

Elevator Control System

EET 275

Experiment #9

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Executive Summary

The purpose of this lab was to design and implement a three floor elevator control system. The system was implemented using the nine step procedure for programming PLCs from the EET 275 text book. Each floor was to have its own illuminated pushbutton to call the elevator to a demanded floor. The elevator door was to be simulated with the use of a 12VDC bench-top mounted motor that opened, stayed open, and reversed after ten seconds at each floor after being called. A 12VDC motor was used to hoist the elevator and IR sensors were used to indicate when the elevator was at the floor in position to open. The entire system included a master start-stop circuit to ensure that the operation could be completely shutdown for emergencies or repair. The final aspect of this experiment was to intelligently organize the ladder logic to make troubleshooting easier. To do this, all of the subroutine jumps were placed in the second ladder and the actual subroutines in its respective ladder.

Discussion of the Nine Step Process of Programming

The first step of the nine step procedure of programming PLCs is to define the process to be controlled. As stated in the executive summary, there were three floors, a simulated door opened and closed when the IR sensor was engaged, and a master start-stop circuit stopped the hoist system.

The second step of the process is to make a sketch of the process operation.

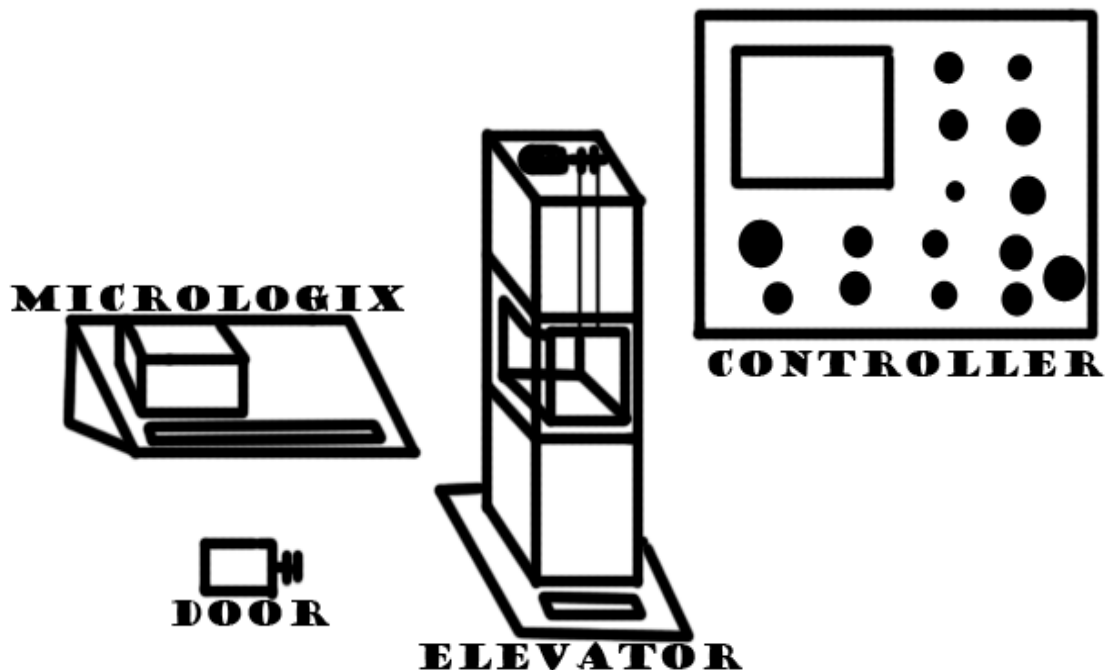


Fig. 9-1, System Layout Sketch

Creating a written step sequence list for the process is the third step of planning a PLC program. Ladder two in the program ladder diagram explains step three well. The way the subroutines are ordered is the order in which we intended on working through the experiment. The first in the process was the jump to the floor sensor subroutine for all of the floors. The next jump went to the floor which housed the code for the call buttons. The hoist subroutine was next in line which actually controlled the hoisting motor. After the elevator was hoisted, the door subroutine commenced. The last subroutine in the program was a master reset subroutine which reset all of the used timers.

The fourth step is to add any sensors to the sketch, and the only sensors which were used were on each of the floors to stop the elevator. The fifth step is to add manual controls. The manual controls used in the design were an emergency stop button, a start button to start the process, and the call buttons for all three floors.

The sixth step makes the point to consider safety and make additions and adjustments as necessary. Safety is a large concern in an elevator process however this model did not really represent many of the extra processes to protect the riders. Such processes may be an overweight for the car protection, emergency call button, telephone, and even fall protection. This emergency stop also satisfies step seven, to include master stop switches to ensure a safe shutdown.

After the first seven steps, a rough version of the ladder logic diagram was created for step eight of the process. Step nine instructs to consider the “what ifs” where the process sequence may go astray. There were many what if questions asked during this lab experiment. One of which was what if more than one call buttons were pressed at once, another was if the third floor were called before the second and the car was on the first, would the car stop at the second before the third, or continue traveling to the third and come back down for the second.

Modular Options:

There were a total of eight modular options presented in the experiment instructions. These options consisted of a door interference limit switch, an elevator stop switch for loading and unloading, an alarm push button, a set of floor queue lights, up or down tones for sightless passengers, a faulty sensor or button monitor and detector, a floor number enunciator LED display, and finally a fire operation switch.

The door limit switch would have been hard to emulate with the provided equipment however it would have been possible if the motor were either geared down or slowed to a lower RPM. The elevator stop switch for loading and unloading would temporarily stop the door motor after being opened to allow for the extra time needed for boarding. The function of the alarm switch would sound an alarm if there was a functional problem with the elevator system which was not picked up by any pre coded alarms. For example, if the motor stopped, the passenger could sound an alarm manually for assistance. The floor queue lights would display that the elevator was on a floor and stopped temporarily. Two different frequencies would be needed to produce the sightless passenger tones. Possibly the “up” sound would be a higher frequency than the “down” tone. The faulty sensor protection would be written into the code to trip if the elevator were operating wrongly. The floor numbers would display the floor of which the elevator was on every floor and the fire operation switch would be a manual override.

Discussion of the System

Five different functions were required for the elevator to work properly and after a function was completed the next could start. After a floor is sensed by the sensor, the elevator car could be called to another floor. With a floor called, the car hoist motor could operate, lifting the car up or letting it down. When the car sensor sensed that the car was at the correct floor, the door open/close function could run. The last function reset the system so the elevator could be called to a different floor. Since there are five functions, five different subroutines were put in place in the program.

In the main ladder, Fig. 9-2, a start/stop seal circuit was put in place to control the system.

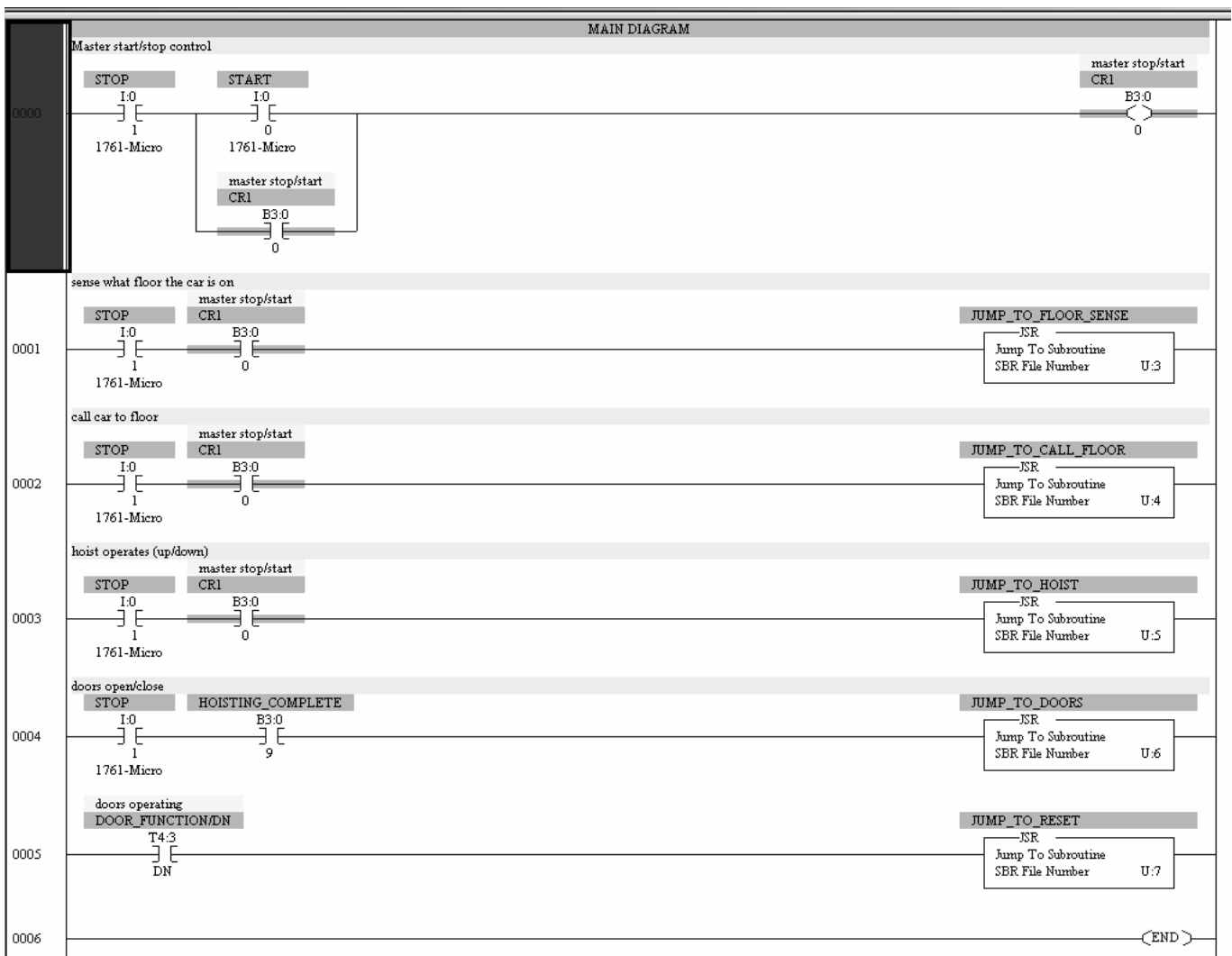


Fig. 9-2, Main Ladder Diagram

With the system started, the first subroutine, floor sense, could operate. As in Fig. 9-3, when a sensor senses the car, its output coil activates, and when a floor is sensed, the subroutine returns to the main ladder.

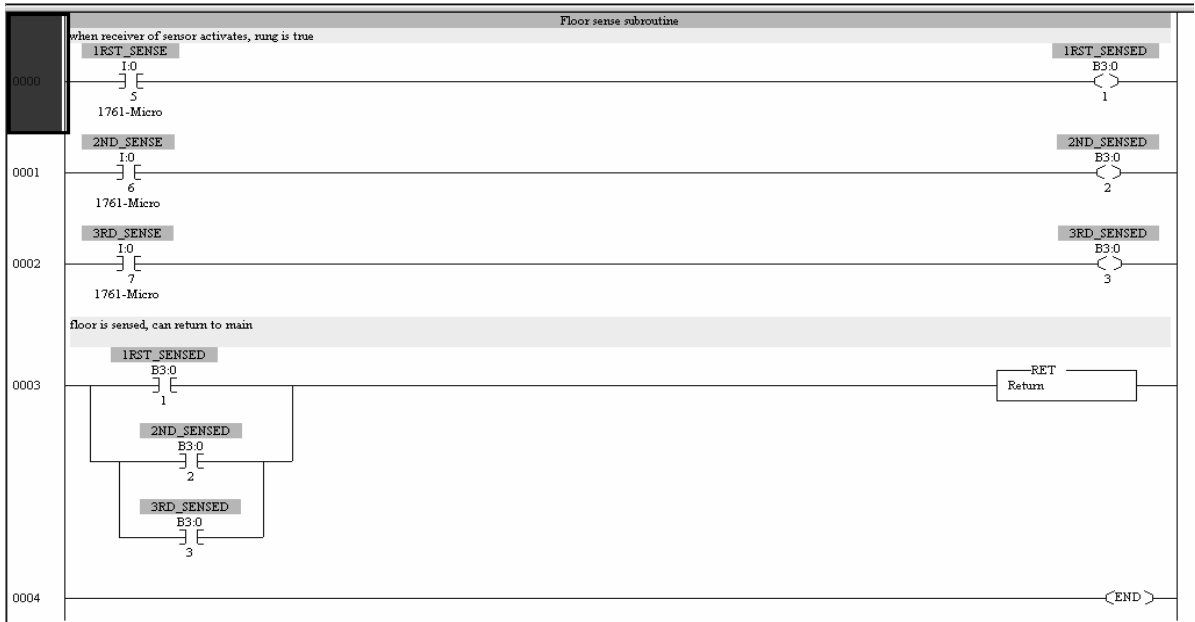


Fig. 9-3, Floor Sense Subroutine

Next, the elevator car could be called to a specific floor when the call floor subroutine, Fig. 9-4, operates.

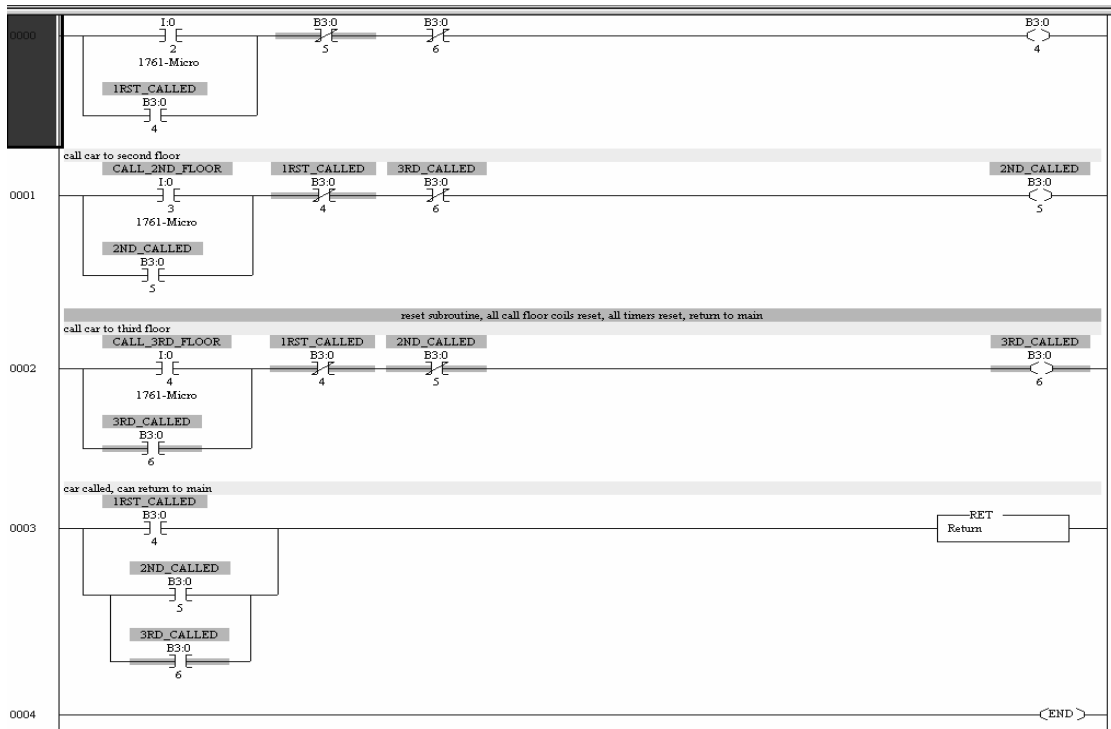


Fig. 9-4, Call Floor Subroutine

When the First, Second, or Third floor call button is pressed, its output coil turns on, sealing the button. The output also deactivates the other two floor's rungs. With a floor called, the program returns to the main ladder diagram.

The master stop/start seal circuit was included in the hoist subroutine, Fig. 9-5, to stop all action since this subroutine worked a moving part. Since the car could go up or down, it was obvious that the only direction the car could go from the first floor was up, and likewise, the car could only go down from the third floor. The difficult part of this subroutine was to discriminate which direction the car would go from the second floor. The floor sense output aided with this problem. When the second floor sensor sensed the car, the second floor sensed output deactivated the second floor call button. So that if first is called from the second floor, the motor let the car down, or if the third floor is called, the motor pulled the car up. When the floor called and the floor sensor of the floor called is true, the hoisting complete output turns on and deactivates the up and down outputs, it also allows the program to return to the main ladder.

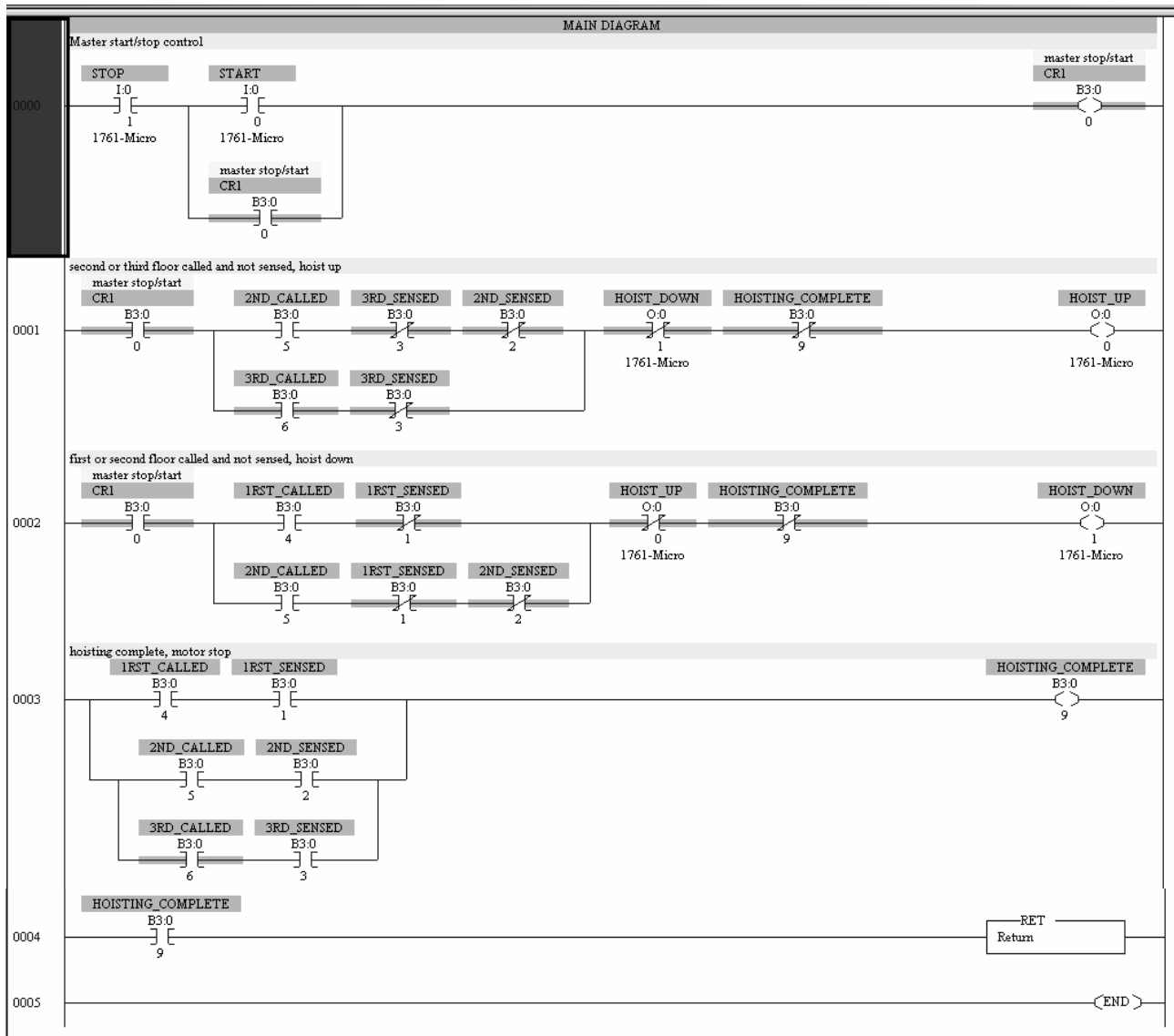


Fig. 9-5, Hoist Subroutine

Once the car reached the floor it was called to, the doors had to open, stay open for ten seconds and then close. Three timers and a master timer used in this subroutine,

Fig. 9-6. When the floor that was called was sensed, a five second timer was activated. While the timer was timing, the motor would run, opening the doors. The done bit of the first timer activated the next timer, which held the doors open for ten seconds. The done bit from that timer activated the motor to close the doors. The master timer started its twenty seconds when the first timer started, when the twenty second timer was done, it allowed a return from the doors subroutine.

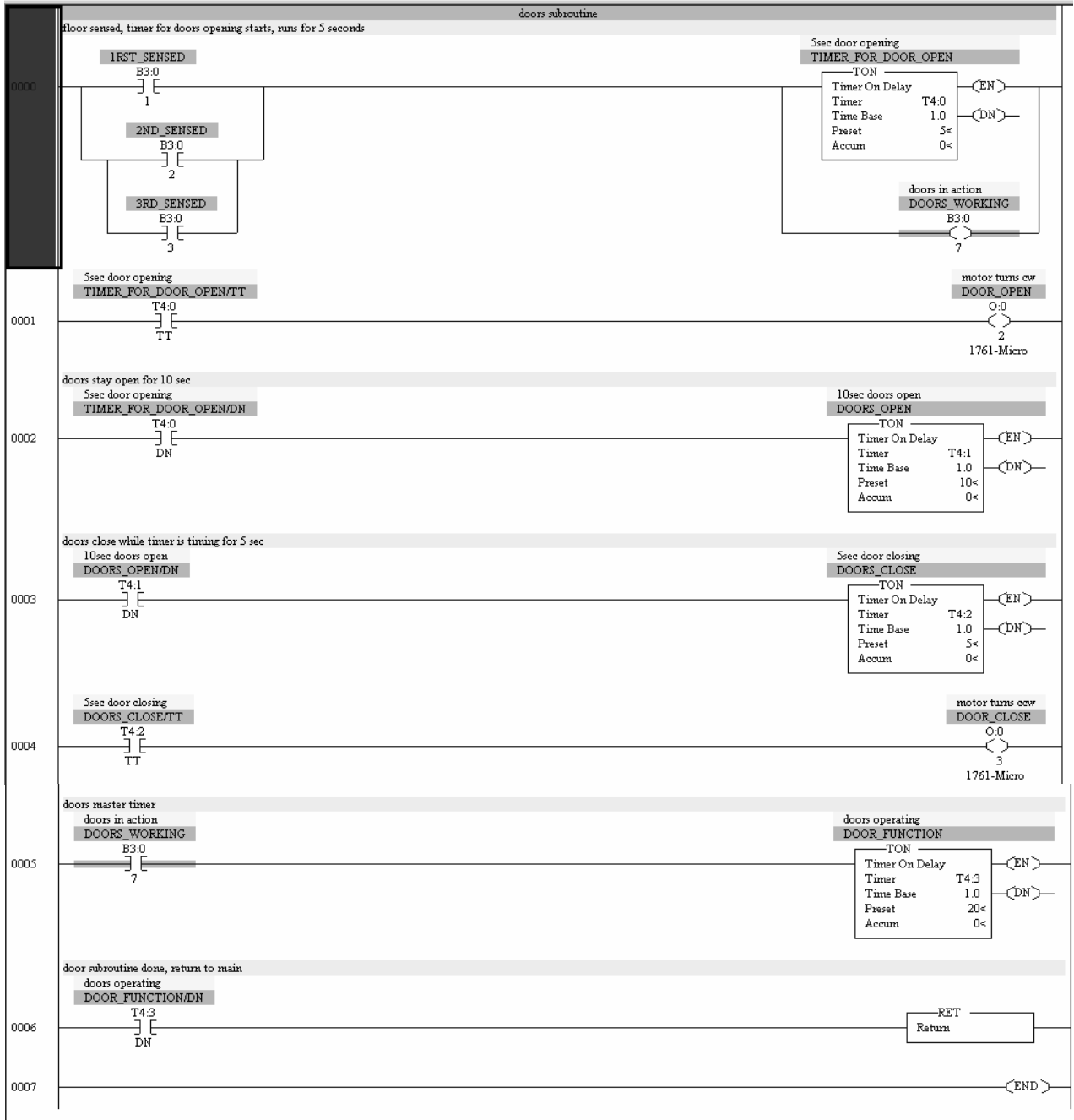


Fig. 9-6, Doors Subroutine

The completion of the doors subroutine signified that the process was over and needed to be reset. The next subroutine of the program reset the outputs so that a new floor could be called and reset all the timers, Fig. 9-7. When these resets were complete, the whole process was finished, awaiting new orders for a floor.

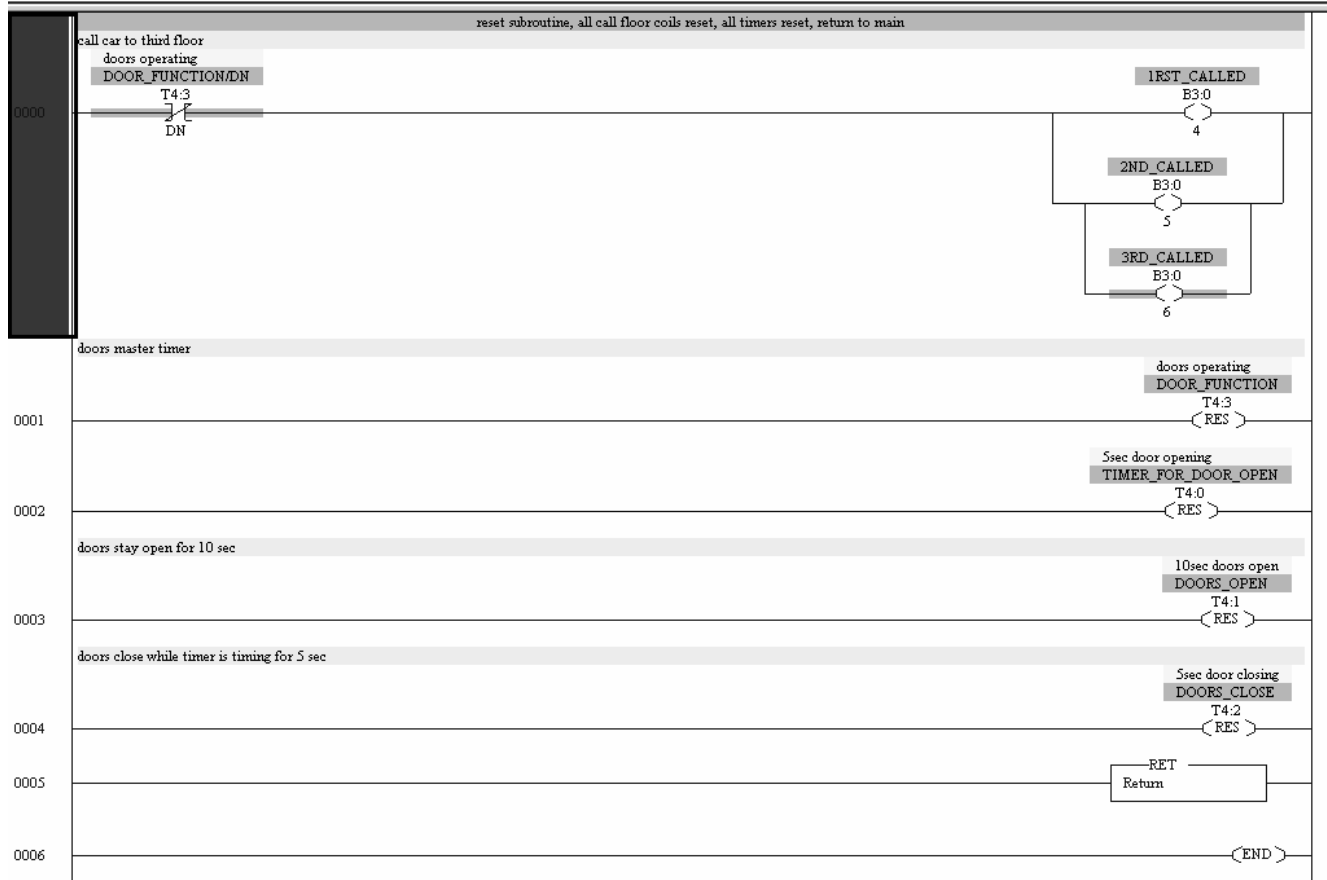


Fig. 9-7, Reset Subroutine

Discussion of Teamwork

One of the key objectives of this experiment was to demonstrate the advantages of working together as a team. The three major components for the successful execution of this lab were the planning, the programming, and the wiring of the PLC. It was decided that we would share responsibility for all components of the lab. First, we came up with our own ideas individually and then came together and work towards a common solution together. For the most part, our final solution was the combination of all of our ideas instead of each person being responsible for their own component.

During the planning portion of our project we all came up with the needed inputs and outputs and wrote a PLC program individually. We then compared notes and discussed what the best solution would be and why. It was decided to take this project one step at a time instead of trying to program and wire it all at one time. In past experiments we had felt a little overwhelmed trying to program and wire the complete project on the first try.

First, we programmed and wired the PLC to operate the hoist motor and the door motor only and tested their operation. Next we analyzed the operation of the floor sensors by measuring the output voltage of the sensor while holding a white piece of paper in front of the sensor and also by observing the output with nothing in front of the sensor. After we were confident of the operation of the sensors, we added them to the PLC program. Next the call buttons were wired so that the lamp would light when the user pressed the pushbutton to call the elevator. Finally, after all of the external wiring was finished and its operation verified we programmed all of the subroutines needed to successfully demonstrate the operation of the elevator into the PLC. This idea of taking this complex project step by step in small increments enabled us to understand the operation of the elevator more completely.

This practice of team building goes a long way in promoting collaboration and understanding across technical disciplines. It also promotes cross training so that if one person in the team goes down, the others can pick up the project and proceed with minimal interruption or down time. The ability to be a flexible member of a team is an absolute must to be competitive in today's manufacturing environment and working together on this experiment was a good example of how to do it successfully.

Conclusion

This lab was very interesting to partake in, in a sense that a modeled elevator was taken and programmed to operate much like a real world functioning elevator. The greatest point learned from the experiment was to understand the great complexity of something that many people take for granted. An elevator system is extremely complex and experiment nine only modeled the core functions. To do so, the nine step process of PLC design was followed from start to finish allowing for a thoroughly complete system. The elevators logic was designed in accordance to the instruction list however the addition of other modular options were not applied to the system but observed as possible inputs to further the system. Teamwork has been a large part of every lab experiment and lab #9 was no exception. Tasks were divided up accordingly, and communication within the group on the processes taken place was vital to the completion of the elevator system.

As far as the nine step process went, all of our personal sketches and drawings of the setup and prospected design of the electronics were saved for reference for the actual design process. Having strictly followed the process in this lab, the lab group seemed more organized than usual. However, during previous labs the process was followed, maybe not that strictly, but the main steps, especially making a sketch and writing the process sequence, were followed. This ended up working out well for the group due to the complexity of the elevators system and many features provided.

With all intentions of creating an exact elevator system, the guideline specs were followed carefully. However, not every aspect of the elevator was covered by the final design. An example of this is how only one floor can be traveled to at one time by the elevator car. What this means is that if two buttons were pressed at one time, the first floor in which the car arrived at would also be the last until another button were hit. This would pose a large problem in real life because the call buttons could only be hit after the doors have been shut and the system has been reset. If this problem were solved earlier on in our experiment, it would have been nice to apply some of the modular options to the overall program. Although these options were not completed, there is no doubt that any one of the extra applications could have been completed successfully.

The final part of this experiment which played a large role in its completion was how well the team worked together. Communication within the group was most important in taking the design from our ideas, to paper, to the computer, and finally to wiring up the overall system. We worked efficiently and affectively on this lab and are proud of the overall performance of the elevator. A lot was learned from this experiment by every member; from how the core operation of an elevator works as well as the potential “add-ons” to make the system work better and safer. Even though this was a scaled model, it is interesting to think of how closely related the designed system is with say an 80 floor elevator system. Experiment nine was a great test of the knowledge learned in the EET 275 class.

I/O Diagram

