STUDENT ABILITY CULTIVATING OF ELECTRONIC TECHNOLOGY EXPERIMENTAL TEACHING ADAPTED TO "NEW ENGINEERING"

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ABSTRACT

To meet the cultivating requirements of the high-quality engineering and technology talents for the development of "new engineering", the electronic information major of the college vigorously carries out the reform of the electronic technology experimental teaching. The electronic technology experiment is an important basic practical course in the electronic information major, which plays an important role in the ability cultivation of the engineering practice talents. Combining with the current needs of China to vigorously develop the "new engineering" construction, this paper discusses the problems existing in the traditional electronic technology experimental courses and proposes to split the electronic technology related modules from the school-enterprise cooperation or currently popular practical topics for the experimental topic selection. This experimental topic requires students to use the virtual simulation software to simulate the experimental tasks and complete the assigned design tasks before the class, and then complete the physical circuit experiments in the offline practical courses, which can cultivate the students' design thinking, exercise the students' hands-on ability and consolidate the knowledge learned in theoretical teaching, thereby adapt to the development of the "new engineering".

KEYWORDS

Electronic Technology Experimental Teaching, "New Engineering", Student Capability Cultivating, Virtual Simulation Teaching, Independent Design Experiment.

1. INTRODUCTION

In the international environment where the concept of the innovation-driven development is becoming more and more obvious, the speed of the Fourth Industrial Revolution is growing exponentially, which has put forward the new requirements for the development of the higher engineering education and the training of the engineering science and technology talents (Hadek et al., 2019; Geng et al., 2020; Barnes et al., 2020; Ntinda1 & Ngozwana, 2021). Because the traditional engineering education may be difficult to meet the needs of the emerging economic development for the engineering and technological talents, the education department has begun to vigorously develop and explore the construction and development of the "new engineering", from "Fudan Consensus" (Ministry of Education, 2017a) to the "Tian Da Action" (Ministry of Education, 2017b), and then to the "Beijing Guide" (Ministry of Education, 2017c), pointed out the reform direction and course of the action for the higher engineering education under the new situation. Shang et al., (2019) has pointed out "five news", which mainly includes establishing the new concept of the engineering education, constructing the new structure of the disciplines, exploring the new models of the talent training, and establishing the classified development of the new system, and creating the new quality of the education and teaching (Wen, 2021). The proposal of the innovative concept of the “new engineering” has made the higher requirement for the higher engineering education and cultivation of the engineering science and technology talents, which requires the engineering majors to focus on the training the high-quality talents with the well basic scientific literacy and engineering innovation spirit, solid experimental foundation, high comprehensive experimental quality, and then can be able to engage in the basic and applied research (Shang et al., 2019; Yuan et al., 2019).

In recent years, the number of the professional talents cultivated by the colleges and universities is insufficient, and the students lack the enough technical cultivating in the training process, and the learning content is seriously decoupled from the industry. Therefore, the industries that are closely integrated with the traditional industrial technologies and develop rapidly (such as the big data, cloud computing, robotics, and so on.) are facing a large industry gap, but the current education model cannot make the students trained well to meet the engineering practice needs of the industry. The students are still lacking in their capability to handle the actual engineering projects, which is consistent with the higher engineering education that is being vigorously promoted in China. Therefore, to meet the development of the “new engineering”, the students’ innovation and entrepreneurship capability should be improved and cultivated. Note that a part work of this research has been published in Xie et al., (2022). This paper explores the student ability cultivating of the electronic technology experimental teaching adapted to the “New Engineering”, which can be listed as follows. Section 2 introduces the cultivating needs of the electronic technology experimental teaching. Teform and practice of the electronic technology experimental teaching is proposed in Section 3. Finally, a conclusion is given in Section 4.

2. Cultivating Needs of Electronic Technology Experimental Teaching

In the recent years, with the continuous expansion of the colleges and universities, the trend of the popularization of the higher education has become more and more obvious, and the training mode of the colleges and universities has gradually changed from the elite education to the mass education. At present, the development law of the emerging technologies represented by the “new engineering” and multi-disciplinary cross-integration shows that the society’s demand for the professional and technical talents is becoming more and more diversified. The electronic technology course is a compulsory course for the majors in the electronics, communication, automation, computer, intelligent science, which is a professional basic course with the wider applications and stronger practicality (Rohde et al., 2019; Kaloostian & Chhetri, 2021; Deng, 2016). To fulfil the requirement for the cultivating of the high-quality engineering talents for the development of the “new engineering”, the college electronic information majors develop the teaching reform of the electronic technology experiment, and explore the cultivation of the active learning ability and practical innovation ability of the students under the development of the “new engineering”, which can provide the support for cultivating the high-level engineering and scientific talents (Kittur, 2020; Passadelli & Klonari, 2021; Li et al., 2018). The electronic information and related engineering students usually have a strong application background whether they are studying for the further studies or employment after graduation, or they need to solve a scientific problem in the practical engineering, therefore the cultivating method has become the first choice for the engineering majors in the colleges and universities.

However, the electronic technology courses contain a large number of theoretical understanding and deduction calculations, which may be not directly related to the practical applications, and the content of the learning is relatively abstract. Although the current "flipped classroom" model combining offline and online teaching helps the students to understand the concepts (Du et al., 2020; Li et al., 2020), the students are still prone to getting caught up in the conceptual understanding and formula derivation without knowing what problems should be solved in the practical engineering. What is the problem, let alone how to solve and optimize the target task in an engineering project based on the knowledge you have learned. Some scholars have combined theory with the practice and apply the project-based teaching method as a new teaching mode in the teaching (Chen & Yang, 2019). At the same time, it is very important to focus on cultivating the students' exploratory capability and innovative thinking, which also requires the teachers to pay more attention to process the evaluation in the curriculum planning (Zhang, 2019). When formulating the overall evaluation criteria, the acceptance of the pre-class tasks is considered, and the tasks corresponding to each group member are carefully understood to ensure that each student can participate in the experiment well.

As a core practical course for the electronic information majors and some non-electronic majors, the electronic technology experiment is a course that requires the students to deeply understand the basic concepts, basic principles and basic analysis methods of the digital circuits and analog circuits in the electronic technology, and to further deepen the grasp and consolidation of the theoretical knowledge. Besides, the experiments are an important part of learning the electronic technology, which can consolidate and deepen the teaching content in the theoretical courses, improve the students' practical capability, cultivate the scientific research thinking, establish the rigorous scientific research style, and establish the complete knowledge system. It plays an important role in the follow-up courses learning, practical technical work and related academic research (Ding et al., 2013). Therefore, the integration of the practical and research activities in the learning process needs to be highlighted. Combined with the teaching characteristics of the "new engineering", the independent design part has been added based on the traditional teaching content of several project experiments, which is step by step from easy to difficult. It not only

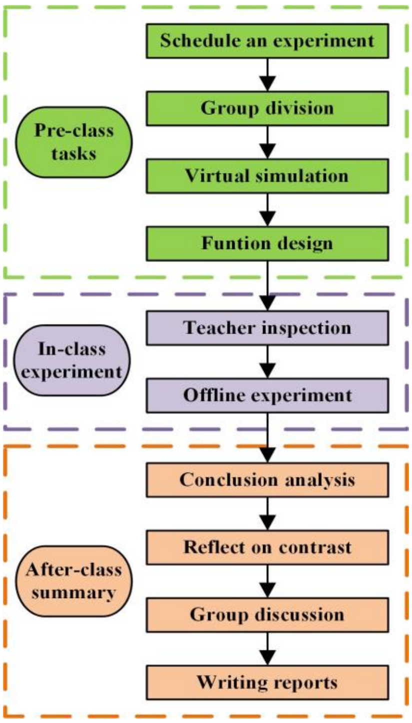
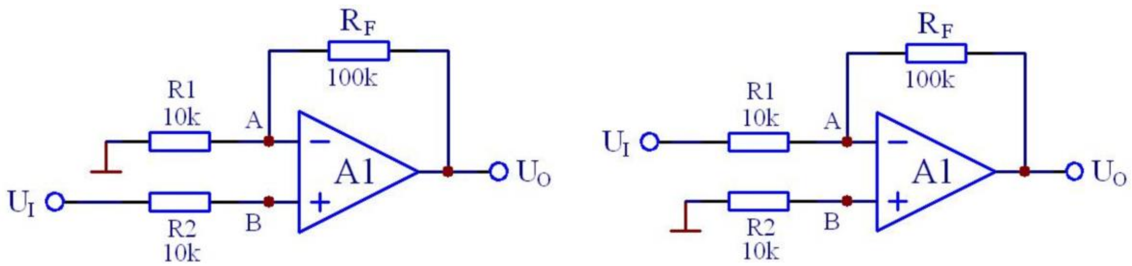


Figure 1. Experimental course arrangement

cultivates the students' capability to think independently, combines the classroom practice with the scientific research tasks to be faced later, but also promotes the students to review the knowledge and accumulate the experience in the designing practical tasks. At the same time, it can also be combined with the current relatively new scientific research competition questions to split and explain for the students (Liu et al., 2018)., and encourage the students to contact the actual scientific research tasks according to their own conditions. It is also possible to refer to the experimental course arrangement of the foreign universities. In the final assessment, not only the experimental report is collected, but also the function and performance of the designed electronic system should be investigated (Du et al., 2013). The course arrangement of the electronic technology experiment proposed in this paper is shown in Fig.1.

3. Reform and Practice of Electronic Technology Experiment Teaching

An example of the analog operation amplifier design experiments with one of the basic applications of the operational amplifier circuit has been given and discussed, which is a high-performance direct-coupled multi-stage amplifier circuit. In addition to the common addition and multiplication, it can form the different linear and nonlinear function characteristics when forming a negative feedback circuit or input with different components, and the more common analog operation circuits such as the integration, differentiation, logarithm and exponential. In the experiment, Fig.2 shows the circuit schematic diagram of the inverse proportional operation circuit and the same-phase proportional operation circuit, which are less difficult but very important. Students are required to perform the virtual simulation through the EDA software such as the Multisim in the preview stage to increase their understanding of the experimental principle and relevant knowledge points.

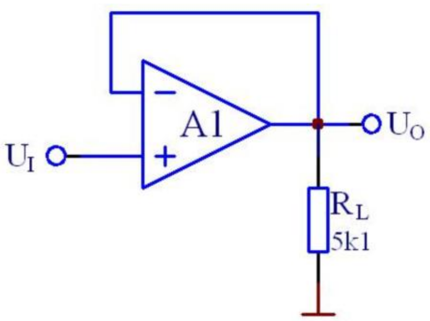


(a) Same-phase proportional operation circuit (b) Inverse proportional operation circuit

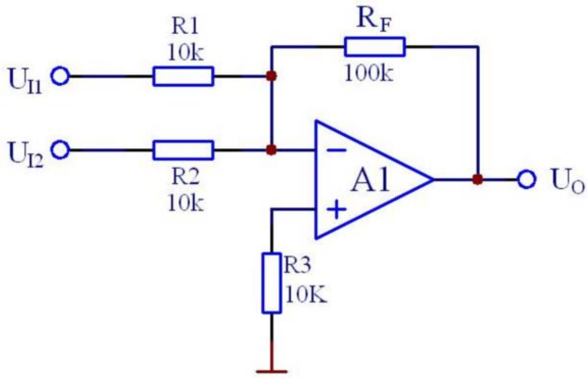
Figure 2. Virtual simulation tasks

The traditional electronic technology experimental course is more like the procedural task. The students can connect the devices according to the experimental books, and then measure the relevant instrument readings and complete the relevant analysis as required. Some students do not even understand what they are doing during the experiment, what each step is for, and what the obtained parameters represent. When writing the experimental report after class, they will carry out recall analysis of the data combined with the knowledge they have learned in the past. Some problems in the experimental process will be ignored, and the training effect required by the experimental course will not be achieved. At the same time, this kind of the course design method is easy to cause separation from the theoretical course, and there is no effective practice in the study of the theoretical course, and the theory cannot be effectively reviewed in the experimental course, so that the teaching situation does not achieve the expected effect.

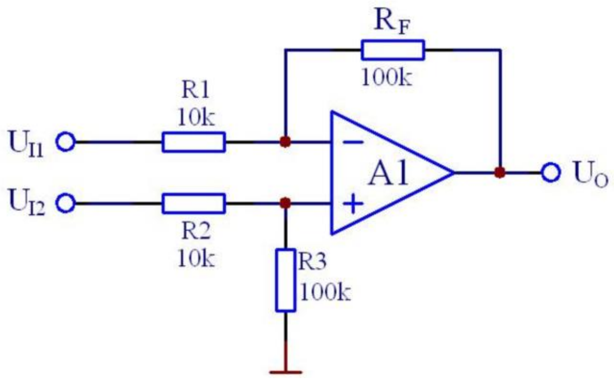
The virtual simulation software has a far-reaching influence and help on the scientific research and work of the electronic majors. Thus, in the electronic technology experimental courses, the simulation design tasks can be appropriately added as preparations for the offline experiments. It not only strengthens the students' review and understanding of the theoretical knowledge, but also enables the students to experience the relevant process of the circuit design practical work in advance, and at the same time enhances the students' awareness of the teamwork. In the arrangement of the experimental tasks, the students are required to design the difficult inverting summing amplifier circuit and voltage follower circuit according to given basic experimental schematic diagram (as shown in Fig.3(a) and Fig.3(b)), and then add the design task of the double-ended input summing circuit (as given in Fig.3(c)) in the course of the group experiment for the students. This will not only enhance the students' understanding of the knowledge but will not occupy too much time for the students due to the difficulty, and at the same time increase the students' familiarity with the EDA software, so that they can get started better in the future work environment of the scientific research. In addition, the students should be encouraged to participate more in the actual scientific research after class, and they should be encouraged to participate in the scientific research competitions and enter the laboratory to get in touch with the practical topics. The teachers can also take the initiative to combine the current relatively novel competition questions to split explanations for the students, help the students build the knowledge system framework, better understand the engineering practice, achieve the knowledge cross-integration, and broaden their scientific research horizons.



(a) Voltage follower circuit



(b) Inverting summing amplifier circuit



(c) Double-ended input summing circuit

Figure 3. Virtual simulation tasks

In addition, the topic selection model of the school-enterprise integration should be encouraged to implement. During the mid-term and final course design assessments focusing on the design tasks, instructors can find the directions from their own cooperation projects with the enterprises and formulate the design topics based on the learning capability of the students, and constantly update the test questions according to the actual situation. For example, it allows students to design a service elevator controller for a seven-story building in the practical application (Thomas, 2019). The controller consists of the logic that controls the elevator operation, a counter that determines the floor where the elevator is located at any given time, and a floor number display. For simplicity, there is only one floor call and one floor request for each elevator cycle. A cycle occurs when the elevator is called to a given floor to pick up a passenger and the passenger is delivered to a requested floor, the elevator sequence for one cycle can be shown in Fig.4 (Thomas, 2019).

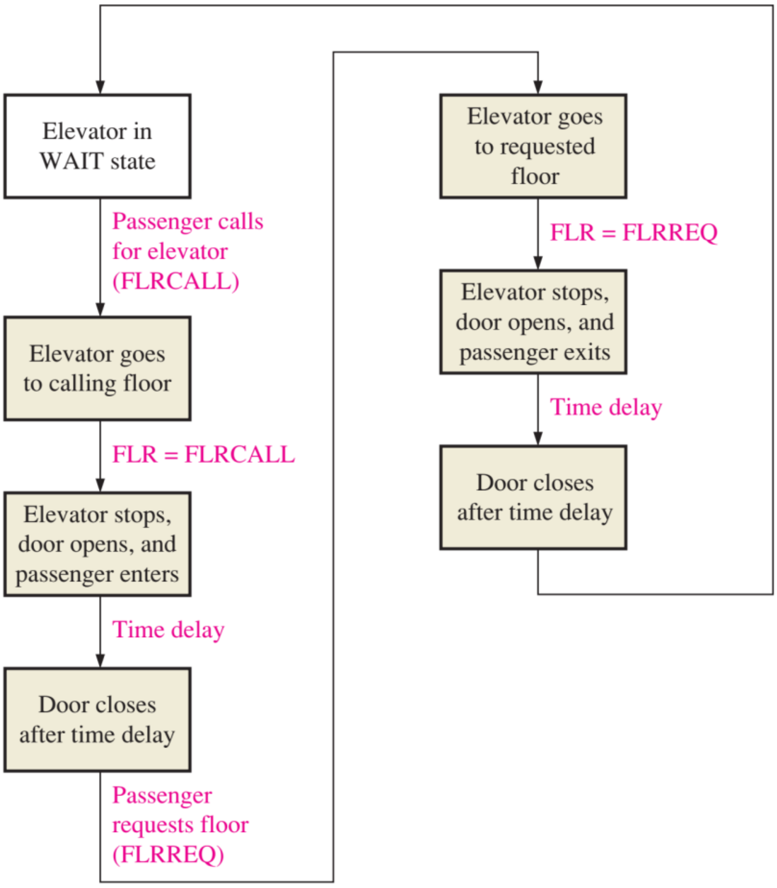


Figure 4. One cycle of the elevator operation (Thomas, 2019).

Five states in the elevator control sequence are WAIT, DOWN, UP, STOP/OPEN, and CLOSE. In the WAIT state, the elevator is waiting on the last floor serviced for an external call button (FLRCALL) on any floor to be pressed. When there is a call for the elevator from any floor, the appropriate command (UP or DOWN) is issued. When the elevator arrives and stops at the calling floor, the door opens; the person enters and presses a number to request a destination floor. If the number of the requested floor is less than the number of the current floor, the elevator goes into the DOWN mode. If the number of the requested floor is greater than the number of the current floor, the elevator goes into the UP mode. The elevator goes to the STOP/ OPEN mode at the requested floor to allow exit. After the door is open for a specified time, it closes and then goes back to the WAIT state until another floor call is received (Thomas, 2019).

Fig.5 shows the elevator controller block diagram, which consists of the controller logic, a floor counter, and a floor number display. Assume that the elevator is on the first floor in the WAIT state. The floor counter contains 001, which is the first-floor code. Suppose the FLRCALL (101) comes in from the call button on the fifth floor. Since FLRCALL 7 FLR (101 7 001), the controller issues an UP command to the elevator motor. As the elevator moves up, the floor counter receives a floor sensor pulse as it reaches each floor which advances its state (001, 010, 011, 100, 101). When the fifth floor is reached and FLR = FLRCALL, the controller logic stops the elevator and opens its door. The process is repeated for a FLRREQ input. The floor counter sequentially tracks the number of the floor and always contains the number of the current floor. It can count the up or down and can reverse its state at any point under the direction of the state controller and the floor sensor input. A 3-bit counter is required for the floor counter state, since there are eight floors (23 = 8) including the basement (Thomas, 2019).

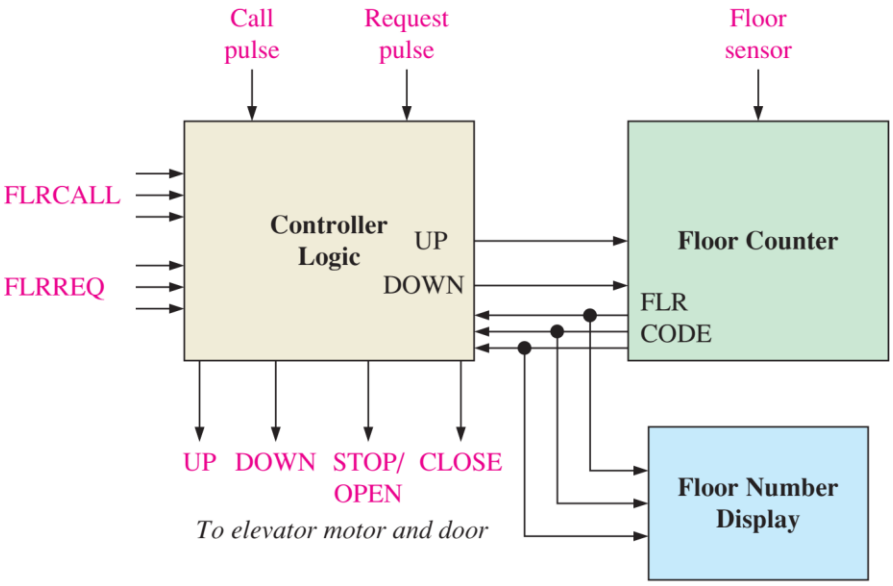


Figure 5. Elevator controller block diagram (Thomas, 2019).

The elevator controller logic diagram is shown in Fig.6. Elevator action is initiated by either a floor call (FLRCALL) or a floor request (FLRREQ). Keep in mind that FLRCALL is when a person calls the elevator to come to a particular floor. FLRREQ is when a passenger in the elevator requests to go to a specified floor. This simplified operation is based on a CALL/REQ sequence; that is, a call followed by a request followed by a call. It is known, FLRCALL and FLRREQ are 3-bit codes representing specific floors. When a person presses a call button on a given floor, the specific 3-bit code for that floor is placed on the inputs to the CALL/REQ code register and a CALL pulse is generated to enter the code into the register. The same process occurs when a request button is pressed inside the elevator. The code is input to the CALL/REQ code register, and a REQ pulse is generated to store the code in the register (Thomas, 2019).

The elevator does not know the difference between a call and a request. The comparator determines if the destination floor number is greater than, less than, or equal to the current floor where the elevator is located. Because of this comparison, either an UP command, a DOWN command, or an OPEN command is issued to the elevator motor control. As the elevator moves toward the desired floor, the floor counter is either incremented at each floor as it goes up or decremented at each floor as it goes down. Once the elevator reaches the desired floor, a STOP/OPEN command is issued to the elevator motor control and to the door control. After a preset time, the delay timer issues a CLOSE signal to the elevator door control. As mentioned, this elevator design is limited to one floor call and one floor request per cycle. The elevator controller can be implemented using fixed-function logic devices, a PLD programmed with a VHDL (or Verilog) code, or a programmed microcontroller or microprocessor (Thomas, 2019).

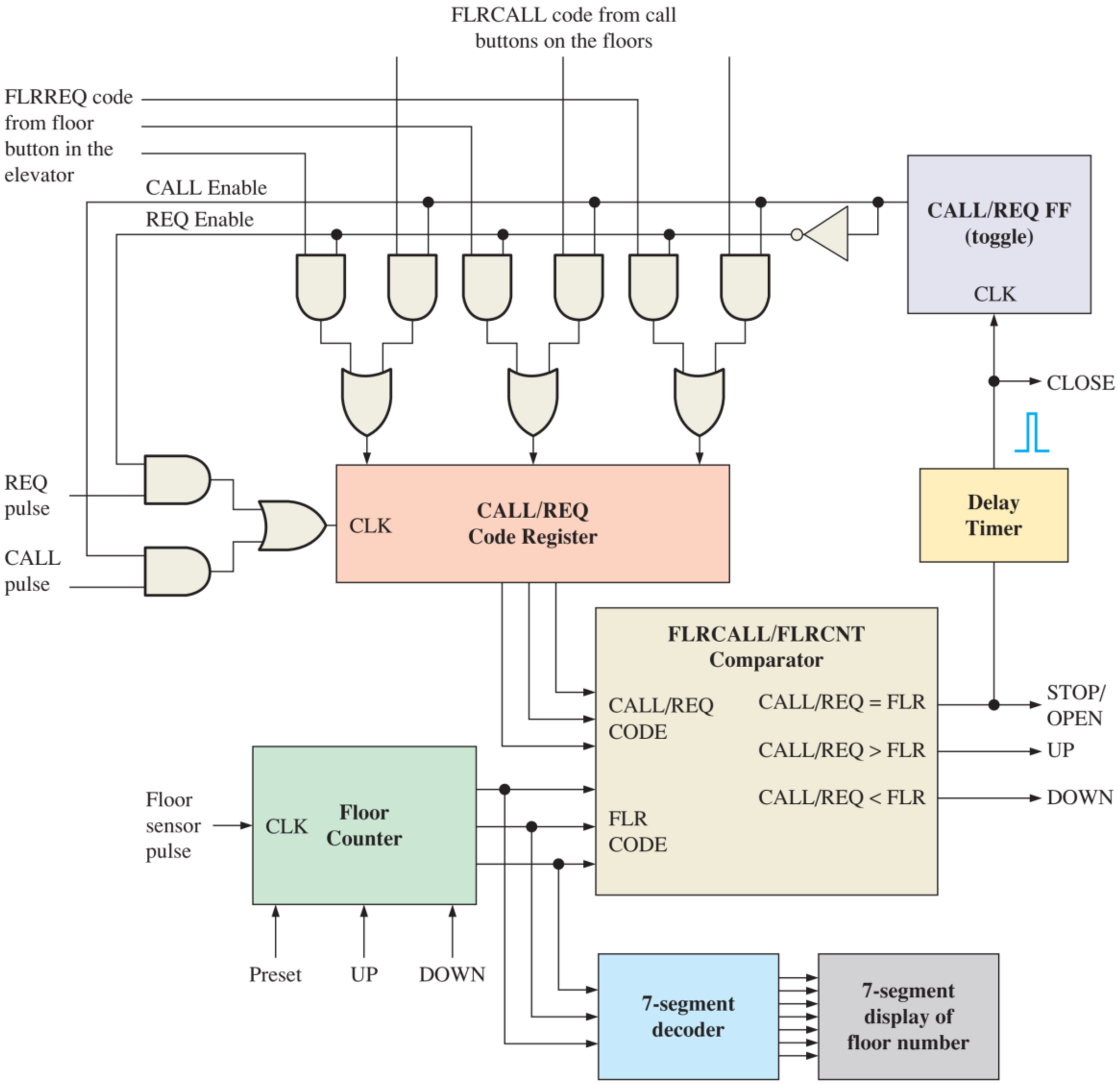


Figure 6. Elevator controller logic diagram (Thomas, 2019).

4. CONCLUSION

At present, the development trend of the “new engineering” is hot, and the training methods of the colleges and universities are increasingly turning to be oriented by social needs. China has the more prominent characteristics of the diversified demand for the talents and overlapping knowledge structure, thus the undergraduate education and postgraduate education also pay the more attention to linking the theory with the practice. The electronic technology experimental course is a backbone practical course that guides the students to combine the knowledge learned in the theoretical courses with the needs of the practical engineering, and better build the engineering design thinking. The teaching task of building the students' knowledge and practice framework is also more protrude.

Through the optimization of the assigned experimental tasks, the students are guided to simulate the experimental principle through the virtual simulation software. Before the experiment, the whole experimental system can be understood as a whole, and the students are guided to learn independently and simulate the design through design tasks. Including the school-enterprise cooperation projects or topics closely related to practice in the mid-term and final course design tasks to help the students understand the engineering more comprehensively and systematically, and help the students adapt to future work and research in advance. In essence, we should understand how the engineering majors should work in the specific practice, and then improve the students' comprehensive capability.

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CONFLICT OF INTEREST

All authors confirmed that there is no conflict of interest involve with any parties in this work.

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