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CONSOLIDATING THE CONTROL OF PREVIOUSLY AUTOMATED HOMES

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Abstract

Nowadays, the number of smart homes is increasing steadily. People tend to try anything for better comfort for their family, or simply for themselves. We spend roughly half of our lives at home, so it's only logical to focus and pursue higher comfort levels for our homes. This phenomenon opens enormous potential for automation, whether it is automatic garage doors, motorized shutters, access control systems, HVAC systems, or anything else that serves our well-being. This project looks at the implementation of some automation tasks, using a PLC (Programmable Logic Controller). This approach is different from conventional automation, thanks to the ability of the PLC to control everything in a building thus condensing three, or even four floors into one central unit.

Keywords: *PLC, Smart home, Control, Feedback control.*

1. The usage of the pushbuttons

The PLC (Programmable Logic Controller) has four pushbuttons (Z1, Z2, Z3 and Z4). Using these pushbuttons, we had to solve 7 controlling tasks. In **Figure 2.** the function of the buttons can be seen: the filled-out rectangles show the operated buttons, while the empty rectangle shows the initial position. Button Z3 doesn't start any process, but has an effect on the other buttons. Its function is like the SHIFT button on a keyboard. Because the combination of the Z3 button with the other three buttons wasn't enough for all tasks, we had to find another combination. This was the combination of the Z3, Z2 buttons, and the Z1 button. The order of button operation had to be started with Z3, the order of the other buttons is not significant. While the combination of Z3 and Z1 increases the value of adjusted temperature, otherwise the combination of buttons Z3 and Z1 reduce it. With this operation procedure we change a signal, but in a few seconds, we restore it. Considering that we speak about temperature that shows a slow runoff process we can see that we don't make any meaningful change of the temperature.

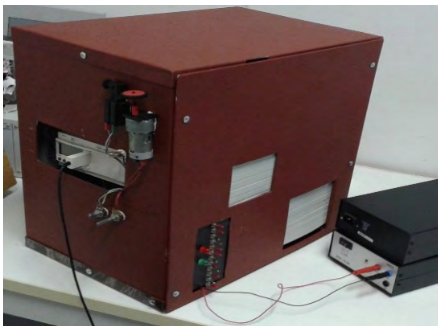

Figure 1. *Model Smart Home*

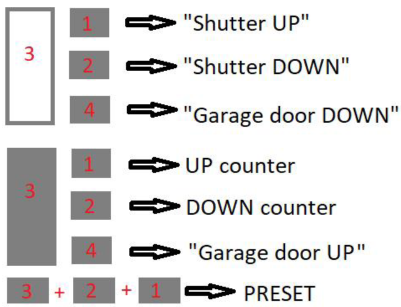

Figure 2. *The diagram of pushbutton functions*

2. Control of the shutter

With help of two pushbuttons we can control the shutter. By operating the mechanism in either way it moves until we press a button, or it arrives in the end position. So, operating the “UP” button the shutter will ascend and pressing the “DOWN” button the shutter will lower. The motor will raise/lower the shutter until we press a button. This function guarantees for us the condition that we can stop the shutter in any required position. If the shutter reaches the end position, we must forbid further movement. This is achieved by the end position sensor that disables the button. If this condition is not met, something in the mechanism might break. Moving up and down the shutter is solved by one motor, additionally, we are using an H bridge, to change the motor rotation. The H bridge contains relays. The XOR gate was not integrated into the bridge construction, thus it did not have an NC (Normally Close) break switch. To make sure that nobody can cause a short-circuit, we integrated the XOR gate in the FBD (Function Block diagram) program. One of the most important duties for programmers is to create a user-friendly interface. This interface is a HMI (Human Machine interface). Due to this HMI it is easy for enyone to use every part of the program. On this HMI every move or change in the house is visible. To overcome this, we must write a program that makes it possible to display this on the HMI with every change. [1]

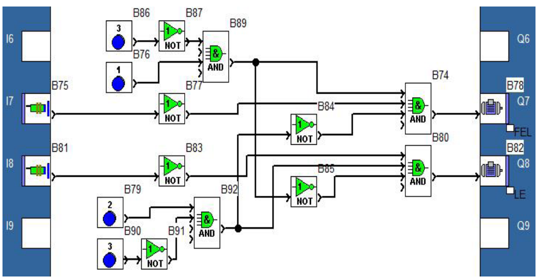

Figure 3. *Shutter Control Program*

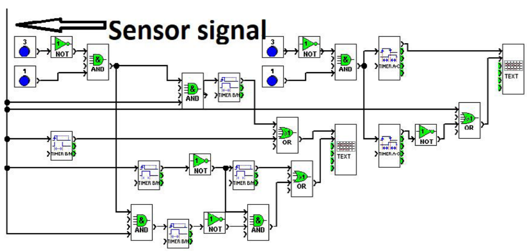

Figure 4. *Shutter position indicator program*

3. Control of the garage

The garage door is controllable, with two pushbuttons. Operating the mechanism in either way, it must move until it reaches the end position(s). The motor will raise/lower the garage door until it arrives in the end positions. It’s our task, to resolve the issue that even if the mechanism reaches the end-position, and the operator doesn’t stop pressing the pushbutton, the movement of the shutter must be stopped. If this condition is not fulfilled, something in the mechanism might break. On top of this we must integrate a light barrier, which prevents the mechanism from closing on a child, car or anything that may get in the way of the garage door. When something gets in the way of the light barrier it creates an electrical signal. This signal changes the motor rotation, so the closing garage door will change its movement direction and will start to ascend. By this process we eliminate the possibility of an accident. Moving the garage door up and down is solved by one motor, with an H bridge which contains a XOR gate. [2]

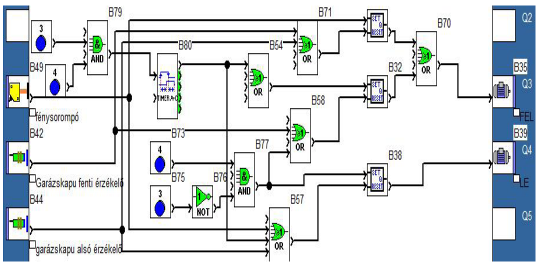

Figure 5. *Garage door FBD program*

Figure 6. *Positions of the garage door*

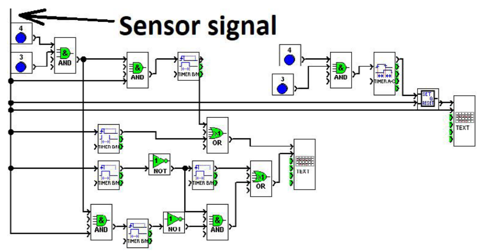

Figure 7. *Garage door position indicator program*

4. Access control system

The task for this part was to create an access control system which utilizes a bit array. Therefore, this array only contains logical zeroes and ones. If we increase the number of logical numbers in the array, then we create more and more possible permutations. The mechanical switches are the bits in the array. Because we don't have many inputs (in the program we used only 5 switches from the whole row), we used "fake" switches that had the role of increasing the code variations. A person who doesn't know the program or the access control system's process, won't even know which one of the switches are used or which ones are not used. With this procedure we eliminate one of the problems; that of potentially revealing the access code. As seen on **Figure 8.** we used 5 switches in the PLC program. (the switches that don't have red plastic caps on the end of them). The whole row contains 12 switches, but just 5 of them give information for the controller. The position of these 5 switches sets the code for access. To be sure that the code isn't easy to figure out we use not just logical 1-s in the code, but also logical 0-s.

The negated pins will give us the logical 0 information. If we turn one of these pins in to logical 1 the controller will not let us in. If we enter the correct sequence, then the electromagnet that keeps the door locked will release and lets us enter the house. By leaving the switches in the open positions, the door will stay open permanently, which is obviously problematic. To prevent this, we integrated a timer into the program, which assures that after few seconds, the electromagnet will close the door.

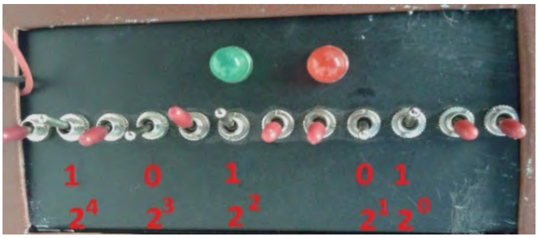

Figure 8. *Access Control System bit array*

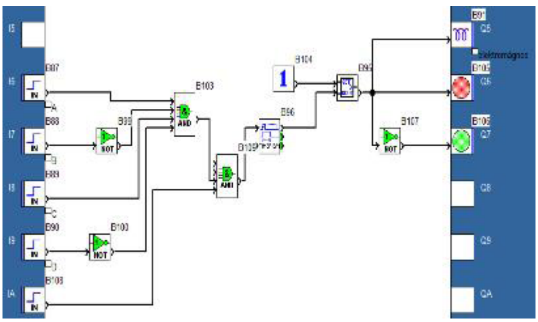

Figure 9. *The FBD program of the access control system*

5. Control of the healing-cooling system

The Heating-cooling system is con-trolled by the internal temperature control systems. The program compares the internal temperature with the required temperature, which is set and adjusted by the user. The adjusted temperature can be changed using the corresponding pushbuttons. In the program, we used an average temperature that can be increased or decreased by the user. This average temperature is 20 °C and can be adjusted using the PRESET pushbutton (ID input). The IB input is the UP counter, while the IC input is the DOWN counter. Operating the up or down counter, we can change the required temperature by 1 Celsius degree. The heating/cooling system will work until the internal temperature reaches the set temperature.

To be user friendly, we display the changes on the HMI (**Figure 11.**).

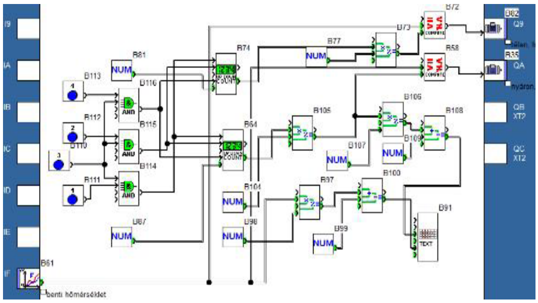

Figure 10. *The FBD program of the heating-cooling system*

Figure 11. *The adjusted temperature*

6. Conclusion

In conclusion, we can say that we have succeeded in building a smart home model, controlled by one singular PLC, with a few inputs and outputs, using cheap materials and sensors to make our lives more com-fortable.

7. Future innovation efforts

Firstly, we wish to solve more automa-tion tasks that are needed in a smart home. The second goal is to create an eco-friendly control system. Many times, the result of correct control of a building automation system comes with a reduction of energy and resource requirements. Another ob-jec-tive is to build a system that may help to con-solidate the various control systems into one. This allows us to overcome the new challenges within the industry, and to open up new horizons in the field of smart homes and automation tasks. With the spread of IoT (Internet of Things) this will slowly become a requirement in the industry. **[3]**

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