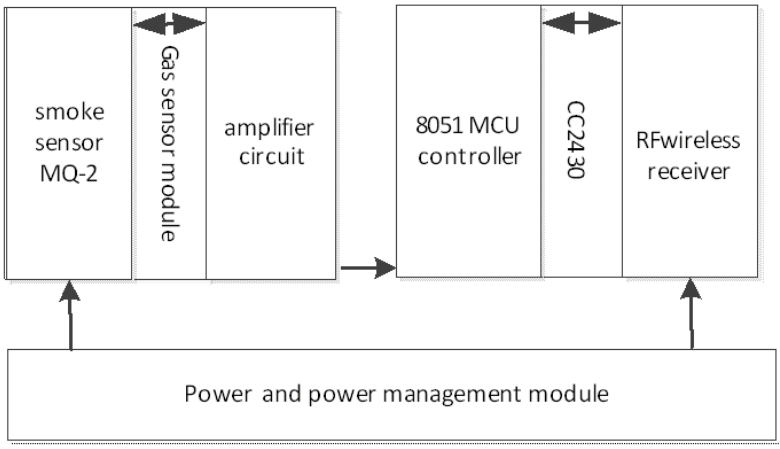

Figure 2. Structure diagram of terminal nodes

The main task of gas data acquisition module is responsible for collection of gas concentration data. The reason why we adopt MQ-2 sensor is that it has extremely high sensitivity to combustible gases. The detection principle is that different kinds and concentrations of gases can bring about difference of resistance, which leads to voltage change. The acquired signal after A/D conversion to corresponding voltage signal can be sent to single-chip, and digital voltage can be converted to corresponding decimal density for gas concentration comparison. At last, when the gas density is over the warning line, the system can report and alarm. Sensor nodes can collect leakage concentrations of gases in monitored area, the signal amplified by 3 op-amp differential amplifier circuit can be converted into standard signal to P1.0 port of CC2430 chips, RF module will send data converted by A/D module to the coordinator, or receive the instructions sent by coordinator to finish the related tasks, and the hardware design of terminal node is shown in Figure 2.

3.2. **The hardware design of coordinator routing node.** Main task of routing node is responsible for establishment of network, address assignment, orders issued and data transmission. The coordinator node is the control center of Zigbee network and responsible for maintenance and creation of network, and the network interface between Zigbee and external communication. The S3C2440 SPI mouth of ARM9 processor can communicate with CC2430 transceiver module. According to the interpretation of Zigbee information, S3C2440 can determine which Zigbee terminal node sends information based on different network addresses. If leakage concentrations of gas can exceed critical value, alarm will start, and indicator will light up. S3C2440 key module can accomplish the sensor calibration regularly, parameter set and data query. The design of hardware circuit is shown in Figure 3.

The CAN communication module is the core part of coordinator node. It is responsible for communication between CAN bus and Zigbee network, instruction transmission to lower network, data reception from lower nodes, and upload to the PC. This module is composed of microprocessor S3C2440, CAN bus controller MCP2510, CAN bus transceiver TJA1050, high-speed photoelectric coupler 6N137 and power supply module. The main task of CAN controller is to realize the assembly and separation of message, filter and calibrate received information. Transceiver TJA1050 is the interface between CAN protocol controller and physical bus, which can realize the CAN controller connection with communication line. Because of CANH and CANL ideal match [5,7], it can improve driving ability and ability of CAN bus to send and receive. In order to improve the anti-interference ability of CAN bus, the power supply of optical coupling circuit must be completely isolated to ensure that each node is completely separate and independent,

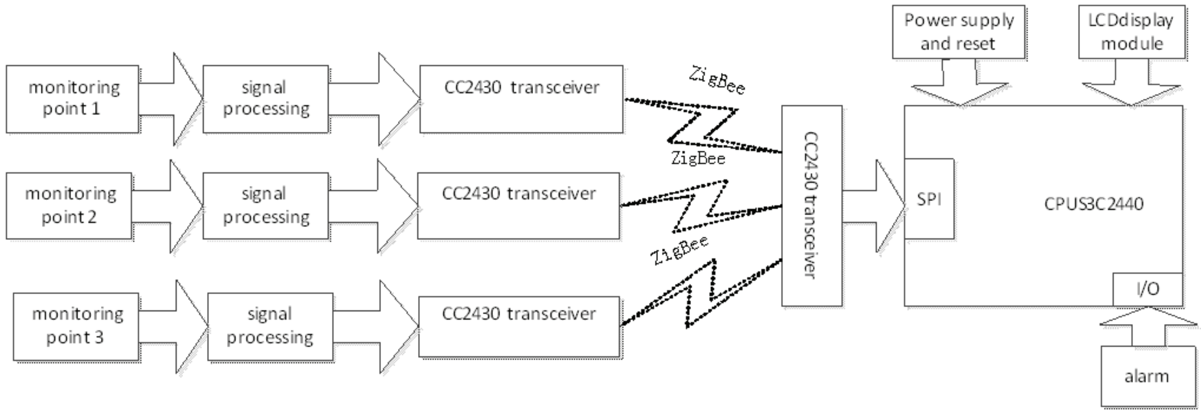

FIGURE 3. Structure diagram of routing nodes

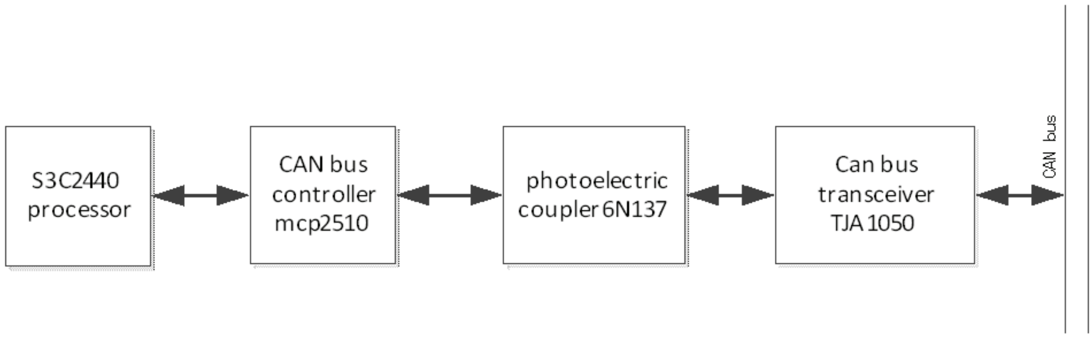

FIGURE 4. The overall structure diagram of ARM and CAN bus connection

TX0 and RX0 of S3C2440 respectively through TXD and RXD from high-speed optical coupling 6N137 and TJA1050 are linked together; the overall structure diagram of ARM and CAN bus connection is shown in Figure 4. As a rule of thumb, adopting shielded twisted-pair cable can further reduce the interference factors of the node; there is no need for shield of the cable to be grounded.

4. The Software Design of System.

4.1. **Zigbee program design.** Zigbee network system is assigned different network addresses for all terminal nodes that can only communicate with the coordinator and each other not. Several sensor nodes can be distributed evenly on building gas pipeline surface to send the collected combustible gas concentration data to CC2430 module, then store after reception, wait for data requesting, concentration gas sensor collected will be displayed on the LCD [11]. Upon receiving the data transmission request command, sensor nodes can read stored data and transmit. After completion of the collection, it can send data to the sensor nodes, which can enter a dormant state at a time. When receiving the wake instruction, it will re-enter working state to ensure the low power consumption. Zigbee routing node is the link of communication between Zigbee and CAN bus. After power-on reset, the nodes will establish new network by means of terminal nodes joining the network; after completion of joining the network, nodes can read collected data from the sensors, send data to the coordinator and routing nodes, check for analysis [3]. Then through CC2430 module it can be sent to the ARM of the CAN module and finally through CAN bus to PC. Data acquisition and transmission flow chart of sensor terminal node is shown in Figure 5.

4.2. **The design of CAN communication program.** The CAN communication module is responsible for receiving instruction of upper machine and uploading data after

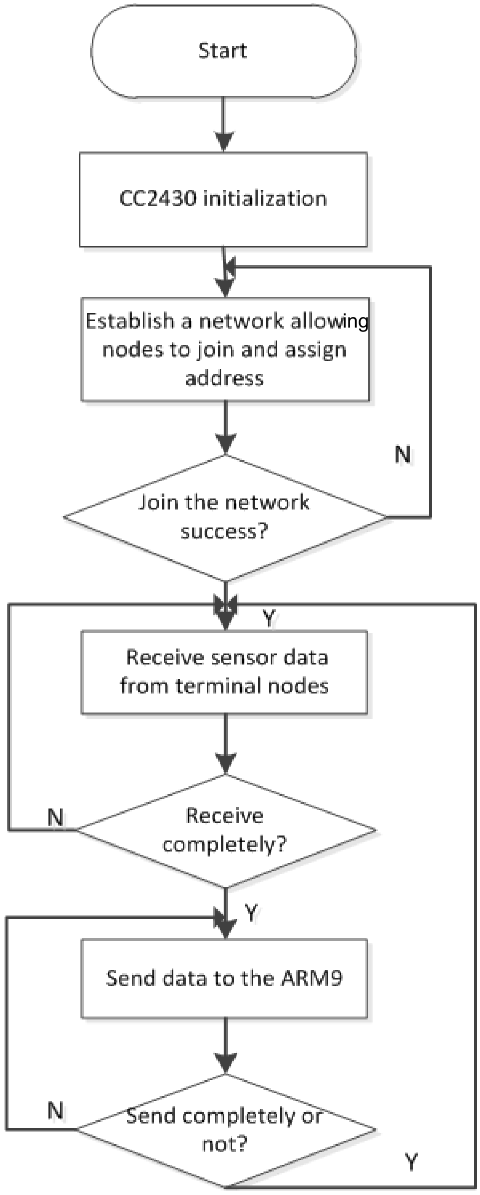

Figure 5. Program flow diagram of data transmission of routing node

receiving terminal data. CAN communication process includes: system reset, ARM microprocessor initialization; CAN controller initialization, testing CAN bus to work properly; send subroutine, take out data stored in the data storage area; regard the host ID address as the header data, and send to buffer controller, start MCP2510 CAN controller to send; the controller put received data into the receive buffer, receive routine can read the buffer data stored in the data storage area. The work flow chart is shown in Figure 6.

5. **Experiment and Analysis.** In order to further verify the precision of the system and make sure the result has stronger persuasion, we specially measure the affection of wall obstructions and the distance of communication to the two different systems. It shows that attenuation of the detection quality changes in different communication distance. It shows that system based on Zigbee and CAN bus is more adaptable to building than system based on Zigbee. While we choose two ten layer large residential building near the school, one hundred leak monitoring nodes are set on gas pipeline interface of each layer in each building, difference of the two buildings is that we add spare nodes for Zigbee coordinator nodes and routing nodes for new system, the old system based on CAN bus and Zigbee not. Months later, we choose a certain amount of

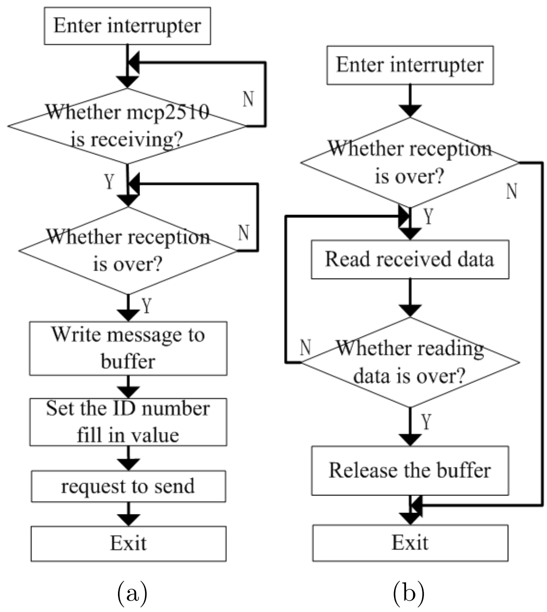

FIGURE 6. Program flow diagram of CAN data communication

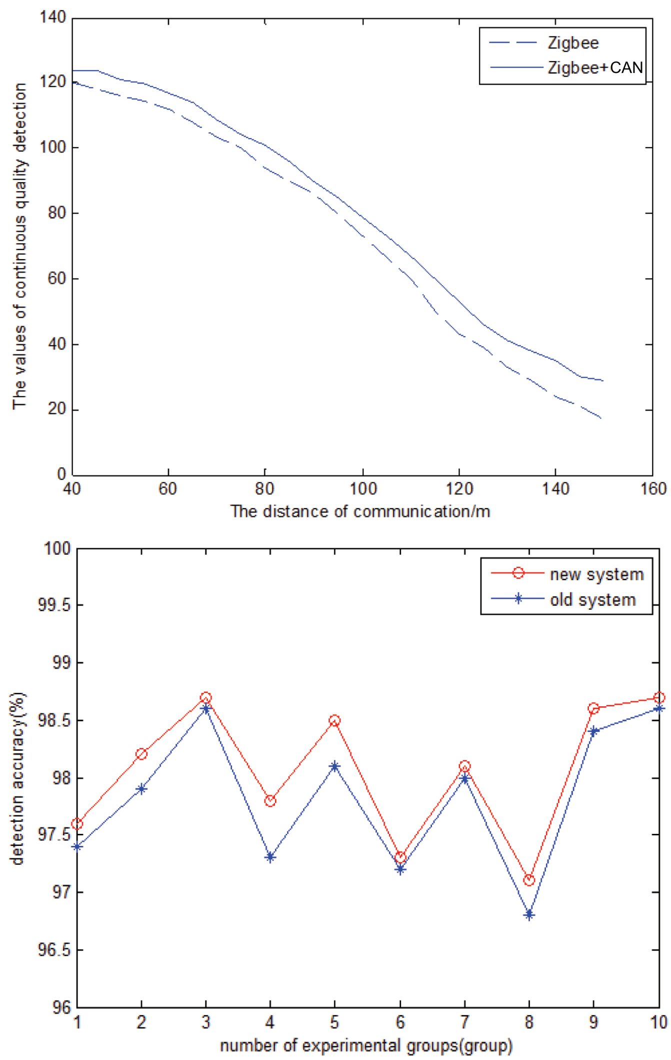

FIGURE 7. The statistical figure of precision testing

nodes to verify the accuracy. Based on statistical analysis of multi-group data, we have drawn the precision test statistics line chart shown in Figure 7, showing that new system runs stably and measurement's average accuracy of the concentration of combustible gas is above 97% better than old system. Considering that strength of signal is affected by wall obstructions, communication distance and communication rate and so many factors in the practical application process, the precision of system on the leakage monitoring and gas leakage detection can better satisfy the requirements of the intelligence community building security monitoring.

6. **Conclusion.** This paper puts forward a kind of combustible gas leakage monitoring system of building based on CAN bus and Zigbee technology and gives detailed architecture scheme of system. Although the old system can have certain extent anti-influence, the wall obstacle will affect the data communication and the quality of system after a long time. Spare node added for Zigbee backbone nodes can improve the working time and better ensure the accuracy and reliability of system, also have great application and popularization value. In the later research we can further upgrade system by adding new terminal nodes to collect other environmental parameters such as temperature, humidity, and adding the network interface module to realize the compatibility with other network and data transmission.

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