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Engineering of industrial technologies

Universidad de Oviedo

FINAL PROJECT

Design and implementation of PLC-HMI based control and monitoring systems

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ILLUSTRATION TABLE

1 INTRODUCTION

The objective of the project is to design relay control of the given discrete machine process by application of Horner PLC controller with HMI (Cscape software), three different processes were considered:

The first one is the burglar alarm system for a house using sensors that give us different signals activated if an unauthorized person is detected. On the other hand, there is a possibility that control system activate some alarm signals.

The second one is a stepper motor activated by appropriate pulse train generated by the controller. Controlling the angular speed and the direction of rotation is possible in this way.

The third one is the materials handling system consists of belt conveyor transporting different pieces to containers. Sensors select elements according to their features. The controller allows to control the number of elements in the containers.

Considered systems are relatively simple examples of mechatronic systems, of which PLCs are often important components.

2 MECHATRONICS

This discipline unites mechanical engineering, electronic engineering, control engineering and computer engineering. Because it combines several engineering in one, its strength is its versatility.
Understanding that Mechatronics encompasses very broad and complex disciplines we can say that it has many fields of application. In fact, Mechatronics aims to be that discipline or Engineering in which the products are manufactured taking into account all engineering and not being separated as traditionally.

Its strong point is the versatility to create better products, processes or systems. Mechatronics is not a new concept or a new engineer, but the synthesis of certain areas of engineering.

Its main objective is to cover certain needs such as:

- Automate the machinery: this way it is achieved that it is agile, productive and reliable.
- Creation of intelligent products: that above all respond to the needs of the human being.
- That there is harmony between mechanical and electronic components (until now mechanics and electronics did not handle the same terms, which made the manufacturing or repair processes of different equipment difficult).

The main industries that use Mechatronics are:

- Companies in the Automation Industry: companies that use computerized and electromechanical systems or elements to control machinery and / or industrial processes.
- Companies of the Flexible Manufacturing Industry: those that are dedicated to manufacture systems or electrical or electronic components automatically.

Therefore, Mechatronics can be applied to many fields, from medicine to mining, through the pharmaceutical industry, mechanical industry, automotive, textile, communications, food, trade ... and much more.

3 SCADA, PLC AND HMI

In the modern control systems (mechatronics systems) specialized industrial computers (PLC) as well as data communication systems and graphical user interfaces (SCADA/HMI) are widely used. The Figure 1 shows the pyramid diagram relation between the control systems.

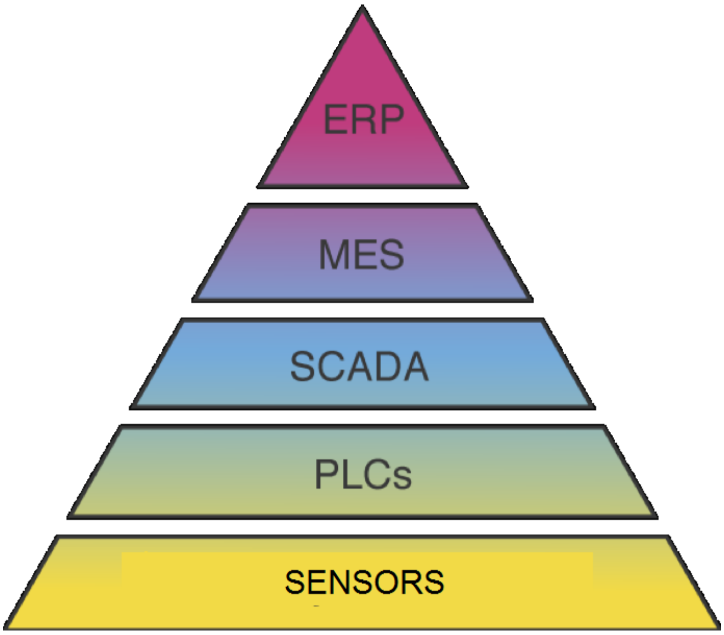

Figure 1. Fig. 2 General SCADA system scheme [18]

3.1 DEFINITIONS

In the Figure 2 we can see a very basic scheme that shows us the relationship between SCADA, HMI, PLC and the equipment.

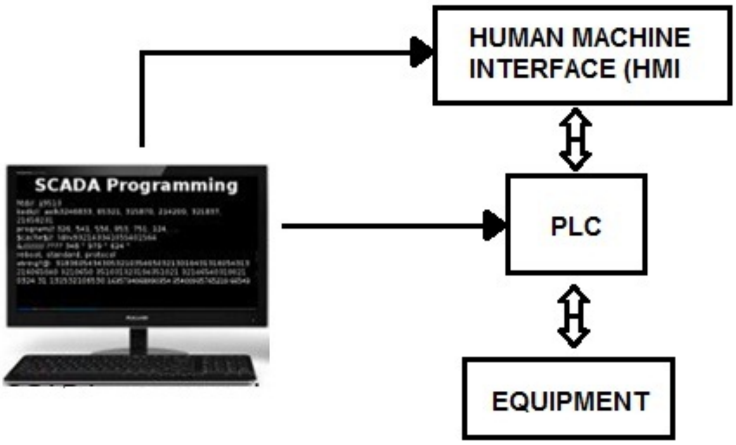

Figure 2. Diagram of relationship between Scada, HMI and PLC.

3.1.1 SCADA [6]

SCADA, acronym for Supervisory Control And Data Acquisition is a concept that is used to make a software for computers that allows to control and supervise industrial processes at a distance. It facilitates feedback in real time with field devices (sensors and actuators), and controls the process automatically. It provides all the information that is generated in the production process (supervision, quality control, production control, data storage, etc.) and allows its management and intervention.

Feedback, is, in an organization, the process of sharing observations, concerns and suggestions, with the intention of gathering information, individually or collectively, to improve or modify various aspects of the functioning of an organization. The feedback has to be bidirectional so that continuous improvement is possible, in the hierarchical hierarchy, from top to bottom and bottom to top.

In control theory, feedback is a process by which a certain proportion of the output signal of a system is redirected back to the input. This is often used to control the dynamic behavior of the system. Examples of feedback can be found in most complex systems, such as engineering, architecture, economics, sociology and biology.

3.1.2 HUMAN MACHINE INTERFACE (HMI) [9]

The user interface is the space where the interactions between human beings and machines take place. The objective of this interaction is to allow the most effective operation and control of the machine from the interaction with the human.

The basic user interfaces are those that include elements such as menus, windows, graphic content, cursor, beeps and some other sounds that the computer makes, and in general, all those channels through which communication between the human being and the human being is allowed.

The objective of the design of an interface is to produce an interface that is easy to use (to explain itself), efficient and pleasant so that when operating the machine it gives the desired result.

3.1.3 PLC [11]

A programmable logic controller, better known as PLC, is a computer used in automatic engineering or industrial automation, to automate electromechanical processes, such as the control of factory machinery in assembly lines or mechanical attractions.

PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple input and output signals, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. The programs for the control of machine operation are usually stored in batteries, backup or in non-volatile memories. A PLC is an example of a real-time system, where the output results must be produced in response to the input conditions within a limited time, otherwise it will not produce the desired result.

In the Figure 3 is represented the Siemens PLC Logo 6ED10551NB100BA0, one type of PLC.

Figure 3. Siemens PLC Logo 6ED10551NB100BA0

3.2 SYSTEM [8]

3.2.1 OPEN AND CLOSED LOOP

There are two types of systems, mainly: open-loop or non-feedback systems, represented in the Figure 4, and closed-loop or feedback systems, represented in the Figure 5,. Closed loop systems work in such a way that they make the output go back to the beginning to analyze the difference with a reference value and in a second option the output is adjusted, so until the error is zero or below a previously defined threshold. Any system that has the purpose of controlling an amount such as temperature, speed, pressure, flow, force, position, among other variables, are normally closed loop. Open-loop systems do not compare to the controlled variable with a reference input. Each input setting determines a fixed operating position in the control elements (for example with timers).

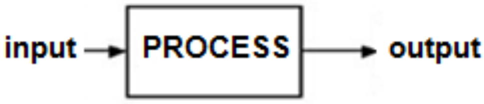

Figure 4. Open loop diagram.

Thus, feedback is a mechanism or process whose signal moves within a system and returns to the beginning of it as in a loop, which is called a "feedback loop". In a control system (which has inputs and outputs), part of the output signal returns to the system as part of its input; This is called "feedback".

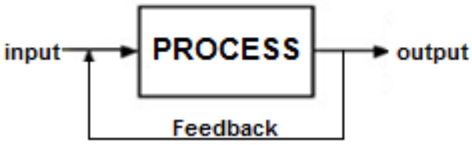

Figure 5. Closed loop diagram.

The feedback includes all those application solutions that refer to the capture of information of a process or plant, not necessarily industrial, so that, with this information, it is possible to carry out a series of analyzes or studies with which valuable indicators can be obtained that allow a feedback on an operator or on the process itself, such as:

- Indicators without inherent feedback (they do not affect the process, only the operator):
  - ♦ Current status of the process. Instant values.
  - ♦ Deviation or derivation of the process. Historical and accumulated evolution:
    - ◊ Measurement of the parameters that are created necessary.
- Indicators with inherent feedback (affect the process, then the operator):

- Generation of alarms.
- HMI Human Machine Interface.
- Decision making:
  - Through human operation.
  - Automatic (through the use of knowledge-based systems or expert systems).

3.2.2 SCHEME OF A TYPICAL SYSTEM

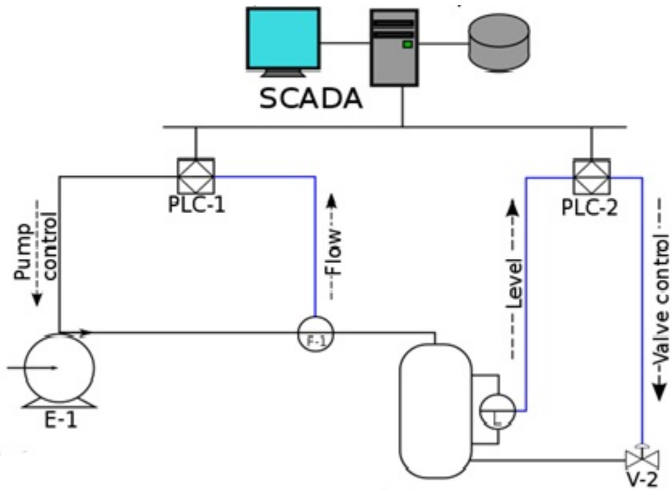

Figure 6. Control diagram of the flow and measure level [19].

The scheme in the Figure 6 is an example of the application of the SCADA system in industrial areas. These areas can be:

Monitor chemical, physical or transport processes in water supply systems, to control the generation and distribution of electricity, gas or pipelines and other distribution processes.
Production management (facilitates manufacturing scheduling).
Maintenance (provides such magnitudes of interest to evaluate and determine failure modes, MTBF, Reliability indexes, among others).
Quality Control (provides in an automated way the necessary data to

calculate stability indexes of CP and CPk production, tolerances, NOK / OK parts index, etc.
Administration (these data from the SCADA can now be linked to an ERP server (Enterprise Resource Planning or Enterprise Resource Planning System), and be integrated as one more module).
Historical treatment of information (through its incorporation into databases).

3.2.3 SYSTEM DEFINITIONS

- Supervision: act of observing the work or tasks of another (individual or machine) that may not know the subject in depth, supervising does not mean control over the other, but guiding it in a work context, professional or personal, with corrective and / or modification purposes.
- Automatic: technological science that seeks the incorporation of elements of autonomous execution that emulate human behavior or even higher.
- Main families: automata, robots, movement controls, data acquisition, artificial vision, etc.
- PLC: Programmable Logic Controller.
- PAC: Programmable Automation Controller.

A SCADA system includes an input and output signal hardware, controllers, man-machine interface (HMI), networks, communications, database and software.

The term SCADA usually refers to a central system that supervises and controls a whole site or a part of a site that we are interested in controlling (the control can be on machines in general, tanks, pumps, etc.) or finally a system that is It extends over a great distance (kilometers / miles). Most of the site control is actually performed automatically by a Remote Terminal Unit (UTR), by a Programmable Logic Controller (PLC) and more currently by a Programmable

Automation Controller (PAC). The control functions of the server are almost always restricted to basic site readjustments or supervisory level capabilities. For example a PLC can control the flow of cold water through a process, but a SCADA system can allow an operator to change the set point of control for the flow, and will allow to record and show any alarm condition. as the loss of a flow or a high temperature. The feedback of the control loop is closed through the RTU or the PLC; The SCADA system monitors the overall performance of that loop. The SCADA system can also show historical graphs, trends, tables with alarms and events among other functions. It can and should be subject to permissions and access of users and developers according to their hierarchical level in the organization and the function that it fulfills within it. Needs of process supervision:

- Limitations of the visualization of the acquisition and control systems.
- Software control. Control loop closure.
- Collect, store and visualize the information.

3.2.4 SYSTEM COMPONENTS [5]

The three components of a SCADA system are:

- Multiple Units of Remote Terminal (also known as UTR, RTU or External Stations).
- Master and Computer Station with HMI.
- Communication Infrastructure

3.2.4.1 REMOTE TERMINAL UNIT (RTU) [1]

The RTU is physically connected to the equipment and reads the status data as open / closed states from a valve or a switch, reading the measurements as pressure, flow, voltage or current. By the equipment the RTU can send signals that can control it: to open it, to close it, to exchange the valve or to configure the speed of the pump, to start it, to stop it.

The RTU can read the status of digital data or analog data measurements and send digital output commands or analog setpoints.

3.2.4.2 MASTER STATION [1]

The term "Master Station" refers to the servers and software responsible for communicating with the field equipment (RTUs, PLCs, etc.) in these is the HMI software running for work stations in the control room, or in any other side. In a small SCADA system, the master station can be on a single computer. On a large scale, in SCADA systems the master station can include many servers, distributed software applications, and disaster recovery sites.

The SCADA system usually presents the information to the operating personnel graphically, in the form of a representation diagram. This means that the operator can see a scheme that represents the plant that is being controlled. For example a drawing of a pump connected to the pipeline can show the operator how much fluid being pumped from the pump through the pipe at any is given time or the liquid level of a tank or whether the valve is open or closed. Representation diagrams may consist of line graphs and schematic symbols to represent the elements of the process, or may consist of digital photographs of the equipment on which the sequences are animated.

The software blocks of a SCADA (modules) allow acquisition, supervision and control activities.

3.2.4.3 FEATURES

- Configuration: it allows defining the work environment of the SCADA, adapting it to the particular application that it wishes to develop.
- Operator graphic interface: provides the operator with control and supervision functions of the plant. The process is represented by synoptic charts stored in the process computer and generated from the editor incorporated in the SCADA or imported from another application during the configuration of the package.
- Process module: executes the preprogrammed control actions based on the current values of variables read.
- Management and data archiving: storage and processing of data, so that another application or device can access them.
- Communications: transfer of information between the plant and the hardware architecture that SCADA supports, and also between it and the rest of the IT management elements.

The HMI package for the SCADA system typically includes a drawing program with which operators or system maintenance personnel can change the appearance of the interface. These representations can be as simple as on-screen traffic lights, which represent the current state of a field in current traffic, or as complex as a multiprojector screen representing positions of all elevators in a skyscraper or all trains of a railway. Open platforms such as GNU / Linux that were not widely used initially, are used due to the highly dynamic development environment and because a client that has the ability to settle in the field of hardware and mechanisms to be controlled that are usually sold UNIX or with licenses OpenVMS Today all the big systems are used in the servers of the master station as well as in the HMI workstations.

3.2.4.4 OPERATIONAL PHYLOSOPHY

Instead of relying on the intervention of the operator or on the automation of the master station, the RTUs can now be required to operate themselves, performing their own control above all for safety issues. The master station software requires more data analysis before being presented to operators, including historical analysis and analysis associated with the requirements of the particular industry. The security requirements are being applied in the systems as a whole and even the software of the master station must implement the strongest security standards in certain markets.

For some installations, the costs that can derive from the failures of a control system is extremely high, it is even possible that there is a risk of injuring people. The hardware of the SCADA system is generally robust enough to withstand temperature, humidity, vibration and extreme voltages conditions, but in these installations it is common to increase the reliability through redundant hardware and several communication channels. A failing part can be easily identified and its functionality can be automatically developed by a backup hardware. A part that fails can be replaced without interrupting the process. The confidence in each system can be calculated statistically and this state is the meaning of mean time between failures, which is a variable that accumulates times between failures. The calculated result means that the average time between failures of high reliability systems can be decades.

3.2.5 INFRASTRUCTURE AND COMMUNICATION METHODS

SCADA systems traditionally have a combination of radios and direct serial signals or modem connections to meet communication requirements, including Ethernet and IP over SONET (fiber optic) is also frequently used in very large sites such as railways and electric power stations. Moreover, the methods of connection between systems can even be through wireless communication (for example if we want to send the signal to a PDA, to a mobile phone) and thus not having to use cables.

For the installation of a SCADA to be perfectly exploited, it must meet several objectives:

They must be open architecture systems (able to adapt according to the needs of the company).
They must easily communicate to the user with the plant team and the rest of the company (local and management networks).
They must be simple programs to install, without excessive hardware demands. They also have to be easy to use.

4 PLC AND HMI PROGRAMMING

The project is divided in three different parts, the house, the stepper motor and the sequential program. Each part consists in one cscape program with his control screen. First of all we going to present the plc besides the programming components used, then the presentation of the variables and his work into the program, after that I'll explain the operation for each part with pictures and finally i will do a brief presentation about the screen and how can we control the whole system.

4.1 HORNER PLC [1]

The horner PLC is represented in the Figure 7. This device combines a controller, I / O, a user interface and networks in a single compact unit (OCS) that offers many more features for both users and users. These types of controllers are increasingly used.

OCS is the current leader in this type of market and has been used successfully in both industrial applications and automata.

Figure 7. Picture of Horner PLC.

4.2 PROGRAMMING COMPONENTS

The most important components used in the project are presented below.

4.2.1 COILS

The coils represent the coil of a relay and by extension any type of actuator that can be activated by an electrical signal.

A coil is an assignment operation, which assigns the result of the logical operation prior to the coil to the indicated memory position.

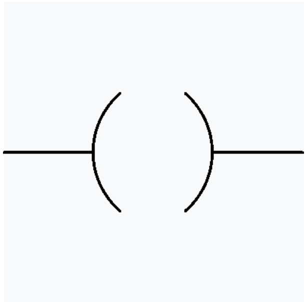

Figure 8. Representation of a coil in a ladder diagram.

4.2.2 CONTACTS

There are two types of contacts:

- Normally open contact: showed in the Figure 9 is an instruction that evaluates whether a memory location has a logical value of "1".

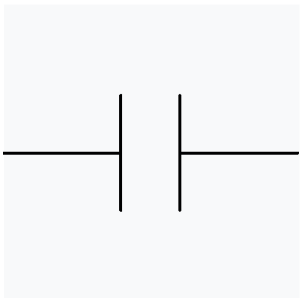

Figure 9. Representation of an open contact in a ladder diagram.

- Normally closed contact: showed in the Figure 10 is an instruction that evaluates whether a memory position has a logical value "0".

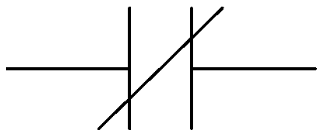

Figure 10. Representation of a closed contact in a ladder diagram.

4.2.3 RELATION CONTACTS/COILS

The more basic relation, when a "1" is represented in the Figure 11 and it is given by the contact the coil give us the same result.

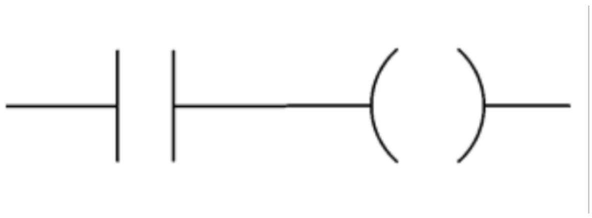

Figure 11. Representation of a closed contact in a ladder diagram.

4.2.4 TIMERS

This tool can be used to activate and deactivate a coil according to a specified time. This way it is possible to program an output, so that in a certain time it turns on or off an external device, two types of counters have been used:

- On Delay Timer (TON): In the Figure 13 is represented this type of timer. It delays the connection of the coil, the time that one determines is that we want the ignition to be delayed.

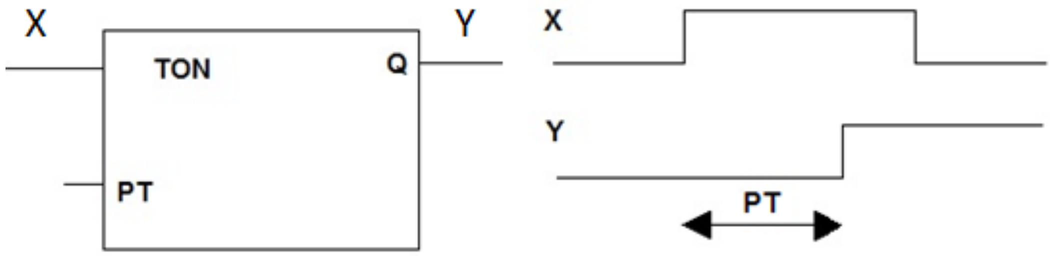

Figure 12. On delay timer block and signal.

- Off Delay Timer (TOF): in the Figure 13 is represented this type of timer. It delays for the pre-established time the coil or memory shutdown.

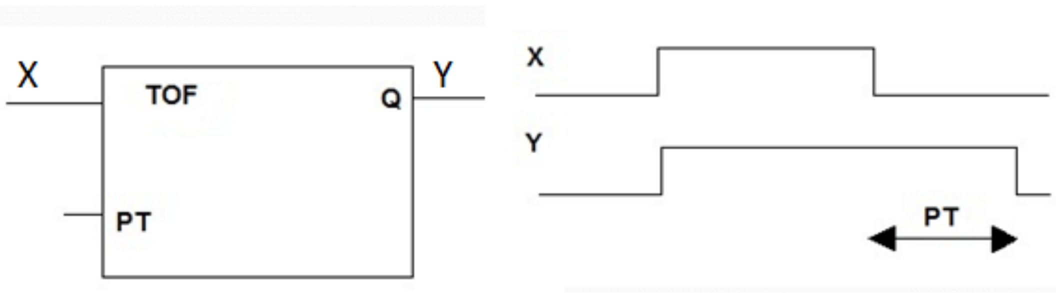

Figure 13. Off delay timer block and signal.

4.2.5 COUNTERS

The figure 14 represents the signal of the counter block.

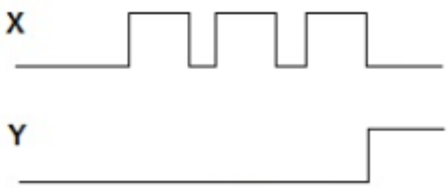

Figure 14. Counter signal.

There are two types of counters:

- In the Figure 15 is represented the counter up (CTU) function block that counts up from the current value up to the preset value (PV) when a positive edge occurs at the input. If the value is greater than or equal to the preset value (PV), the counter output is activated. The signal R is used to reset the counter.

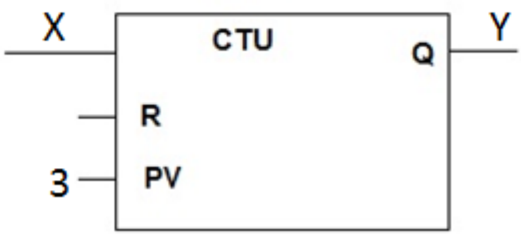

Figure 15. Up counter block.

- In the Figure 16 is represented the counter down (CTD) function block that counts down from the preset value (PV) when a positive edge occurs at the input. If the value is equal to zero, the counter output is activated. The counter stops when it reaches zero value. The signal R, as before, is used to reset the counter.

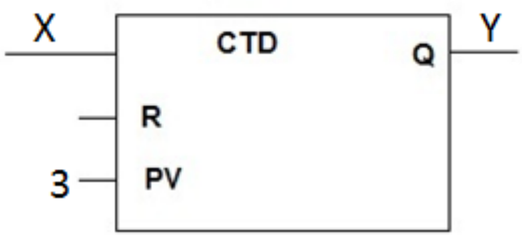

Figure 16. Counter down block.

4.2.6 MATHEMATICAL FUNTIONS

There are too many types of mathematial functions but only four were used:

- SUM: in the Figure 17 is represented the block that sums the inputs.

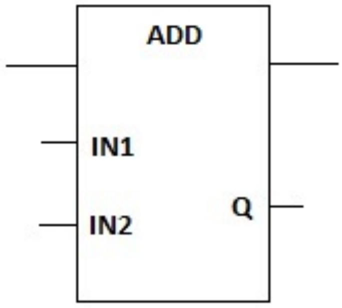

Figure 17. Sum block.

- SUBSTRACTION: in the Figure 18 is represented the block that substracts the second input of the first one.

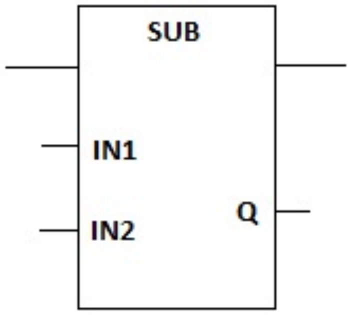

Figure 18. Substract block.

- DVISION: in the Figure 19 is represented the block that divides the second input of the first one.

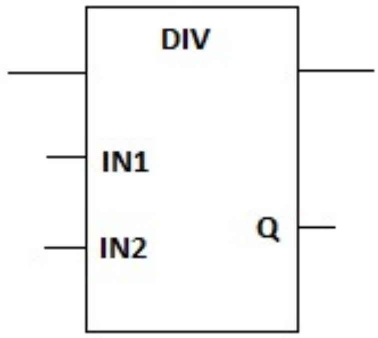

Figure 19. Division block.

- MULTPLICATION: in the Figure 20 block multiplies the two inputs.

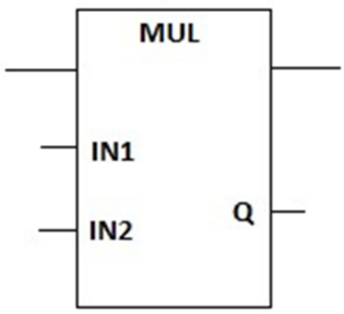

Figure 20. Multplier block.

4.3 HOUSE CONTROL

4.3.1 INTRODUCTION

The house program is used to detect anomalies with different sensors located throughout the house. We have a total of four of them in addition to two outputs associated with them. Depending on which sensor detects something we will have a permanent or intermittent output for each of them, which makes each sensor have its own output.

4.3.2 SCENARIO

- If the door sensor detects something, both the light signal and the acoustic signal act intermittently.
- If the window sensor 1 detects something, the light signal acts intermittently and the acoustic signal permanently.
- If the sensor of window 2 detects something, the light signal acts permanently and the acoustic signal intermittently.
- If the movement sensor detects something, both signals act permanently.

4.3.3 INPUTS

The house control has six inputs:

1. ON switch (%T99) The switch that turns on the program
2. OFF switch (%T51) The switch that turns off the program
3. Door sensor (%K1) The sensor which detects the problems with the door
4. Window 1 sensor (%K2) The sensor which detects the problems with the window 1
5. Window 2 sensor (%K3) The sensor which detects the problems with the window 2
6. Movement sensor (%K4) The sensor which detects the movement outside the house.

4.3.4 OUTPUTS

The house control has three outputs:

1. Sound alarm %T89 When one of the sensors detects something the sound alarm is activated in different forms depending of the sensor.
2. Light alarm %T90 When one of the sensors detects something the light alarm is activated in different forms depending of the sensor.
3. ON/OFF lamp %T88 The light which indicate us if the program is turned on or turned off.

4.3.5 Screen

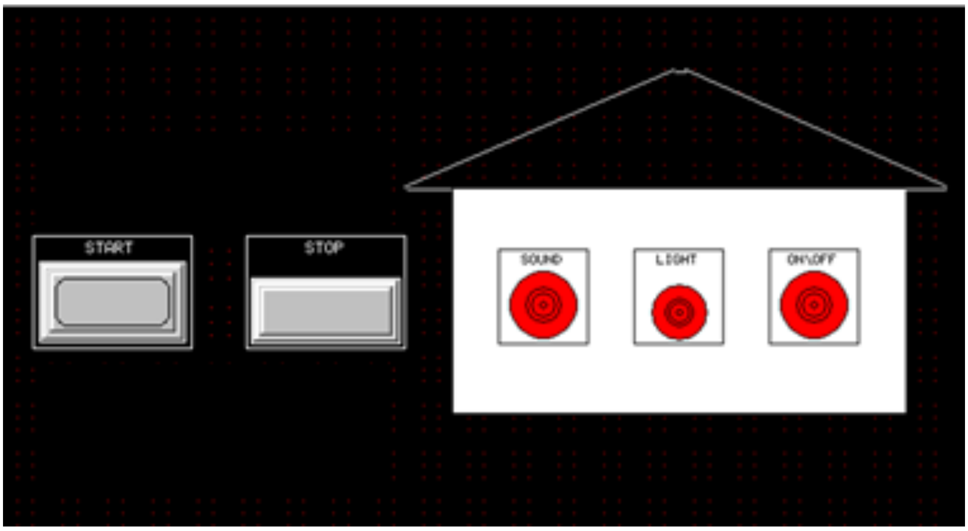

Figure 21. HMI sreen related to the home alarm system.

In Figure 21 the control screen of the house is represented. There are three outputs that represent the light signal, the auditory signal and whether the system is connected or not; and the six entrances, two buttons to turn the system on and off and another four to represent the different sensors.

4.3.6 CONTROL PROGRAM

Constructed control program is presented on Figures 22 – 27.

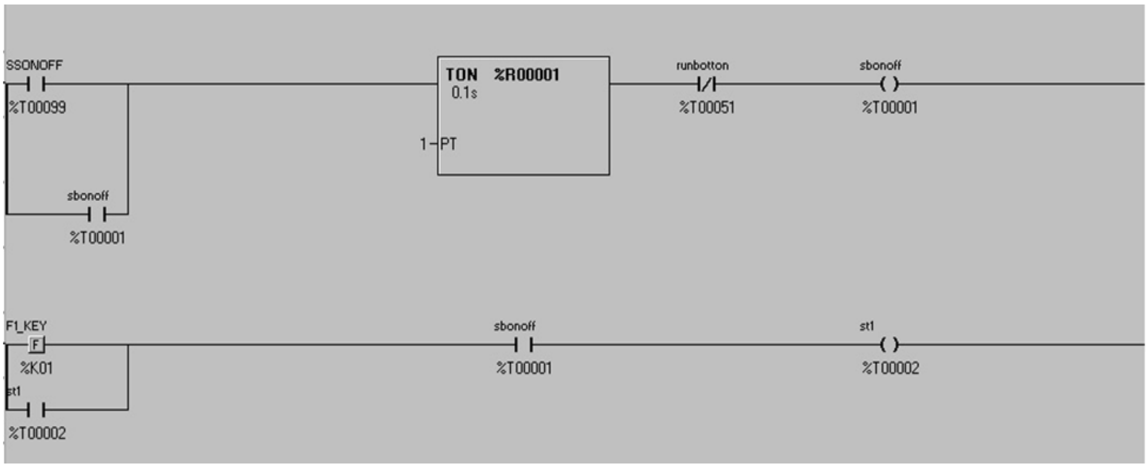

Figure 22. Part 1 of the house program.

In the Figure 22 we can see the variable “SSONOFF”, which is the input that turns on the program. This part consists on a feedback which give us a “one way” switch because of the impossibility to do an ON/OFF switch in CSCAPE. To solve it we have another switch that turns off the program, the variable “run botton”. The timer gives some delay to start the program unless we want that the program detect us as a intruders. The second line give us the feedback that we needs for the door sensor (F1KEY).

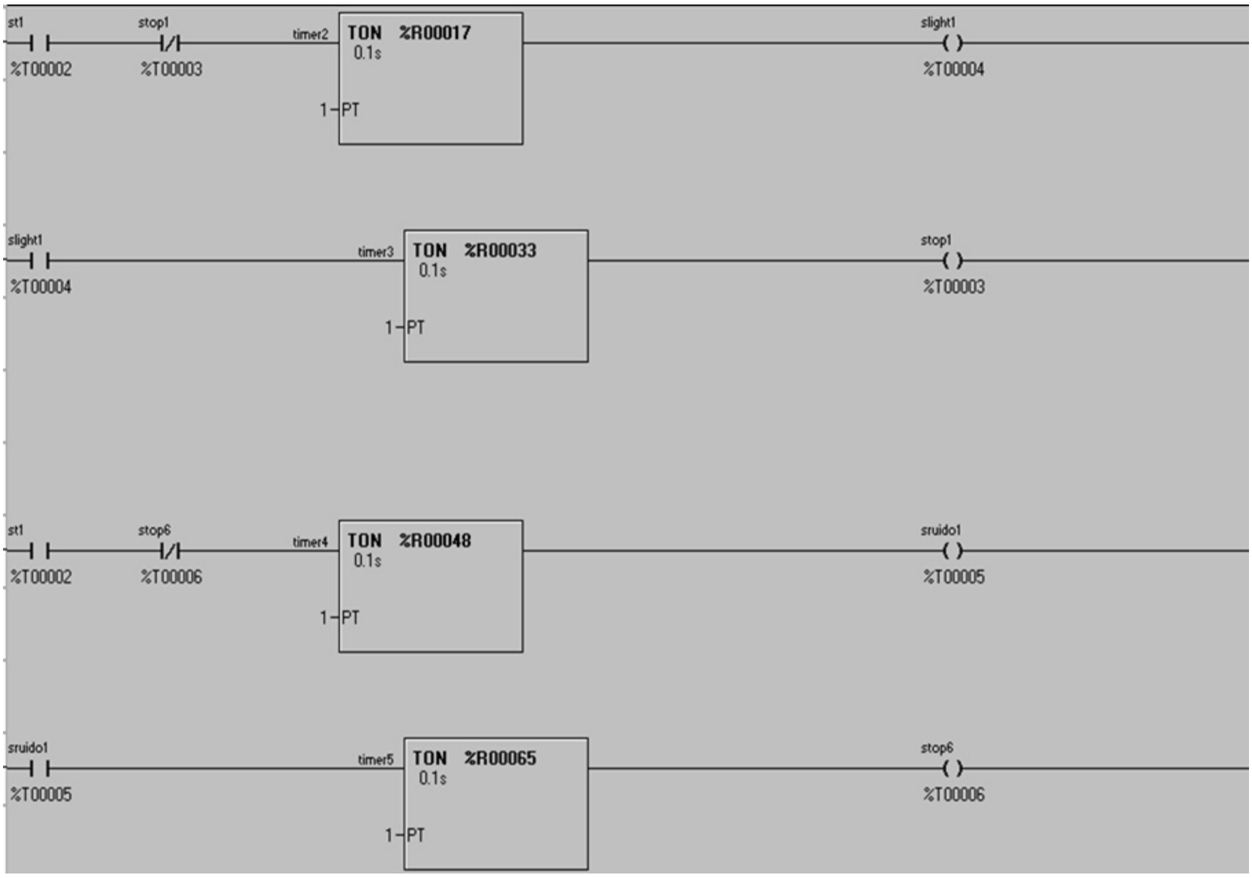

Figure 23. Part 2 of the house program.

The Figure 23 there are two different parts, the first second lines give us the light signal for the door sensor and the others the sound signal. The two timers for each part give us an intermitent signal that we need to have different type of alarms depending of the sensor that was activated.

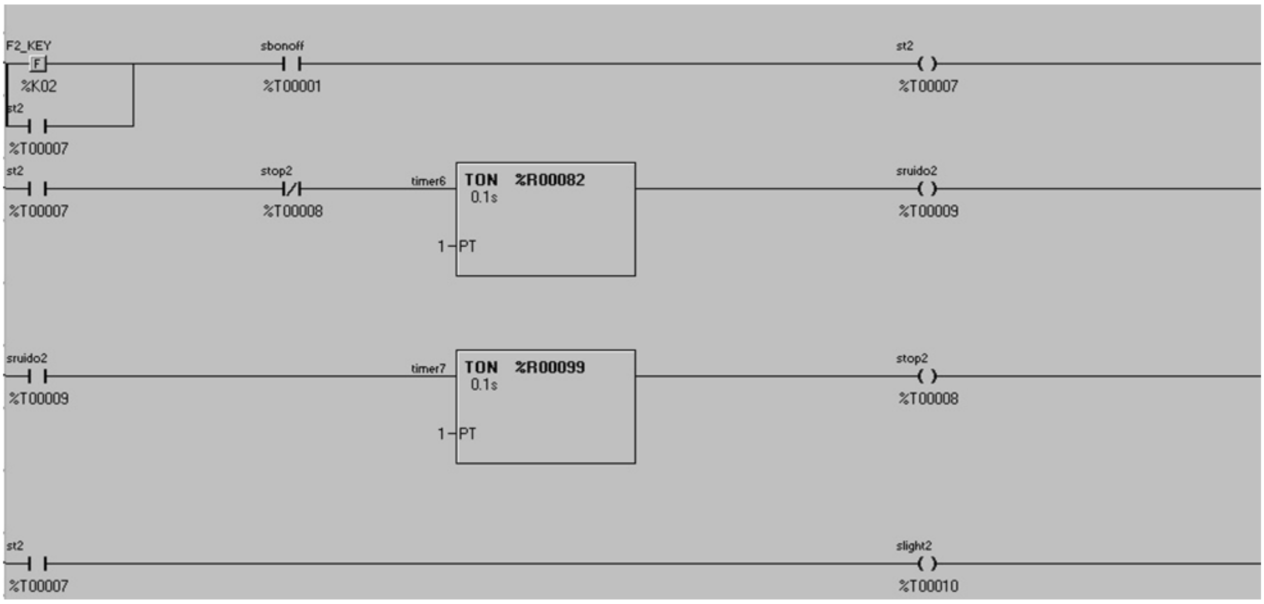

Figure 24. Part 3 of the house program.

In the Figure 24 is represented the whole system control for the window 1 sensor. The feedback and the timers works like the previous program controls, the first one give us the permanent input signal and the second one the intermitent sound signal. The last line give us a permanent light output 2.

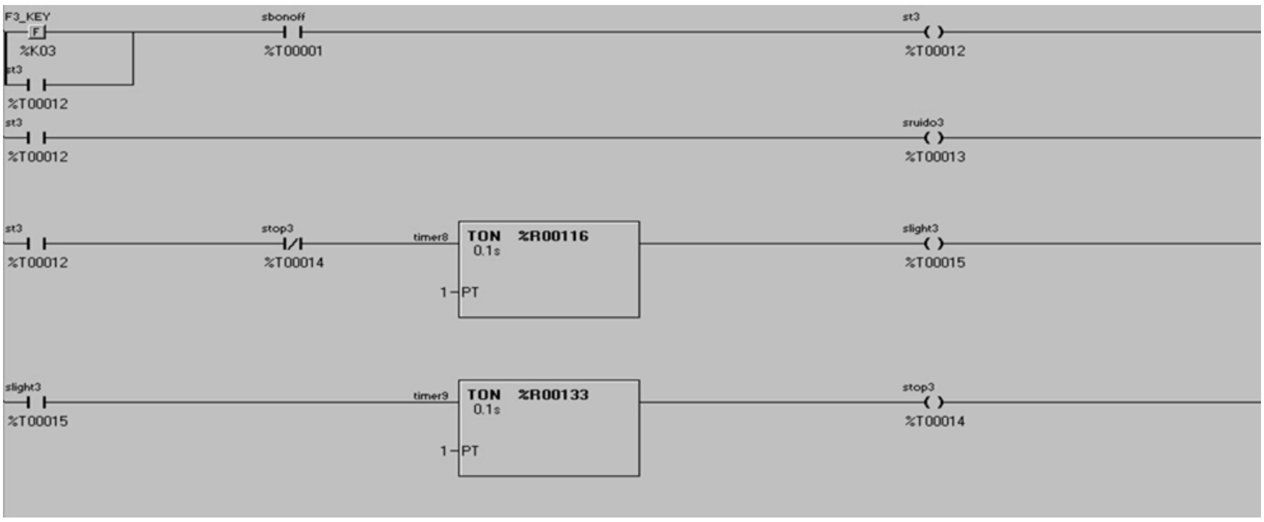

Figure 25. Part 4 of the house program.

In the Figure 25 is represented the window's 2 control system. This one works in the same way like the previous program but changing a permanent sound signal and an intermitent light signal instead of the permanent light signal and the intermitent sound signal. All of these signals are temporary.

Figure 26. Part 5 of the house program.

In Figure 26 is represented the control program movement sensor with the same structure like the previous programs; the light and the sound signal are constant.

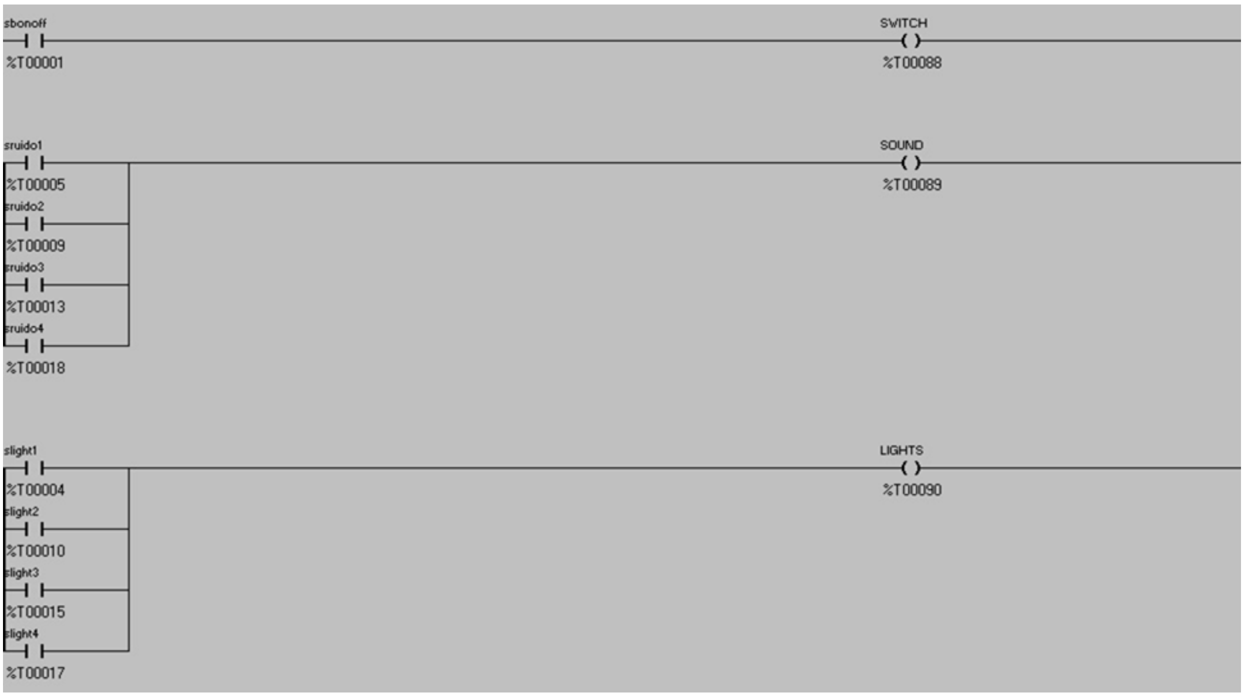

Figure 27. Part 6 of the house program.

In the Figure 27 is represented the compilation of all the temporary output signals in two unique outputs, LIGHTS and SOUND, which are refered to the real outputs, the lightning signal and the sound signal.

4.4 STEPPER MOTOR

4.4.1 INTRODUCTION

The stepper motor has two directions that are controlled manually with two switches. The motor runs with pulses, each time it detects one, the motor advances one step. We have two ways to control it, one through four speeds already established and another through an analog control.

4.4.2 SCENARIO

- If the on / off button is pressed the program turns on or off.
- If the mode change buttons are pressed, change from one to the other.
- If the direction buttons are pressed the stepper motor will change its rotation.
- If the buttons in the 4-speed mode are pressed, the stepper motor will change at the speed assigned to each switch.
- If the bar in analog mode is slid, the speed will vary according to the bar between 0 and a value.

4.4.3 INPUTS

The stepper motor has eight inputs:

1. START switch (%T01203) The switch that turns on the program
2. STOP switch (%T01202) The switch that turns off the program
3. Right switch (%T00027) The switch that change that turns the rotation to the right.
4. Left switch (%T00018) The switch that change that turns the rotation to the left.
5. SELECTOR (%R00300) The selector with four velocities.
6. SLIDER (%R02500) The slider that permit us the analogic control of the step motor.
7. Change mode 4p (%T12000) switch that let us change to the four velocities program.
8. Change analog mode (%T12001) switch that let us change to the analog program.

4.4.4 OUTPUTS

The stepper motor has three outputs:

1. Rotation (%Q0003) The indicator that let us know the direction of the step motor.
2. Velocity (%Q0004) The indicator that let us know the speed of the pulses of the step motor.

4.4.5 SCREEN

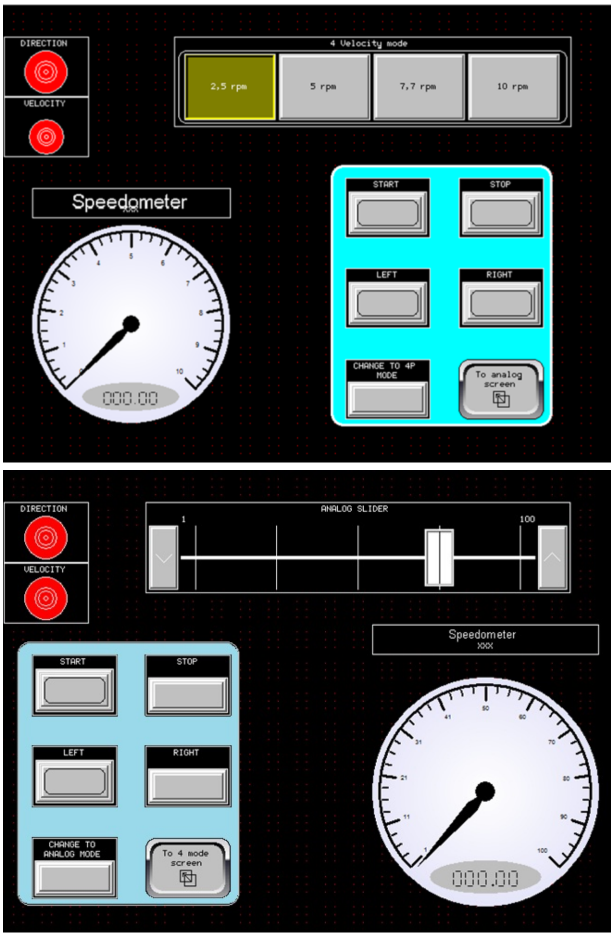

Figure 28. Step motor screens.

In Figure 28, are represented the control screens of the stepper motor. The first screen is for the 4-speed mode and the second is for the analog control. Both have buttons to start and stop the program, to change the rotation, and to change the screen in addition to a speedometer and and two lamps for pulses and rotation. The differences between these two are:

- The up screen has four buttons for different speeds and a button to switch to analog mode.
- The down screen has a slider to handle the speed and a button to switch to 4-speed mode.

4.4.6 CONTROL PROGRAM

Constructed control program is presented on Figures 29 – 35.

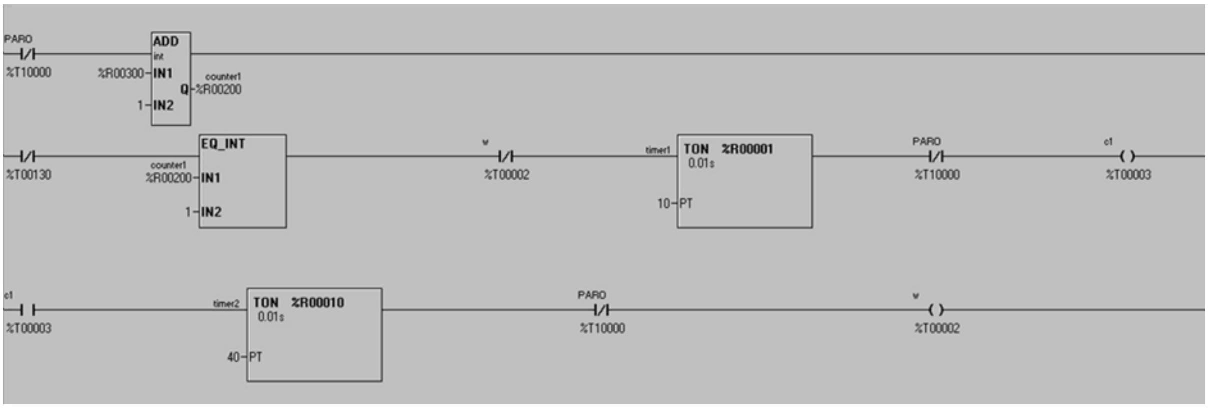

Figure 29. Part 1 of the step motor program.

In the Figure 29 is represented the four mode program, the first line it is only for the representation of the screen control. The other two lines are necessary for the steps of the motor, like in the previous program. This speed is the lowest of the four.

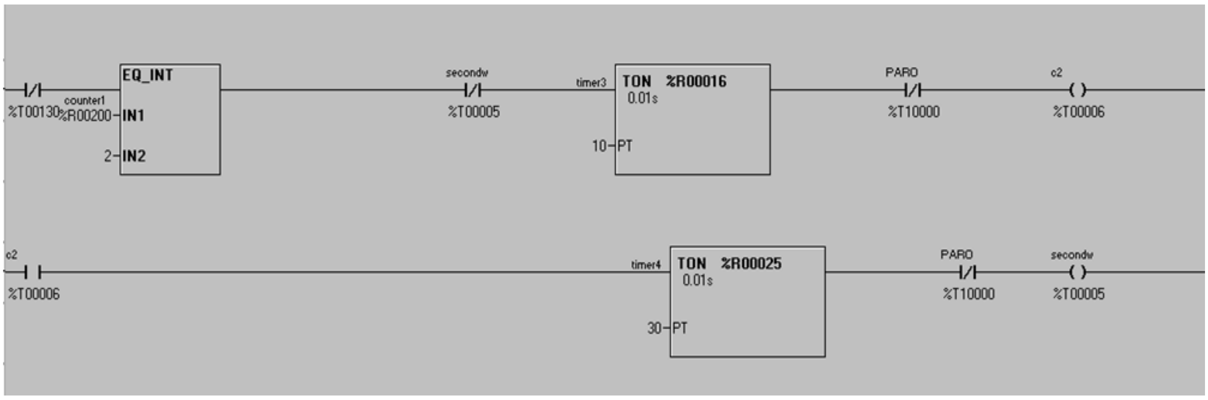

Figure 30. Part 2 of the step motor program.

In the figure 30 is represented the second lowest speed of the four mode program.

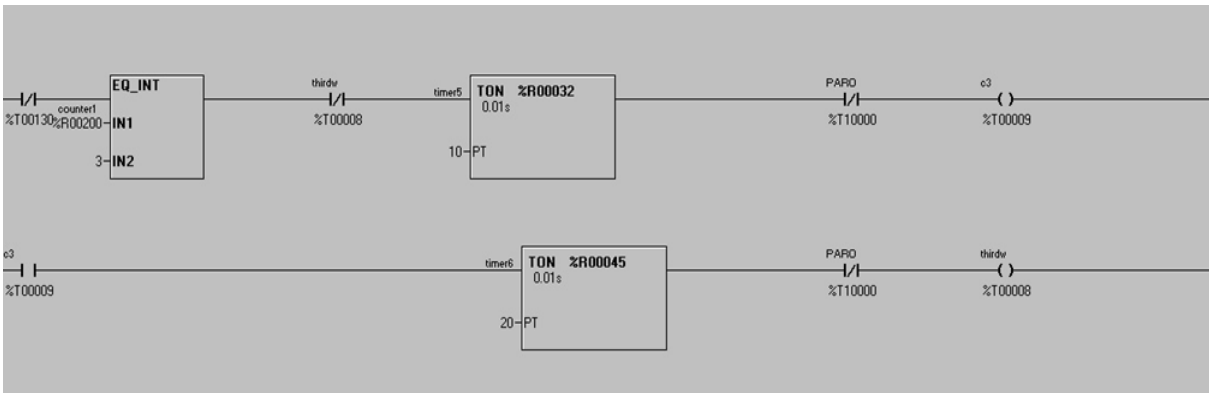

Figure 31. Part 3 of the step motor program.

In the Figure 31 is represented the second highest speed of the four mode program.

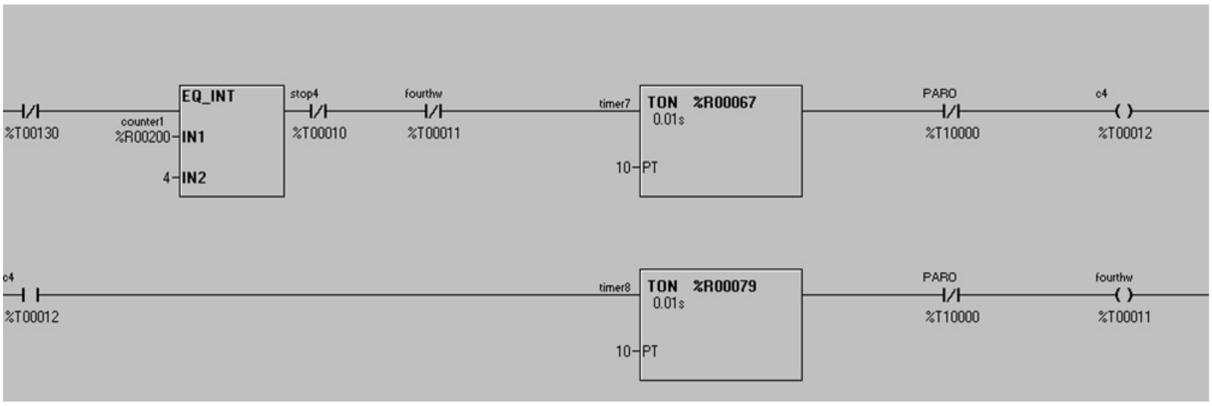

Figure 32. Part 4 of the step motor program.

In the Figure 32 is represented the top speed of the four mode program.

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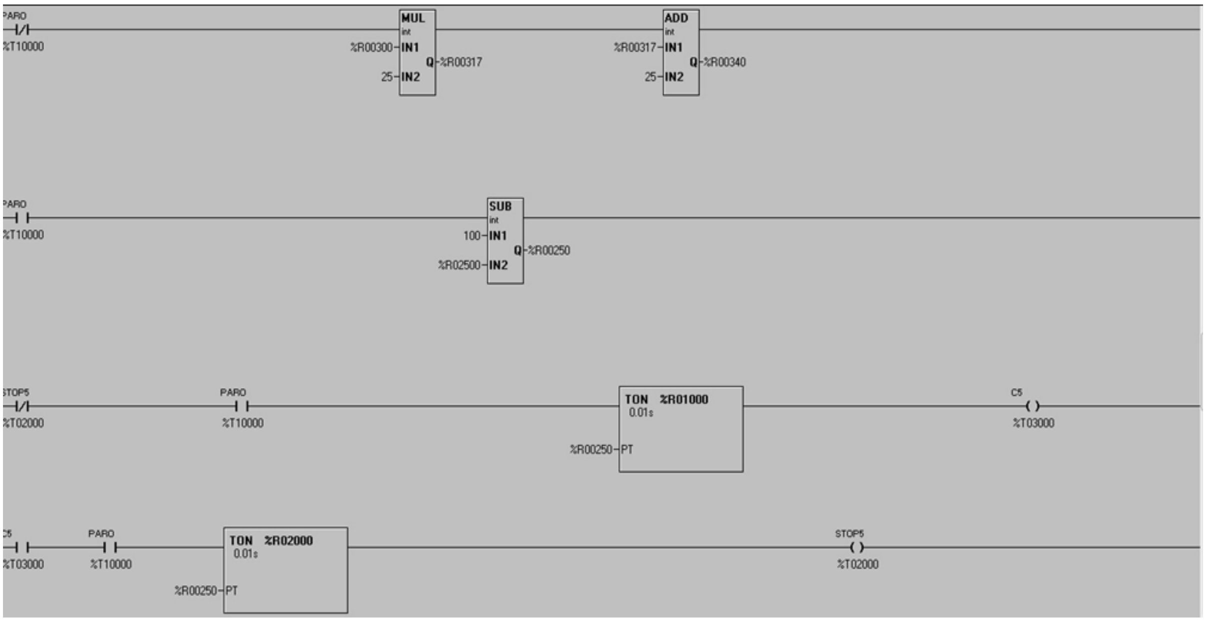

Figure 33. Part 5 of the step motor program.

In the Figure 33 is represented the real value that we need to the analog control. After that is introduced into the timers to reach the necessary value for the slider.

Figure 34. Part 6 of the step motor program.

In the Figure 34 is represented the compilation of all the temporary output signals in one output (clck2) and the feedback for the start switch.

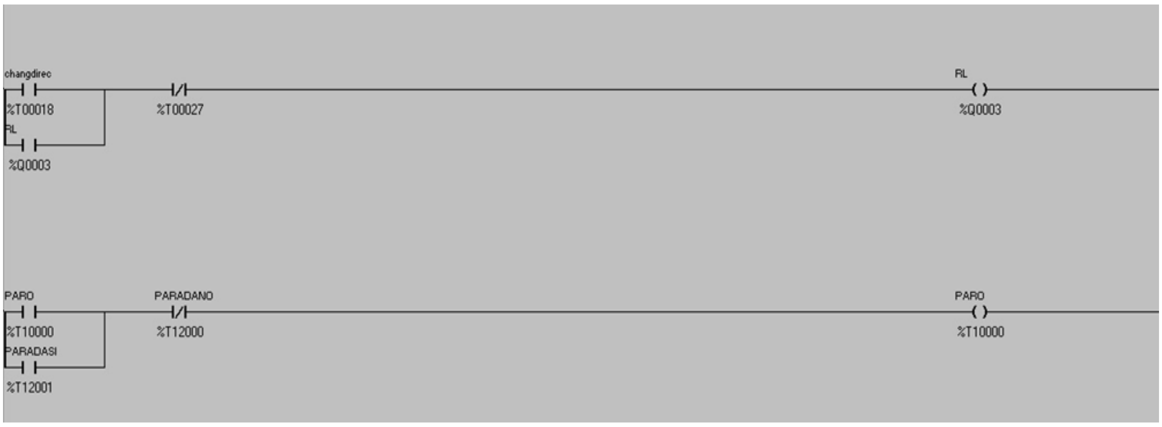

Figure 35. Part 7 of the step motor program.

In the Figure 35 are represented the two final lines of the control program which are necessary for the direction control (the first one) and the stop switch (the second one).

4.5 MATERIALS HANDLING SYSTEM

In the Figure 36 is possible to see the picture of the material handling system.

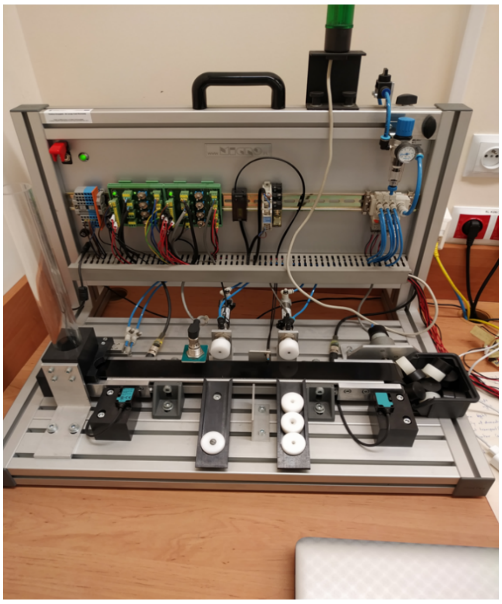

Figure 36. Picture of the materials handling system.

4.5.1 INTRODUCTION

It is a system that controls and classifies seventeen pieces of material according to its characteristics. These are the color and the presence of a metal inside it. We also have lights that give us information about the status of the program, if it is working, if there is a problem or if it is stopped. If the number of pieces exceeds a certain limit the band stops until we give back to the start button with the pieces already removed.

4.5.2 SCENARIO

- If the power button is pressed the program starts.
- If the off button is pressed the program stops.
- If the program works correctly, the green light will come on.
- If the program is stopped, the red light will come on.
- If the program has a problem, the orange light will turn on.
- If the overload sensors are activated, the program stops.

4.5.3 INPUTS

1. START switch (%I1) The switch that turns on the program.
2. SENSORLEFT (%I2) Pneumatic motor sensor left
3. SENSORRGHT (%I4) Pneumatic motor sensor right
4. METALSENSOR (%I5) Metal sensor
5. WHITESENSOR (%I6) White sensor
6. OVERLOADSLEFT (%I7) Overload sensor left

7. OVERLOADSRIGHT (%I8) Overload sensor right

4.5.4 OUTPUTS

1. OLIGHT (%Q4) Orange light
2. GLIGHT (%Q5) Green light
3. SUPPLIER (%Q6) Supplier of elements
4. RAIL (%Q7) Element transport
5. MOTORLEFT (%Q8) Pneumatic motor left
6. MOTORRIGHT (%Q9) Pneumatic motor right
7. RLIGHT (%Q10) Red light

4.5.5 SCREEN

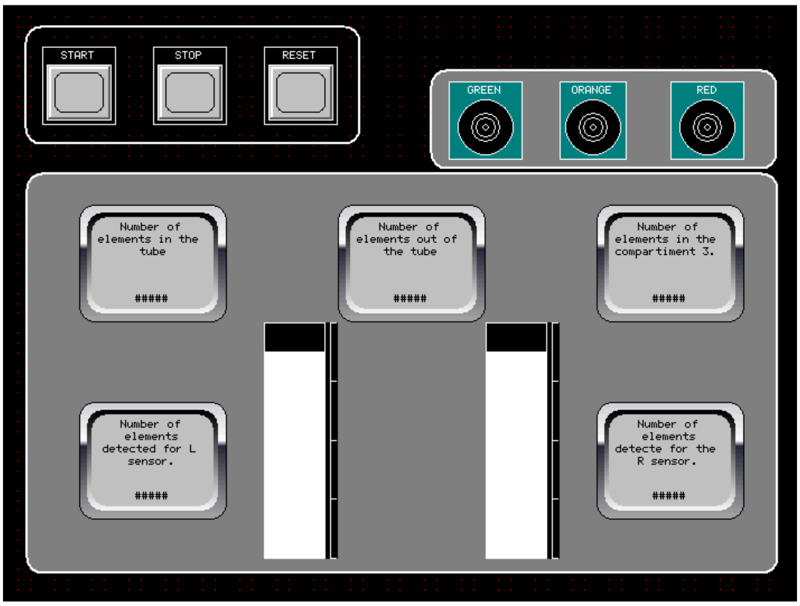

Figure 37. Materials handling system screen.

In Figure 37 the screen that controls the system is represented. The three lamps flash with different colors according to the problem as previously mentioned. As in the rest of the programs we have the shutdown buttons and a reset button that we will explain later. We have two bars that graphically represent the number of pieces that each sensor has detected and different blocks that represent the pieces of material that are in each site. These numbers and the bars will return to their default value if you press the reset button.

4.5.6 CONTROL PROGRAM

Constructed control program is presented on Figures 38 – 42.

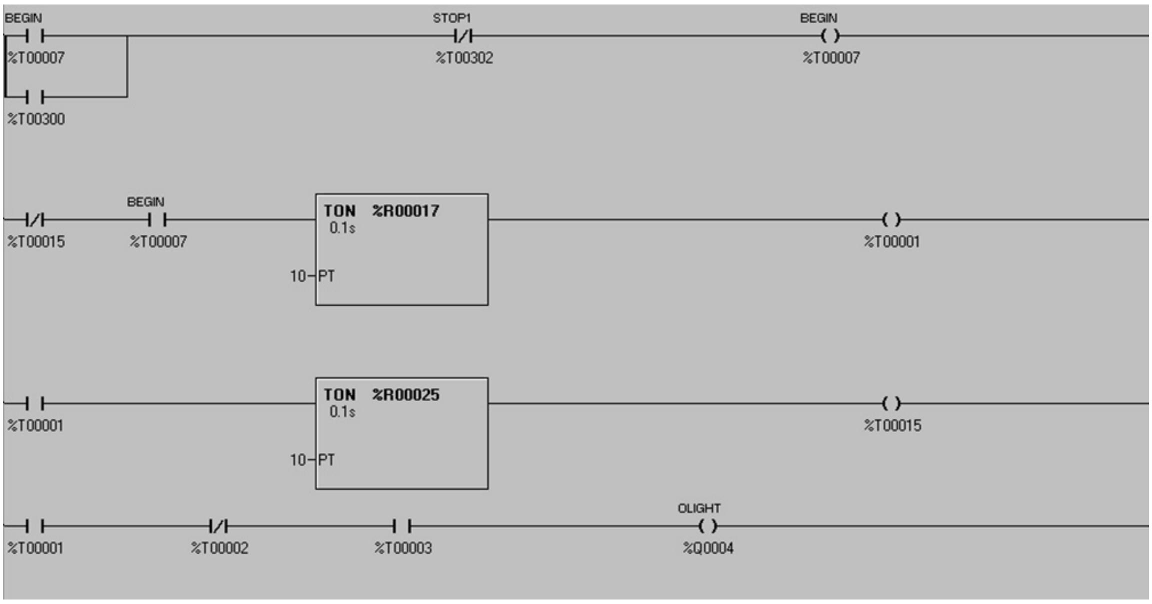

Figure 38. Part 1 of the material handling system.

In the Figure 38 is represented the same structure as in the previous programs. The closed loop and the two timers for the intermitent signal are also present in this first part of the program. The last line controls the orange light.

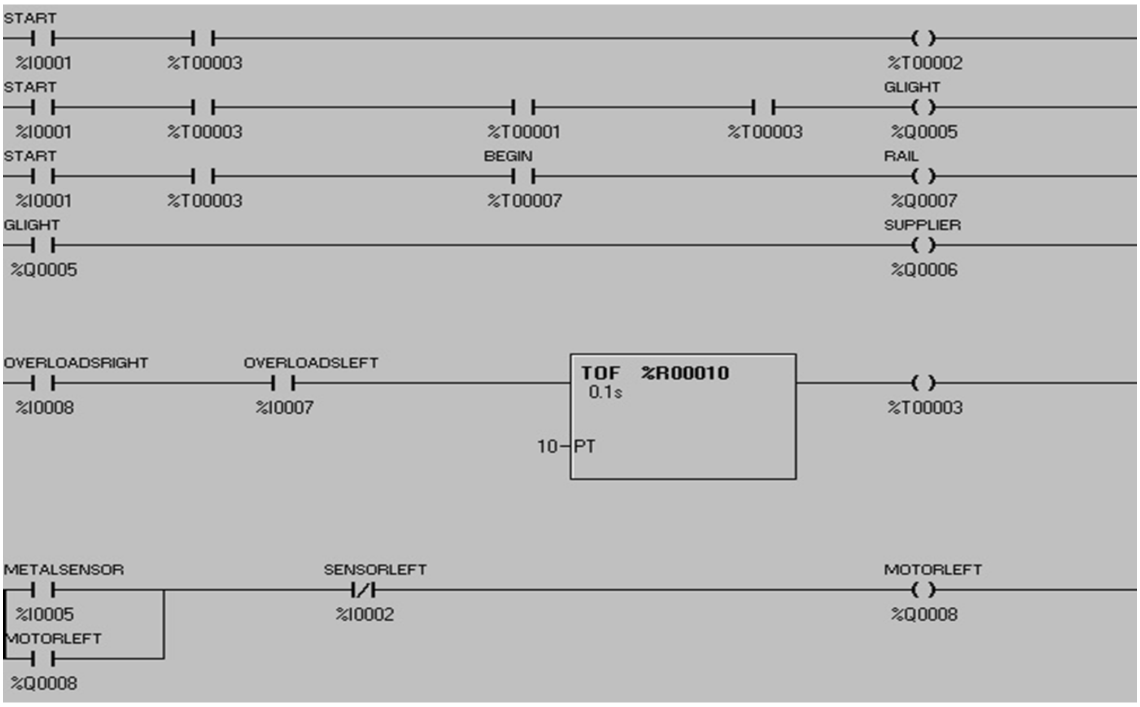

Figure 39. Part 2 of the material handling system.

In the figure 39 are represented two inputs and four outputs. The structure is the same only changing the on delay timer for the off delay timer. The motors are controlled by a closed loop feedback.

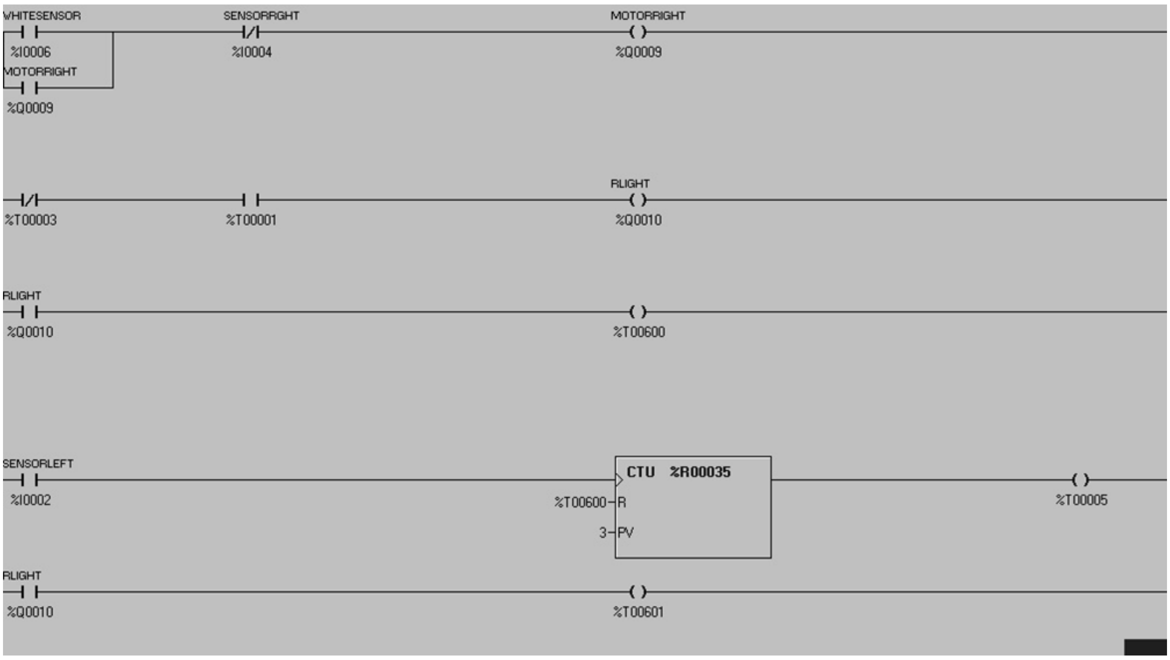

Figure 40. Part 3 of the material handling system control program.

In the figure 40 are represented another inputs and outputs. The first line controls the other motor. As always, we have the same structure having also a counter which give us the currently number of pieces that the left sensor detect. The second line controls the red light.

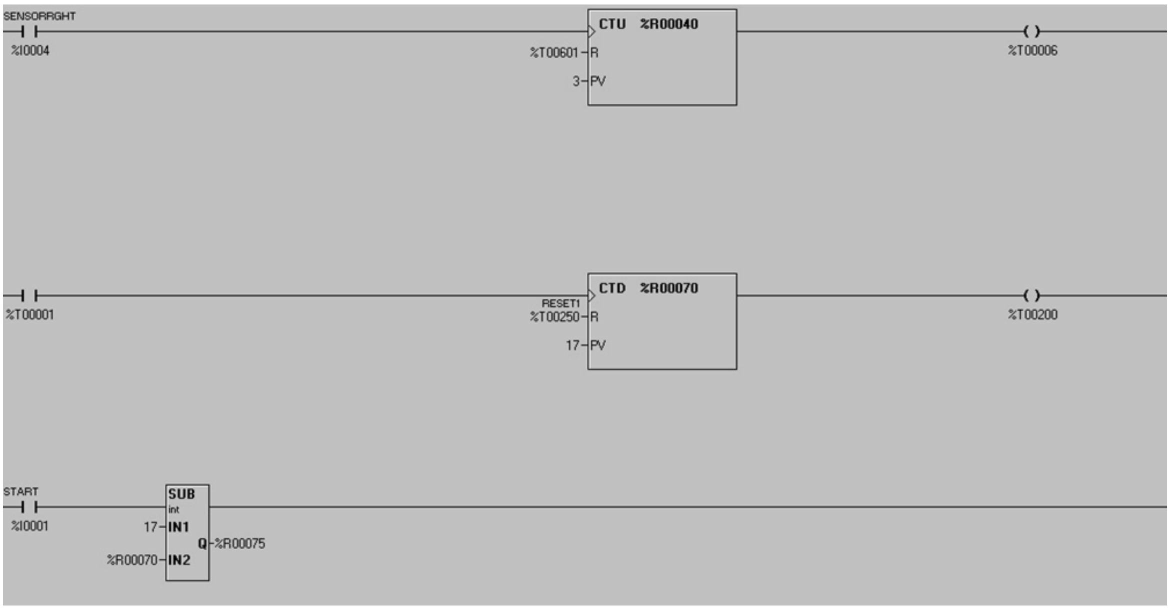

Figure 41. Part 4 of the material handling system control program.

In the figure 41 is represented the control program of the right sensor and the number of pieces that we have in the tube in every moment. The counter for the right sensor is in the first line. There are a difference between this second line and the other programs, previously we had an up counter to count the number of pulses (in the motor) or to detect number of pieces (this program), but now we have a down counter which starts from the full number of pieces and goes down when some of the pieces are detected. The operational function of the last line of the picture is one of the three that we need to reach the number of pieces we have in the last box.

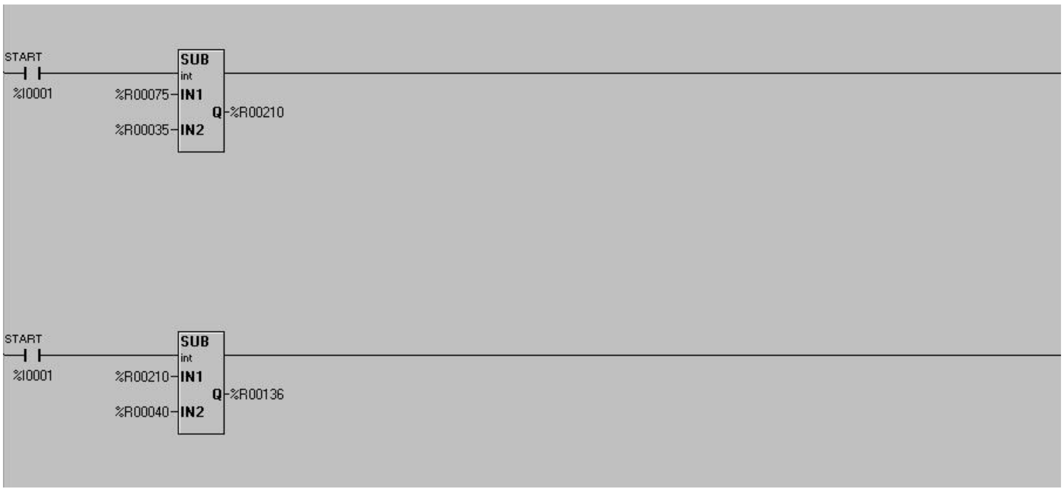

Figure 42. Part 5 of the material handling system control program.

In the figure 42 are represented the other two functions that are necessary for counting the materials which are in the box.

5 CONCLUSIONS

The objective of the project was to realize three different projects with an HMI screen.

Using a screen to control the system compared with the traditional system gives incredible advantages:

- The elements on the screen can be represented in a clearer and more concise way.

- Each program has a screen adapted to it, unlike the generic buttons.

- The use of this one is much more intuitive and graphic than the traditional method.

- It does not depend on mechanical elements, which give more problems.

According to the last point, there were problems with one of the mechanical devices, to which the inputs and outputs were connected, but was solutioned quickly.

The major difference between the programming in cimplicity and cscape is the impossibility to create a normal switch, this is the reason why there are so many closed loops, because it is the only way to replace these switches having one to start and one to stop.

It would have been better to have more options to design the graphic interface and make it more realistic and easier to manage, but because of the time and the options that the program gave, it was not possible. In the end, the most important part that was that the programs worked as planned was a success, so the goal was achieved.

6 LITERATURE

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