Analysis on the Circuit Design of Fire Alarm

Shaoxuan Kang

1Beijing No.80 High School, Beijing 100000, China
*Corresponding author’s e-mail: angela@cas-harbour.org

Abstract. In the large airtight cinema and school, there are a lot of people in public places, thus the fire safety problems always attach great importance to everyone. The appearance of fire alarms can definitely help audience who are immersed in watching movies and students who are listening to the teachers carefully to remind them of a fire, so they can leave the scene in time and reduce property losses. This paper will take the fire alarm circuit as an example to realize the combined logic circuit by using various integrated circuits of different scales. This design is very flexible, effective and operable. In the actual process of use, the appropriate scheme can be selected according to the design requirements and the resource of the device. The object of study is a logic circuit, which is composed of an integration gate or a medium scale synthesizer. The experimental methods include practical ideas, application of Boolean logic principles, and sampling of data from others through the Internet, which are mentioned at the end of the paper. The conclusion is that abstract logic can be used step by step to design a practical and effective circuit diagram.

1. Introduction

After taking the online course of logic circuit, the author was very curious about the principle of Boolean logic, so close attention to the news was paid in real life. When the author knew that a recent fire had temporarily shut down a movie theater that the author had been to, the author began to think of ways to reduce the damage caused by a fire alarm, which is a common tool in public places that could alert people to impending disaster. Therefore, the author began to think about the circuit structure of fire alarm, the working principle and the space for improvement in design [1]. Some simple circuit templates of fire alarm based on the information of fire alarm on the Internet were constructed, with some of its existing circuit design adding the author’s own understanding, in order to further understand its structure and generate some ideas for its future transformation. The study not only lets the author deepen the understanding of logic circuit, but also further sparks his interest in the application of it. It is hoped that one day in the future a better fire alarm can be designed. For instance, earthquake alarm security is closely linked with people, and small instruments could help reduce the loss for creating a more safe and stable living environment.

An ideal, nearly perfect fire alarm should be able to quickly perceive or predict the danger and make effective feedback very quickly. In order to ensure the two requirements of "fast" and "sensitive", a very fast information transmission circuit is needed, which is the reason that the author chooses the combinatorial logic circuit as my first choice [2]. The characteristic of combinatorial logic circuits is that the output at any time depends only on the input at that time, independent of the original state of the circuit. This feature makes it have an efficient timeliness, which can be in a variety of emergency occasions (especially in the case of sudden disaster) in the early warning, reduce the loss of society. At present, the design structures of combinatorial logic circuits are still needed to be improved. Most combinatorial logic circuits used in reality are very complex, and a large part of them need to be
simplified. In addition, "crisis" sensors, for example, smoke sensors and temperature sensors in a fire, need a lot of technological progress to ensure that they do not fail or "lie". This may require advances in fields other than electricity, such as chemistry, heat science and materials science.

2. Analysis of the Circuit
Fires are often accompanied by the spread of flames, dense smoke and the threat of high temperature. The characteristics of these three factors can be detected by flame sensor, smoke sensor and temperature sensor respectively. At the same time, in order to prevent the false alarm of the alarm from affecting people's daily life, only when two or more than two sensors detect abnormal situation, the circuit will produce an alarm signal [3].

Since the circuit is composed of three main sensors, the author needs to apply the combinational logic circuit to realize the normal operation of the circuit. As combinational logic circuit is mostly composed of gate circuit and medium scale integrated chip, and it is necessary to consider the specific design requirements of reality and the resource of devices. In the following experiments, these two devices will be mainly used for design.

Table 1 The “Truth table”

|   | A | B | C | D |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 1 | 0 | 0 | 0 |
| 3 | 0 | 1 | 0 | 0 |
| 4 | 0 | 0 | 1 | 0 |
| 5 | 1 | 1 | 0 | 1 |
| 6 | 1 | 0 | 1 | 1 |
| 7 | 0 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 |

Firstly, according to the abstracted 3-2-1 model (three sensors, alarm will only go off when two or more detect abnormalities), all the combinations of situations that will happen are listed. Here, A stands for flame sensor, B for smoke sensor, C for temperature sensor, and D for alarm. Among them, A, B, C are inputs and D is output. The input "1" represents detection of abnormalities and the input "0" represents no abnormalities. The output "1" represents alarm signal generation, and the output "0" represents no alarm signal generation, which are shown in the table above.

From table 1, the author can get the expression $D = AB'C + ABC' + A'BC + ABC$ [4]. And with this expression, the logical diagram corresponded to the table above can be drawn.

![Figure 1. Electrical Circuit 1](image)
3. NAND Gate

There is a method which is to use and NAND gate. In real life, NAND gate is very common, because it is cheap and fast, with strong load capacity. The following figure shows that the logic is converted into NAND gate form [5].

![Figure 2. Electrical Circuit 2](image)

Then a common decipher is needed (Y means D stated before which is the output alarm):

![Figure 3. Simple Common Decipher](image)

Next, the full one looks like the diagram below [6]:

![Figure 4. Full Common Decipher](image)

Based on the figures above, the logic diagram is realized by gate circuit and medium scale integrated device respectively. With the logic diagram, the circuit can be built according to the actual components, where A, B and C are respectively connected with flame sensor, smoke sensor and temperature sensor. Light emitting diodes and buzzers can be used as the output to detect fire, to realize sound and light alarm, and also to connect subsequent circuits according to needs, which is very practical. The effect is obvious and the output is stable and the physical diagram of the circuit is shown in the following figure.
4. Application of Combinational Logic Circuits
There are also many real-world applications of combinational logic circuits. The following pumping motor is one typical example of it.

When there is no water in the pool, the two detection heads of A and B are not connected with the O probe, then the input of A and B are at A low level. At this time, no matter what the original state of the control circuit is, the output is at A high level to control the SCR conduction, so that the motor is connected to the power supply for pumping [7]. When the water in the pool is immersed in probe A but not probe B, because the water contains a small amount of electrolyte, it will conduct electricity, so A and O are connected, A is the high level, B is the low level. At this time, the control circuit will analyze whether the pump is in the "pumping" state or in the "non-pumping" state. If it is "pumping" state, then the control circuit output high level, continue pumping; If it is in the "non-pumping" state, then output low level, no pumping. When the three probes A, B and O in the pool are immersed in water, the probes A and B are connected with the probes O, A and B are high level. At this time, no matter what the original state of the control circuit is, the output is low level, so that the SCR stops and the control motor stops pumping.

5. Conclusion
Combinational logic circuits can be designed by implementation of gate circuits and medium-scale integrated chips. Both of them require logical abstraction first and logical abstraction of column true value table. After that, writing logical expression from truth table, and drawing logical graph from logical expression should be followed. What needs to be distinguished is that, when using gate circuit design, the logic formula generally needs to be simplified, and the logic diagram is drawn from the simplified results. But when using the medium-scale integration chip design, it does not need logic
formula or logic diagram. To simplify, the emphasis should be on deciding which medium scale chip should be selected, and also asking the actual question. The logical expression of the question is transformed into the response expression of the selected scale integration chip.

The ways of choosing the design methods of different types of medium scale integrated chips are also different. Comparatively, the gate circuit price is cheap and the design is flexible, which does not suffer the integrated circuit power. However, the scale integrated circuit function is more powerful and has fewer input variables which can be the advantage of it. On the contrary, it also has certain drawbacks. They have their own different advantages and disadvantages in the actual use of the need to choose the appropriate scheme according to the design requirements and device resources.

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