Automatic shutdown system for unmanned air-conditioned room

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Abstract. With the development of society and economy, air conditioning has also become an integral part of our lives and it allows us to enjoy warmth in winter and cool in summer. However, there is also a phenomenon that people do not turn off the air conditioner due to personal savings awareness or anxious to go out. This paper intends to design a system where the air-conditioning room is automatically turned off if there is no one in half an hour. Pyroelectric sensor is used to detect the presence of people in the room, and wind speed sensor detects whether the air conditioner is on. If the room is empty and the air conditioner is not turned off for more than half an hour, the system is used to automatically turn off the air conditioner. It can reduce some waste of resources, it can also reduce certain environmental pollution, and realize economic and social benefits.

1. Introduction
In our daily life, air conditioners play a very important role in creating a comfortable life. However, the electricity cost of air conditioning is also the higher of many appliances. Therefore, there is no one in the room but the air conditioner is turned on, which will waste electricity costs, and bring some energy waste and environmental pollution. For example, there is a hanging air conditioner, and its cooling power is 795W and heating power is 1330W. If someone goes out at 8 am without turning off the air conditioner and returns at 5 pm, then it wastes about 7KW of electricity in summer and about 12KW of electricity in winter, this is not only a waste of money, but also a waste of energy.

Therefore, this paper intends to design a system where the air-conditioning room is automatically turned off if there is no one in half an hour. When no one is in the room and the air conditioner is not turned off, the system detects by sensors and counts the chip to realize the automatic shutdown of the air conditioner if no one comes back within half an hour, thereby reducing waste.

2. System components
The automatic shutdown system for unmanned air-conditioned room is mainly composed of 4 parts: pyroelectric sensor detection, wind speed sensor detection, timing system, and signal control system.

- pyroelectric sensor detects whether there is someone in the room
- The wind speed sensor detects whether the air conditioner is “off”
- The timer is turned on when the room is empty and the air conditioner is not turned off
- when the room is empty, the air conditioner is automatically turned off for more than half an hour
2.1. Pyroelectric sensor detection section

Pyroelectric sensor[1-6], also known as human body infrared sensor, its principle is to convert the released charge into voltage output through the amplifier: Piezoelectric ceramic-based dielectrics can remain polarized after electrodeposition (spontaneous polarization). Spontaneous polarization decreases with increasing temperature. Therefore, when this material is subjected to infrared radiation, the increase in temperature causes the surface charge to decrease, which is equivalent to releasing the charge, which is converted into a voltage output by an amplifier.

The pyroelectric sensor consists of a filter, a pyroelectric detection element, and a preamplifier. The filter can selectively pass infrared radiation of a specific wavelength to the pyroelectric detection element. The infrared wavelength of the human body is 9-10μm, the bandpass range of the filter is 7-10μm, and the wavelength sensitivity range of the detection element is 0.2-20μm. So as to detect human infrared radiation. When someone enters the sensing range, it outputs a high level, and when someone leaves the sensing range, it automatically delays closing the high level and outputs a low level.

![Figure 1. Schematic diagram of pyroelectric sensor.](image)

In Figure 1, VDD represents a positive power supply, OUT is a high or low level output, GND is a low level, H represents a repeatable trigger port, and L represents a non-repetitive trigger port. This paper chooses the repeatable trigger mode (H), that is, after the induction output is high, if someone moves within its induction range during the delay time period, its output will remain high until the person leaves and becomes low.

2.2. Wind speed sensor detection section

The wind speed sensor[7] uses a three-cup structure, which can rotate under the action of wind, which drives a small DC generator to generate electricity, converts the wind speed into voltage, and the wind speed is close to a proportional relationship with the voltage. Therefore, we can set a comparator link according to the wind speed of the air conditioner. When the air speed of the air conditioner is greater than the rated voltage, the comparator outputs a high level, and this signal can be transmitted to a valid high level pin of the 74LS161 chip described later.

2.3. Timing section

The timing section uses 555 chip[8-12] and 74LS161 chip[13-16] for timing. In order to avoid misjudgment caused by the user's short-term leaving, the timing range is set to 30 minutes, and the single chip 74LS161 counts to 16 pulses, which simplifies the system and this section sets the clock pulse part to transmit pulses every 2 minutes. Figure 2 is a clock pulse circuit diagram. This part consists of a 555 chip and 6 4.12M resistors, 0.018μF and 4.7μF capacitors to form a multivibrator. The calculation of the pulse period of the circuit output is as follows:
Figure 2. The clock circuit section

\[ t = R' C_1 \ln 2 + (R^2 + R^2) C_2 \ln 2 = (2R^4 + R^2) \times C_2 \ln 2 = 4.12 \times 3 \times 3 \times 10^6 \times 4.7 \times 10^3 \times \ln 2 \approx 120.8s \]  

\[ R' = R_1 + R_2 + R_3 \]  

\[ R^2 = R_4 + R_5 + R_6 \]  

The result is approximately 120s, that is, 2min, so this pulse circuit can be applied to the system, where the 3 pin of the 555 chip is the output terminal and is connected to the CLK pin of the 74LS161 in Figure 3.

Figure 3 is a circuit diagram of the timing part. When the pyroelectric sensor detects that there is no one in the environment, it outputs a low level. The OUT of the pyroelectric sensor is connected to the \( LOAD \) of the 74LS161. When no one is present, OUT outputs a low level and \( LOAD \) is valid, and 74LS161 starts timing. When the time reaches 30 minutes, there are 16 pulses in total \( Q_3Q_2Q_1Q_0 = 1111 \). The A port outputs a high level.

2.4. Signal control section

Similar to shutdown function in air conditioner remote control[17-18], the air conditioner will automatically turn off when it receives the infrared signal from the remote control. Therefore, when the
air conditioner needs to be automatically turned off, the electrical signal from the timer can be converted into the same infrared signal as the remote control. When the infrared signal is received by the air conditioner, it is similar to receiving the "off" signal from the remote control to turn it off.

3. Overall flowchart

![Flow chart of Automatic shutdown system for unmanned air-conditioned room.](image)

The entire system starts with a pyroelectric sensor. If someone is detected, it continues to detect until no one is detected in the room. At this time, if the wind speed sensor detects that the air conditioner is still blowing out, that is, the air conditioner is still on, the timer start timing; Assume that the user leaves the room in the middle. At this time, it cannot be judged that the user goes out and forgets to turn off the air conditioner. Therefore, if the time is within half an hour and someone can still be detected, then return to the original state; if no one comes back within 30 minutes, it is judged to forget to turn off the air conditioner, and the signal of the A output port in Figure 3 is converted to infrared which controls the air conditioner to turn it off.
4. Conclusion
In this paper, an automatic shutdown system for unmanned air-conditioned room is designed by using sensors and chips. This system can automatically turn off the air conditioner when there is nobody in the room for half an hour, thereby reducing energy waste and environmental pollution.

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References
[1] Liu, Shuai., Zhang, Zhiyong., Zhou, Ying., Liu, Huiheng. (2019) Device for Automatic Door Closing and Locking Based on Single Chip Microcomputer and Human Body Infrared Sensor. J. Physics Bulletin, (11): 107-108.
[2] Tan, Fukui., He, Houfeng., Yao, Ping. (2019) Design and implementation of classroom lighting switch control system. J. Journal of Xingyi Teachers College for Nationalities, (05): 120-124.
[3] Ma, Yixu., Zhang, Yihua., Zhou, You., Zhao, Yufei., He, Zhipu., Chen, Xingwen. (2019) Design of Intelligent Monitoring System for Home Environment Safety. J. Shanxi Electronic Technology, (05): 35-37.
[4] Han, Qin., Zha Xi, Dunzhu., Shang, Yongshang. (2019) Design of intelligent corridor lighting control system based on single-chip microcomputer. J. Hubei Agricultural Mechanization, (14): 117-118.
[5] Luo, Weifang. (2019) Intelligent classroom electricity control system based on pyroelectric. J. Electronic Components & Information Technology, 3 (09): 68-70.
[6] Gao, Meizhen., Hong, Jiaping. (2019) Design of indoor intelligent lighting system based on single chip microcomputer. J. Journal of Hubei Normal University (Natural Science Edition), 39 (03): 96-100.
[7] Liu, Haifeng., He, Ran., Zheng, Teng., Tian, Yujie., Yang, Meng. (2019) Design of intelligent controllable switch windows based on multiple sensors. J. Application of Automation, (06): 153-154.
[8] Zhou, Daolong., Hu, Ben., Xiang, Yanan. (2020) Design of small and medium power wireless charging circuit based on 555 timer. J. Electronics World, (04): 130-131.
[9] Guo, Qing., Wu, Jinfei. (2018) Design of acousto-optic three-control lighting circuit based on 555 timer. J. DiGital Technology and Application, 36 (11): 135-136.
[10] Hu, Kai. (2017) Selection of 555 timer components. J. Electronic World, (09): 75 + 77.
[11] Zang, Danhong. (2017) Analysis of typical application circuit based on 555 timer. J. Electronics World, (06): 66-67.
[12] Gao, Zhidong., Bai, Zesheng. (2017) Design of a Gas Sensing Alarm Based on NE555 Timer. J. Electronic Design Engineering, 25 (02): 114-116.
[13] Ma, Ding. (2019) Discrimination and Analysis of Arbitrary Binary Counter with 74LS161. J. Information System Engineering, (07): 151 + 153.
[14] Yu, Wenqian. (2015) Simple Stopwatch Design Based on 74LS161. J. Science and Technology Outlook, 25 (15): 45-46.
[15] Zhao, Jing., Ge, Bin., Song, Xiaoyong. (2000) Application of CT54 / 74LS 161 chip. J. Journal of Dalian University, (04): 35-41.
[16] Ma, Jingmin. (2011) Multisim simulation of integrated counter 74LS161. J. Modern Electronic Technology, 34 (03): 166-167 + 170.
[17] Wu, Qiong. (2018) Design of infrared remote control for air conditioner based on single chip microcomputer. J. Electronics World, (16): 157 + 159.
[18] Liu, Wenjing. (2016) Design of infrared remote control based on MCU 430 J. Industry and Science Forum, 15 (01): 61-62.