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Research on Bed Call System Based on AT89C52

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Abstract: How to realize intelligent and fast bed calls has been a key concern of hospitals. The traditional wired bed call system is not only costly but also less efficient. In this paper, research on bed call systems based on AT89C52 microcontroller is carried out. The nurse-side host (AT89C52) and the bedside slave (AT89C52) communicate over long distances using wireless communication technology. The system transmits signals, including Liquid Crystal Display (LCD), voice announcements, and beeping alarms, to indicate the bed number requiring assistance. This allows the nurse to respond promptly. The system supports real-time updates, where calls and processing occur independently, ensuring efficiency. It is not only cost-effective but also enables a rapid and intelligent call-and-response process.

Keywords: Bed call system; AT89C52; Wireless communication technology; Real-time update; Call and processing

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1. Introduction

With the development of society, the intelligent era is gradually entering people's lives, and fast and convenient treatment services are the common expectation of patients [1]. The traditional bed call system consists of digital circuits, and the host and the slave are connected by wires but the wiring is very troublesome [2]. It takes up a lot of space, narrow range of use, and is not only slow but also high cost, so the patient cannot get effective treatment quickly [3]. Therefore, how to realize fast and intelligent bed calls has become a key concern of hospitals [4]. In recent years, China has made remarkable achievements in the field of wireless technology and realized many major technological breakthroughs [5].

AT89C51 is a microprocessor control chip, which is of low-voltage, high-performance Complementary Metal-Oxide-Semiconductor (CMOS) 8-bit microprocessor with 4 K bytes of Flash memory, and not only has a very high degree of integration, but also can fully utilize the input/output (I/O) ports of the microcontroller, and its energy consumption is relatively low [6,7]. In this paper, an intelligent bedside call system is designed using AT89C52 as a microcontroller chip and wireless communication technology for long-distance signal transmission [8]. The slave at the bed end sends a call signal to the host at the nurse end through the GH_xUART serial wireless transmitting module, it generates a voice announcement, a buzzer alarm, and displays the need for help bed number on the Organic Light-Emitting Diode (OLED) LCD [9]. The host side then sends processing instructions to the slave for immediate processing [10]. This system enables patients and nurses to realize zero-distance communication, which is more convenient and faster and can improve the quality of hospital services and enhance the social competitiveness of hospitals [11].

2. System design ideas

Firstly, the patient of the slave machine at the bed presses the key, and the corresponding call indicator of the patient's bed lights up. Then, the information of the pressed button of the slave machine is transmitted to the host of the nurse station through the wireless serial port, the English character "Bed Call" is displayed on the first line of the host's OLED screen, and the corresponding bed number is displayed on the second line. When there is more than one bed call, the first line of the host's OLED screen displays the "Bed Call," and the second line displays the corresponding bed number. At the same time, the buzzer alarm is issued, the alarm light is on, and the voice broadcasts that the patient needs help. Finally, at the nurse station, the host display coordinates the assignment of nurses to provide service and treatment for the corresponding beds. If there are multiple bed calls, the host processes them sequentially using the processing key KEY0. Each time KEY0 is pressed, the system processes the next call in order, extinguishing the corresponding bed number on the OLED LCD screen and turning off the associated indicator light. When all calls have been processed, the alarm stops, and the Light-Emitting Diode (LED) screen displays "Bed Call" on the first line only. The overall design of the system is illustrated in **Figure 1**.

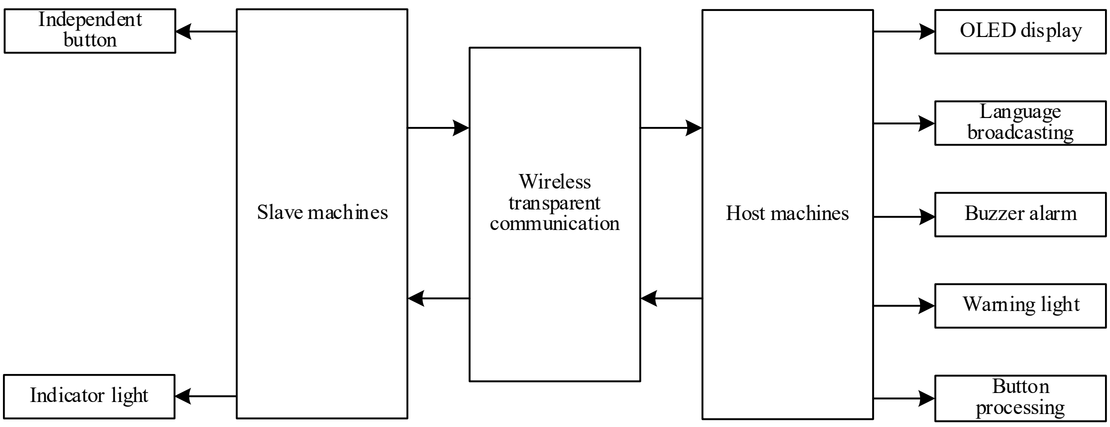

Figure 1. Overall system design

3. System hardware design

The hardware design mainly includes STC89C52 minimum system module, DFPlayer Mini voice broadcasting, OLED0.96 LCD module, GH_xUART serial wireless transmitting module, buzzer module, power supply module, and key module.

The design requires two AT89C52 chips (master and slave), whose minimum systems and their pins (shown in **Figure 2 (a, b)**), 4 K bytes of Flash memory, and 256 bytes of on-chip data memory [12]. The minimum system of the AT89C52 microcontroller consists of 32 general-purpose ports, a reset port for external reset circuitry, two crystal ports for external crystal circuitry, a power supply circuit, and a 5 V power supply for its work [13].

The design uses a 12 V input voltage, with 5 V as the standard operating voltage for the AT89C52 chip and 3.3

V to 5.5 V as the operating range for other modules. To minimize the use of additional regulator chips and reduce costs, 5 V is standardized as the uniform voltage for the system. To step down 12 V to 5 V, a KIA7805 voltage regulator chip is employed. The schematic diagram is shown in **Figure 2(c)**.

The GH_xUART Serial Wireless Transmission Module is a module that allows simultaneous data transmission and reception, with no interference between the two processes. The module sends data to the target module and automatically switches to the receiving state once the transmission is complete [14]. Upon power-up, the LED flashes once to indicate the module has started successfully. During data reception, the LED blinks once, and it also blinks to confirm successful transmission. The minimum interval for sending data is 40 ms. The module features a simple design, is not easily affected by physical factors, and has a compact size with a straightforward circuit design. It operates on a voltage range of 3.3 V to 5.5 V, but can be directly powered by a 5 V supply for simplicity. The pins of the wireless transmission module can be connected directly to the Microcontroller Unit (MCU), as shown in the pin interface diagram in **Figure 2(d)**.

The DFPlayer Mini voice broadcasting module requires minimal peripheral circuitry and can be directly controlled via a serial port. It operates on a 5 V power supply and offers relative independence. However, due to its low audio output, an external audio amplifier is needed for adequate sound amplification. The module requires only a speaker and a power supply to function. Its pin interface is shown in **Figure 2(e)**.

The buzzer module is designed to meet the alarm requirements of the system. When a patient issues a help signal, the host generates an alarm. Through the program, the buzzer can be controlled to alert the nurse. The pin interface for the buzzer module is shown in **Figure 2(f)**.

The Liquid Crystal Display (LCD) module is essential for displaying patient information. At the nurse station, the LCD screen shows the patient's call, enabling more accurate and efficient service. This module is critical for improving service efficiency. The OLED 0.96 display is an organic light-emitting diode with high resolution (128 × 64 pixels) and ultra-low power consumption (0.06 W). The circuit construction is simple, and it can be directly connected to the microcontroller, powered by an external 5 V supply. Its pin interface is shown in **Figure 2(g)**.

Each key on the slave module is equipped with an indicator. When a key is pressed, the call is successful, the LED indicator turns on, and the host's alarm light is activated. When the LED indicator turns off, the host has pressed the processing key, indicating that the patient is being served or treated. The schematic diagram is shown in **Figure 2(h)**.

In this system, the key module consists of eight keys for the slave module and one processing key for the host. The eight keys on the slave represent the eight beds, and the processing key on the host is used to manage the beds, signifying service and treatment. This setup enables human-computer interaction. The schematic diagram for the key module is shown in **Figure 2(i)**.

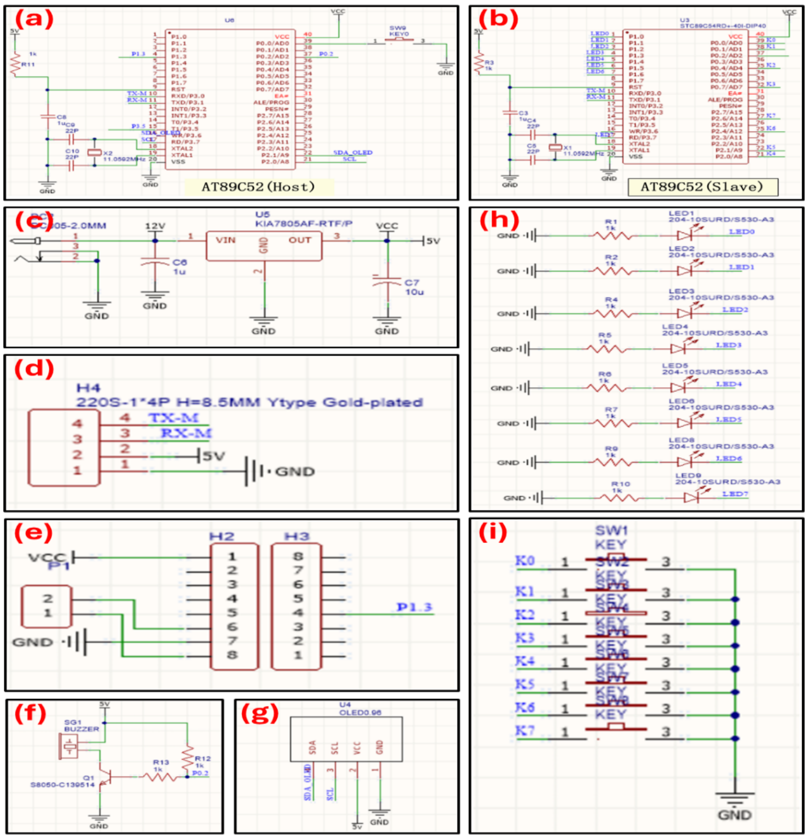

Figure 2. Schematic diagrams of each module: (a,b) master-slave AT89C52 minimum system module, (c) power supply module, (d) GH_xUART serial wireless transmitting module, (e) DFPlayer Mini voice announcing module, (f) buzzer module, (g) OLED liquid crystal display module, (h) LED display light module, (i) key module

4. System software design

4.1. Host program design

First, when the host is powered on, the program begins reading, and the serial port is initialized. The baud rate is set to match the slave, and an initial value is assigned. All interrupts are enabled. The OLED display program is initialized, and continuous updates are performed. The voice module is also initialized, awaiting a response from the slave when a key is pressed.

The host then receives data from the slave through serial communication. If no key is pressed on the slave, the host display functions normally. If a key is pressed on the slave, the OLED screen displays the corresponding bed number of the pressed key, and the buzzer and voice alarm respond immediately [15].

Finally, the host continuously monitors the KEY0 for processing. When KEY0 is pressed, the host sends data to the slave through the serial port, turning off the corresponding key light and indicating that the treatment and service for the respective bed have been provided [16]. The design diagram is shown in **Figure 3**.

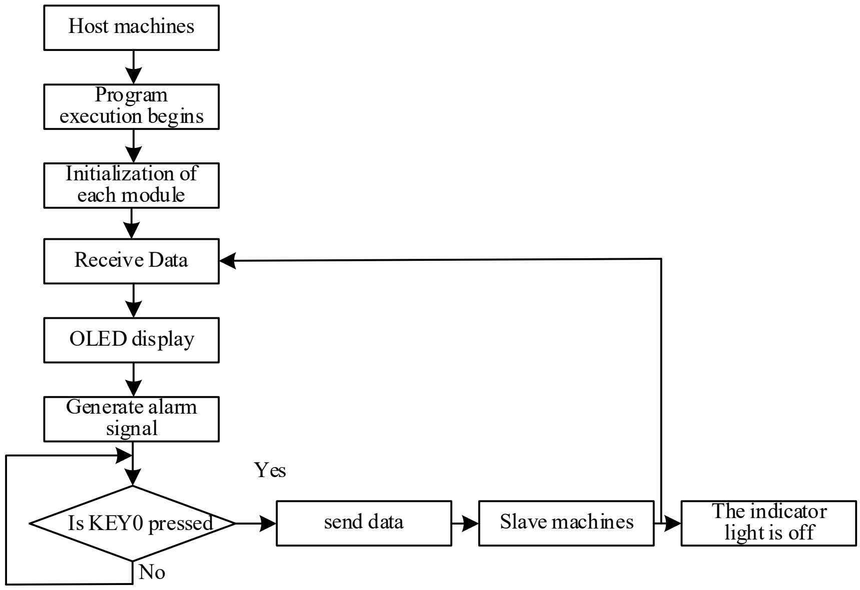

Figure 3. Host program design diagram

4.2. Slave program design

First, when the slave is powered on, the program begins reading, and the serial port is initialized. The baud rate is set to match the host, and an initial value is assigned. All interrupts are enabled. Next, the key status is analyzed. If no keys are pressed, the program continues to check the status of the eight keys. If a key is pressed, the corresponding bed's alarm will be triggered, and the bed's indicator light will turn on, signaling a call. If no key is pressed, the process repeats, continuously checking the status of the eight keys. Finally, the key status is transmitted to the host via serial communication, requesting service or a call. The slave will always wait to receive information from the host. The design diagram is shown in **Figure 4**.

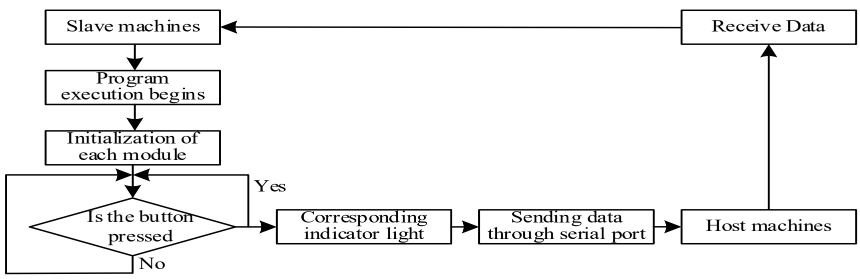

Figure 4. Slave program design diagram

5. System design results

According to the design idea of the bed call system, the specific hardware circuit diagram was constructed and the functional programs were embedded in the master and slave machines to realize the expected design goals.

5.1. No bed call

The master and the slave are powered on at the same time, and the program is downloaded on the master and the slave through the downloader. When there is no bed call from the slave, the OLED of the host only shows "bed call," which indicates that there is no bed call, and at the same time, there is no alarm. The physical debugging diagram is shown in **Figure 5**.

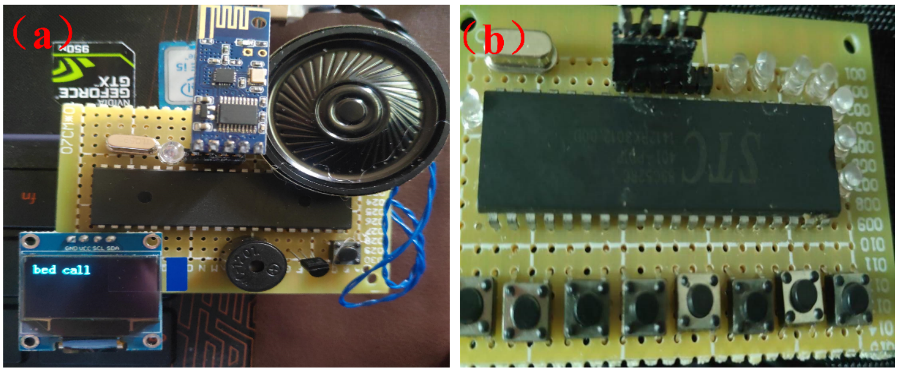

Figure 5. (a) Physical diagram of the master and (b) physical diagram of the slaves

5.2. Only one patient bed calling

When the button for slave No. 4 bed is pressed, it indicates that a patient in bed No. 4 has called for help. The corresponding bed indicator light will turn on, confirming that the alarm has been triggered. Through serial communication, the call for help is sent to the host computer, which will display "Bed Call" on the first line of the OLED screen, and the corresponding bed number on the second line. At the same time, the system triggers an alarm: the buzzer sounds, the alarm light turns on, and a voice prompt announces, "A patient needs help." The physical debugging diagram is shown in **Figure 6 (a, b)**.

After the nurse presses the processing key KEY0 on the host, the host will send the processed information to the slave via serial communication. The host's alarm is canceled, and the slave's indicator light turns off, signaling that the nurse should proceed with service and treatment for the patient. The physical debugging diagram is shown in **Figure 6 (c, d)**.

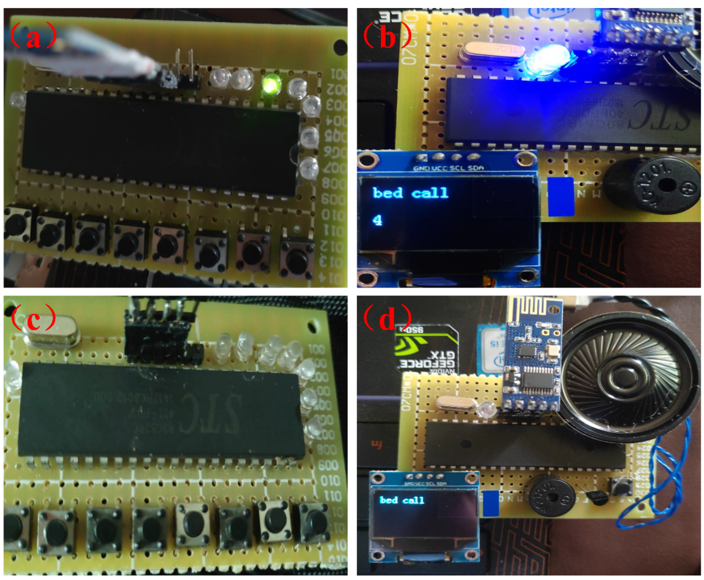

Figure 6. When only one bed is calling: (a) Slave bed No. 4 is calling, (b) the master displays bed No. 4, (d) the slave is extinguished, (d) the master presses the processing key and the bed No. 4 display disappears

5.3. Multiple beds call

When multiple bed calls are made, such as pressing the keys for beds 4, 5, 6, 7, and 3 in sequence, the indicator lights for beds 4, 5, 6, 7, and 3 will turn on. The host receives the signal from the slave and displays "Bed Call" on the first line of the OLED screen, while the corresponding bed numbers (4, 5, 6, 7, and 3) are shown on the second line in the order of key presses. Simultaneously, an alarm is triggered: the buzzer sounds, the alarm light turns on, and the voice prompt announces, "A patient needs help." The physical debugging diagram is shown in **Figure 7 (a, b)**.

Next, the nurse presses the processing key KEY0 on the host. Each time the key is pressed, the bed calls are processed in order. For example, bed 4 will be processed and treated, its indicator light will turn off, and the OLED screen will continue to display the calls for beds 5, 6, 7, and 3. The physical debugging diagram for this step is shown in **Figure 7 (c, d)**.

The system is updated in real time, allowing the processing and calling functions to operate simultaneously without conflict. Calls can be made while processing and the logic remains intact. If, while processing bed 4, the key for bed 8 is pressed, the bed 8 indicator light will turn on, and the OLED screen will update to display "Bed Call" on the first line, with the bed numbers 5, 6, 7, 3, and 8 on the second line, in the order of the key presses. Simultaneously, the bed 4 indicator light will turn off. The physical debugging diagram is shown in **Figure 7 (c, d)**.

Finally, when the bed 4 call is processed, its indicator light will go off, as shown in the physical debugging diagram in **Figure 7 (e, f)**.

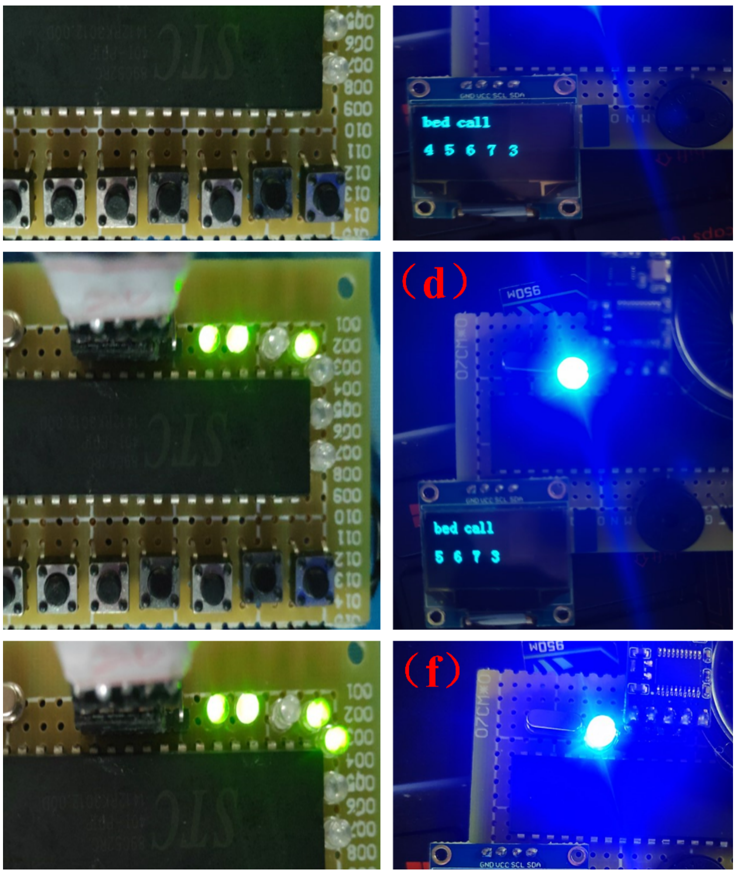

Figure 7. When multiple beds are called: (a) bed numbers 4, 5, 6, 7, and 3 are called sequentially, the indicator light of the corresponding bed is on, (b) the bed number is displayed sequentially on the OLED, (c) the light is extinguished on bed 4, (d) the host computer presses the processing key and the display of bed 4 disappears, (e) while processing is being done, bed 8 is called, and the indicator light is on, and (f) bed 8 is sequentially on the OLED

The alarm will only stop once all processing is complete, and the OLED display will return to showing no bed calls. The alarm cannot be stopped as long as there is an active call. Through debugging, the functionality of this design has been essentially fully realized.

6. Conclusion

In this work, the AT89C52 microcontroller is used as a compact control chip, combined with wireless communication technology to transmit information from the slave side to the host side. The system is equipped with an alarm module that generates real-time alarms and voice announcements during a call. When a patient makes a call, the slave sends a signal to the host, which then receives and processes the signal. If multiple patients make calls, the host will handle them in the order received from the slave. The system updates in real-time, allowing calls and processing to occur simultaneously without interfering with each other, enabling direct communication between patients and nurses. The system is convenient, fast, and low-cost. It is fully functional and can be implemented in hospitals to improve the quality of healthcare services.

Disclosure statement

The authors declare no conflict of interest.

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