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TFG REALIZADO EN PROGRAMA DE INTERCAMBIO

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ABSTRACT

This document is the final thesis of the degree of Electrical and Automation Engineering. It contains the mechanic, electric, electronic, automatic and pneumatic design approach and the manufacture, programming and construction of the small-scale machine classifier of pieces. This classification will be made according to different configurable characteristics by the user through a touch panel. The main objective of this project is to integrate the machine into the university itself as a means of learning for engineering students. The machine will be composed of a mechanical part, an electrical and pneumatic part, and an electronic and automatic control system. All of them will work together to get the full operation of the machine with two operating modes, automatic and manual. The machine is going to be connected to a robot so that a small-scale industrial automatic process can be simulated. It is going to be used as a learning element method in University of HAMK.

KEYWORDS

Classifier of pieces, programming, PLC or programmable logic controller, sensor, engine.

Pages 65 pages including appendices 103 pages.

CONTENTS

1 INTRODUCTION AND OBJECTIVES

1.1 Background of the project

When we talk about a piece sorting machine we imagine a big machine in which we can introduce several things and all of them are sorted according to some criteria. Well, this project will be something similar to this first idea, although on a small scale.
First of all we have to understand what a machine is and everything that goes with it. The term machine can be defined as "any manufactured object and composed a set of interlocking parts, which is used to facilitate a particular job, usually by transforming a form of energy into movement or work" (Oxford Dictionaries 2016). As we can see in figure 1, a machine consists of a transmitting system and a supporting system, is driven by a drive system and acts on a receiving system.

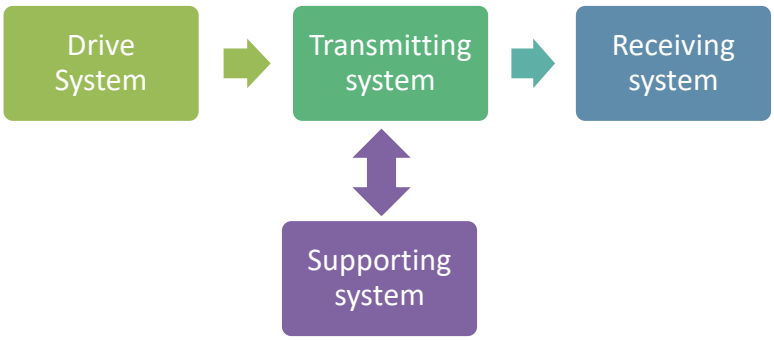

Figure 1- Operating scheme of a machine

Among the main components of a machine we can highlight the motor or motors, which will be in charge of generating and transforming energy into work (motors are also considered as machines) and the mechanisms, which will transform the energy provided by the motor into a useful effect (J.C. García Prada, C. Castejón Sisamón & H. Rubio Alonso n.d. 1-7). In conclusion, we can say that the machines have the objective of making people's work easier.

The machine we are going to create will serve as a learning method in the use and implementation of programmable logic controllers. This type of controller, more commonly known as a PLC, is an electronic machine designed to control sequential control processes in real time and industrial environments. Its programming and operation can be carried out by personnel with electrical or electronic knowledge, with

minimal previous knowledge of computers. (Vallejo, H. D & la Web 2005.) Therefore it is a very common area within engineering.
These devices were born in the beginning of the 1970s when industries sought to reduce costs in control systems as substitutes for relay-based control systems. These devices have been a great revolution within the industry and automation, as they adapt to any type of process, environment and situation, providing them with great flexibility and versatility. This electronic device is digitally operated and uses a programmable memory for the internal storage of specific instructions such as logic, sequential, timing, counting and arithmetic, among others, to control several machines or processes through digital or analog input or output modules. The programmable logic is a family of components that contains sets of logic elements, which can be configured to meet the desired function or the function supported by the component. The external structure of these controllers is compact, as all the elements are grouped together in a single enclosure. It should be noted that they are modular systems and therefore we can add to our PLC as many peripheral devices as necessary, such as analog and digital input or output modules. (Vallejo, H. D & la Web 2005.)

Regarding the internal structure, it is formed by a memory that has an operating system and will be responsible for storing the data and states, as well as the internal variables and the program or set of instructions created by the user. It also has a CPU or central processing unit, which will be responsible for running the program, monitoring the execution time (Watchdog) and performing a system check during the work cycle. Other internal components are the input and output units, which can be digital if based on the all-or-nothing principle, or analog if they can be worth any value within a specified range, and the interface, which allows the PLC to communicate with a computer. In the figure 2 we can see a summary of the internal structure of a PLC.

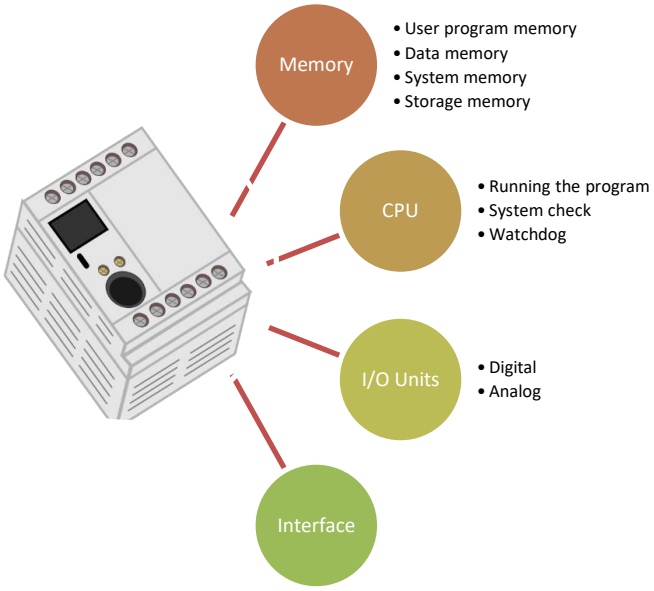

Figure 2- Internal structure of a PLC

Once we know the elements that make up a PLC we can understand how it works. We are going to follow the scheme showed in figure 3 to explain the work cycle. First, the user will create and load a program into the controller through its interface. After this has been done the controller will start working with its work cycle. The first time it will receive a series of inputs, and according to these will make a selection of the functions to be performed, then runs the user program, selects the actuation outputs and apply the corresponding actuators, and finally it will monitor the Watchdog. It will then run the program cyclically again until it is stopped by the user or other cause.

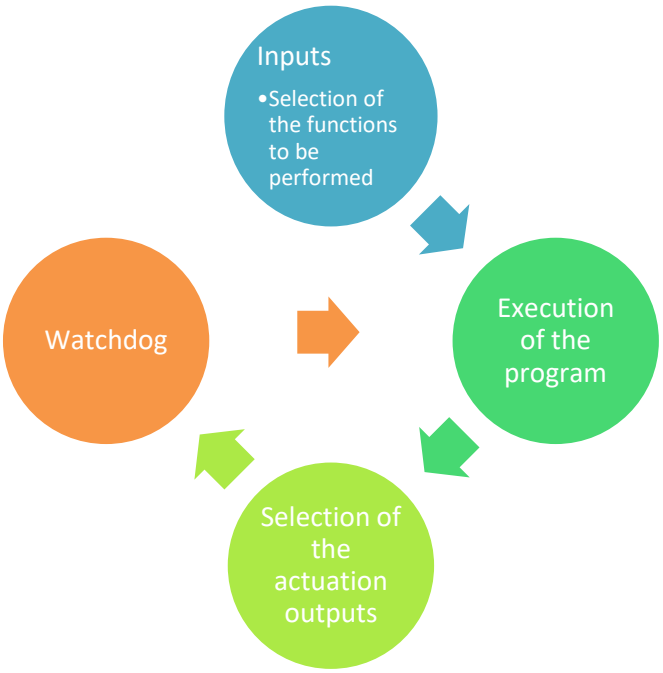

Figure 3- Work cycle of the PLC

The PLC is a device widely used in industrial automation as it is used as a controller of electromechanical processes such as factory assembly lines, machines or other industrial processes. They are able to control movement, be part of distributed control systems, make decisions based on programmed instructions and even communicate through the network with other devices. In addition, they provide numerous advantages, such as the reduction of materials to be used and manpower, their large storage capacity, less time spent on projects, among others. It should be noted that the technician in charge of programming must be properly trained to do this, in addition to the high initial costs that the client will have to incur, although in the long term it will be a profitable, effective and efficient system.

1.2 **Objectives of the project**

The main objective of this thesis is to create a machine capable of selecting and classifying different pieces according to certain user-configurable characteristics. The machine can perform the task automatically without the need for human intervention. This machine will be integrated into the university as a learning element for students. It could also be used for industrial applications, such as waste separation, metal separation, package sorting, …

In order to achieve the general objective, several more specific objectives are proposed:

- Selection of all the materials with which the machine will be built, after a market study, in accordance with the specifications.
- Mechanical design of the parts of the machine.
- Production of the necessary parts by means of 3D printing. Mechanical assembly and adjustments.
- Electrical and pneumatic design of the wiring system using electrical schemes.
- Realization of all necessary electrical and pneumatic connections.
- Realization of a control program using a PLC and a touch screen.
- Commissioning and start-up of the machine, making the necessary adjustments and analysing the results.

The user must select the sorting criteria, according to the characteristics of the pieces, through the touch screen, then proceed to place the different parts at the beginning of the conveyor belt 1 and the machine will do its job. It will only be able to order 2 different types of pieces, those that do not correspond to any of these two types will be discarded, and those that are in doubt due to their analysis will be returned at the beginning of the machine.
It should be noted that the placement of the pieces at the beginning of the process can be done by a robot, thus allowing connection with another type of previous process or machine.

1.3 Parts of the project

Every project consists of several parts. As we can see in figure 4, first we have the specifications of the system or client, in our case the University of HAMK, then we will carry out the mechanical, electrical and pneumatic design as well as the control design, which in our case will be the PLC, that is, we carry out both the hardware and the software of our machine. Once we have all the above we will have the virtual prototype finished, so we can proceed to manufacture, build and implement the physical prototype. Finally we have to verify the final physical prototype by performing various tests and trials to proceed to correct the errors that may arise.

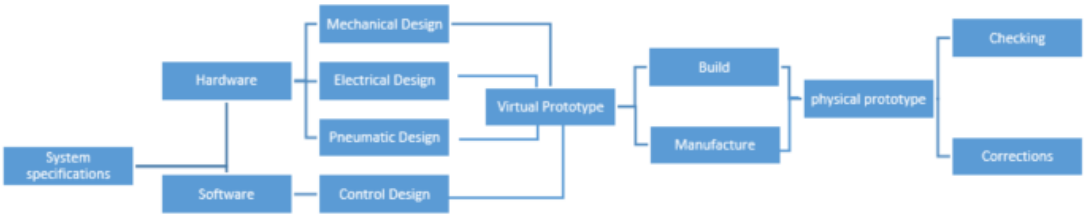

Figure 4-Parts of a project scheme

2 SPECIFICATIONS

The technical specifications of a project are all the standards, requirements and procedures that must be used and applied in its development. In general, these are given by the client. In our case the client will be the University of HAMK, which requires:

- The use of:
  - Two conveyor belts already built.
  - A gantry crane.
  - Pneumatic Systems.
  - Reused material.
  - PLC of the Beckhoff brand.
  - Touch Panel of the Beckhoff brand.
  - Different types of sensors, at our own choice.
  - Two Beckhoff stepper motors.
  - Two DC motors.
  - 3D printer for the manufacture of some pieces.

- The realization of:
  - List and bill of material
  - Electrical schemes.
  - Pneumatic schemes.
  - Programming with TwinCat.
  - Electrical panel.
  - Control manual panel.
  - Programming a graphical interface

3 MATERIAL

In order to choose the material, we must take into account the specifications mentioned above, in addition to carrying out a small market study to assess the options available in it for each product.

3.1 PLC and Touch panel

The market for programmable controllers is very large and moves large amounts of money. There are numerous manufacturers of PLCs and industrial touch panels, including SIEMENS, Rockwell Automation Allen Bradley, Mitsubishi Electric Corporation, Schneider Electric and OMRON, which are the most widely used brands worldwide as we can see in figure 5, although there are many other emerging brands or smaller vendors. It should also be noted that in each continent or even in each country, a particular brand predominates.

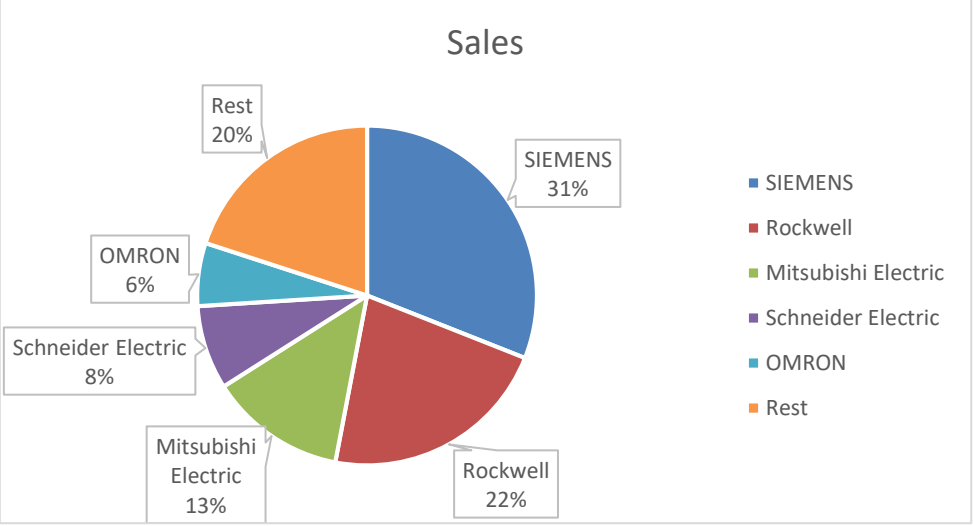

Figure 5- PLC sales in the global market (Global Market Share of PLC Brands 2012).

Among these emerging brands is Beckhoff, founded in 1980 by Hans Beckhoff in Germany. Since then, it has experienced great growth in the international market year after year, which we can see reflected in its sales level. Its great growth has been thanks to subsidiary companies and to the global cooperation with partners. This company is present all over the world, on all continents. (Beckhoff n.d.) In the next figure we can see the evolution of the sales of Beckhoff Company.

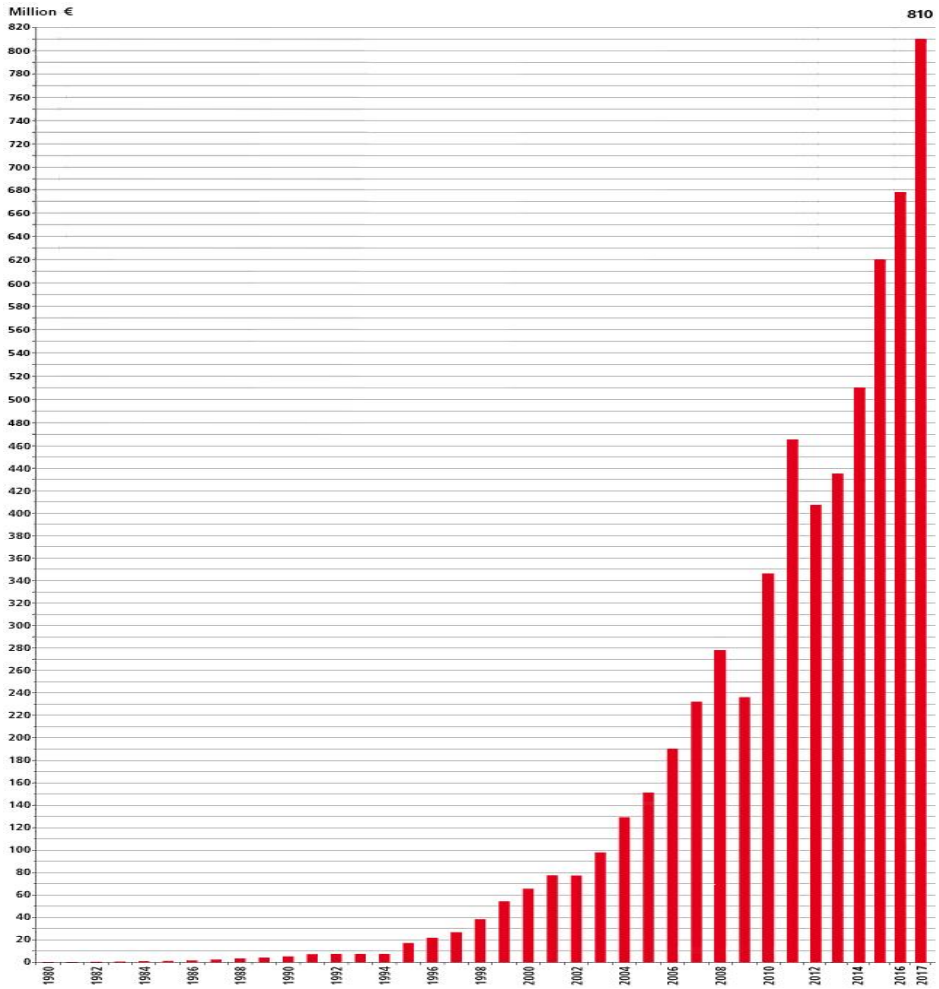

Figure 6- Beckhoff sales trend (Beckhoff n.d.).

One of the initial specifications was to use this brand of PLC. We will have a PLC with a built-in touch panel CP2215-0020 (figure 7), as well as other essential complements for its operation, detailed in Annex 3.

Figure 7- PLC and Touch Panel CP2215-0020

3.2 Sensors

There are a large number of sensors to measure different physical quantities, so we will start from a classification to be able to make a later choice of which must contain the classifier. We will establish the classification that most closely approximates to the point of view of the electronic engineering, that is, we will classify the sensors according to the variable parameter. (Giner, P., Cetina, C., Fons, J. & Pelechano 2010.) Although we will also have to take into account its corresponding classification according to the criteria of the type of electrical signal generated. In the following figure (figure 8) we can see the classification according to these two criteria.

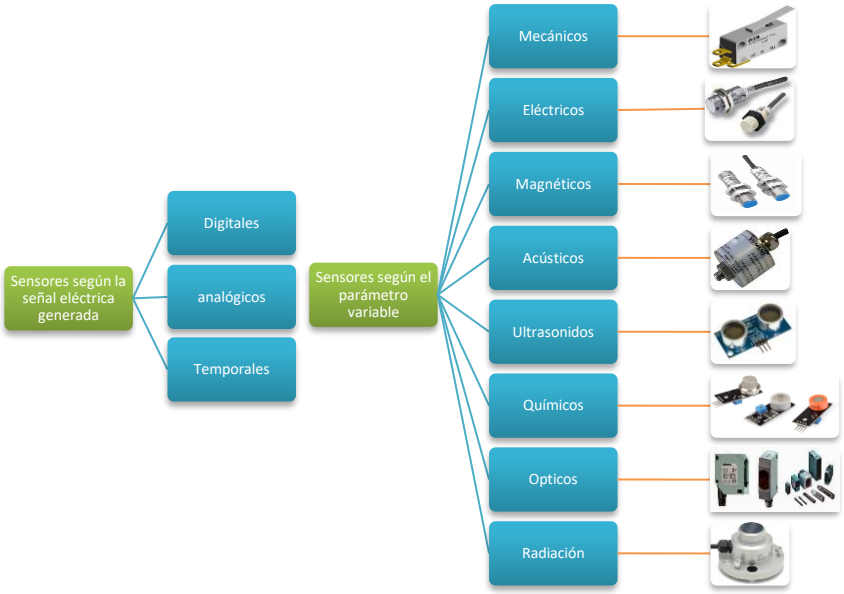

Figure 8- Classification of the sensors

Mechanical sensors are those that use mechanical contacts that open or close to measure magnitudes such as position, shape, speed, force, torque, pressure, vibration, deformation and mass (Serna, A., Ros, F., & Rico, J. C. 2010). The machine requires this type of sensors to measure the position of the stepper motors and to limit their movement, so 4 limit switches have been used. These will provide us with a digital output signal.

On the other hand, there are electrical sensors used to measure voltage, current, load and conductivity. Within this group are the inductive and capacitive sensors. The inductive are capable of detecting metals, even through opaque plastic, and the capacitive detect both metals and non-metals, that when approaching their active surface exceed a certain

capacity. (Type of sensors n.d.). In this case the machine will use 2 inductive sensors for metal detection.

Magnetic sensors are able to detect magnetic fields from magnets or electric currents (Sensors n.d.). The sorter will use 2 magnetic sensors to detect pieces composed of magnetic material.

Optical sensors are generally capable of measuring magnitudes such as position, velocity and deformation, as well as characteristics or different factors of an object through an optical lens. There are numerous sensors within the field of optics.

Within this group are the photoelectric sensors or photocells, which emit a response according to a change in light intensity. They consist of an emitter and a receiver, and depending on how the reflection occurs, there are several types:

- Light barrier photoelectric sensor, which consists of two parts, an emitter and a receiver component.
- Mirror-reflective photoelectric sensor, which contains both the receiver and the emitter in the same body and the reflection takes place on a retro-reflector or mirror
- Object-reflective photoelectric sensor, which also consists of a single body and which, as its name indicates, reflects directly on the object to be detected.

In this case, 4 photocells with mirror reflection and infrared system will be used, as they have a high response reliability regardless of the appearance and material of the element to be detected and also involves an easy wiring process. As a mirror we will use 4 retro-reflectors.

Another type of optical sensor is the colour sensor, which emits a response based on the colour detected on its surface. This response is produced after a calculation of the chromatic coordinates according to the reflected radiation and its comparison with the previously stored chromatic values. It uses 3 LEDs (R, G, and B) as light source and a receiving lens. A sensor of this type shall be used to detect pieces of specific colours and to classify them according to this characteristic.

The laser distance sensors measure a distance without any displacement or friction on the workpiece. They can also be included within the group of optical sensors. They contain a laser light emitter, which will emit a beam with different frequencies on a surface and a receiver, which will receive the signal reflected on the object to be measured. The machine must be equipped with this type of sensor to measure the distance at which an object is located and to be able to obtain its current position so that the grippers can be positioned at the exact point where the piece can be picked up.

As for the sensor brands, after a study of the main manufacturers and options on the market, Pepperl+fuchs will be used for the new sensors acquired, as it is the most economical. Reused OMRON sensors will also be used. In the table 1 we can see all the sensors we have used.

Table 1- Sensors used in the machine

Sensor	Reference	Brand	Nunber	Photo
Switch	-	Honneywell y otras	4	
Inductive	NBB8-18GM50-E2	Pepperl+Fluchs	2	
Magnetic	MMB60-12GH50-E2-V1	Pepperl+Fluchs	2	
Photoelectric	E3F-R2B4	OMRON	2	
Photoelectric	OBR7500-R100-2EP-IO-0,3M-V1	Pepperl+Fluchs	2	
Colour	DF12-11-3K/145/151	Pepperl+Fluchs	1	
Distance	VDM28-8-L1-IO/73c/110/122	Pepperl+Fluchs	1	

It should also be added that each sensor will have its own connection cable or other components necessary for its operation or programming. All the elements used are listed in Annex 3 and all their characteristics in Annex 4.

The distance sensor has different parameters that must be set via an IO-Link system and the PactWare4.1 software.

3.3 Inputs and Outputs modules

As specified, the brand of the PLC that will be used will be Beckhoff, so we must choose a communication protocol with our PLC. With the intention of using one of the most effective, efficient and fast at the moment, EtherCAT communication will be used. It is a high-performance industrial communication protocol that works in real time based on Ethernet. This fieldbus system transports data directly into a standard Ethernet data packet or frame, without changing its basic structure. In addition, EtherCAT slave devices can read the data addressed to them and write input data at the same time as the frame is transmitted to the rest of the network. The effective data rates are higher than 100Mbits/s because the data rate is over 90% of the available bandwidth. It should be noted that EtherCAT networks are easily configurable according to their application. (Hbm 2017). The operation of this protocol is done as follows: one or more slave controllers must be connected to input and/or output terminals; the controller will read the data relevant to the device as the frame passes through it while the input data is being inserted into the data stream at the same time. Once all the data has been transmitted, the slave recognizes and executes the relevant commands. Therefore the process will be implemented by hardware in the slave controller, thus being independent of the software runtimes. Once the last EtherCAT slave returns the fully processed data stream to the first slave, it is sent back to the master as a response telegram. (Beckhoff n.d.).

In the case of the sorting machine, a synchronization of several measuring modules or fast and precise input and output modules with a single controller is required, so this EtherCAT communication protocol is used with the PLC.

The module that will act as slave controller will be the EK1100. This will convert the telegrams that pass from Ethernet 100BASE-TX to the E-bus signal representation (Figure 9).

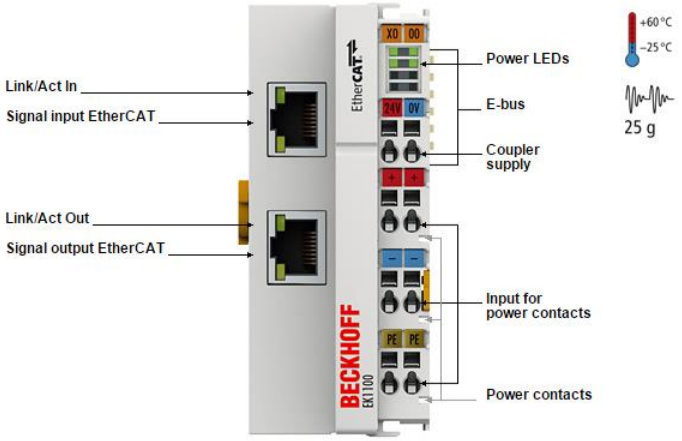

Figure 9-EtheCAT module EK1100

Any number of EtherCAT input and/or output terminals of Beckhoff ELxxxx type can be connected. Therefore we will have to evaluate which types of terminals are required and because of this we will take into account the first classification of sensors that we have in the Figure 8, types of sensors according to the electrical signal generated. We also have to take into account that we will need other inputs and outputs, such as those of the 2 stepper motors, the 3 solenoid valves, the 2 DC motors, the manual control panel and the connections with the robot. Therefore we will need the following input and output terminals:

– EL9188, power distribution terminal to extend the 24 V supply outputs (Figure 10).

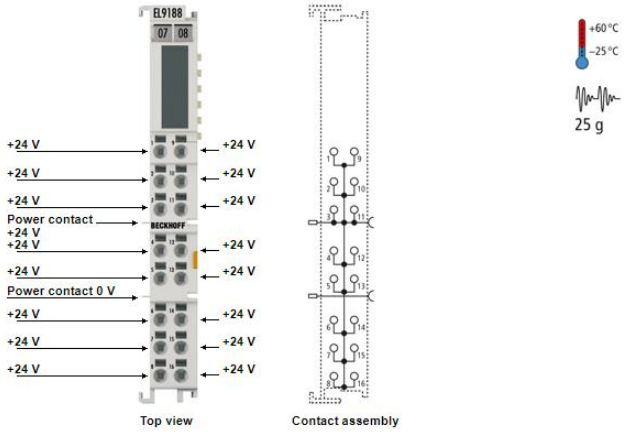

Figure 10- EL9188 module

– EL9189, power distribution terminal to extend the terminals that supply 0V (Figure 11).

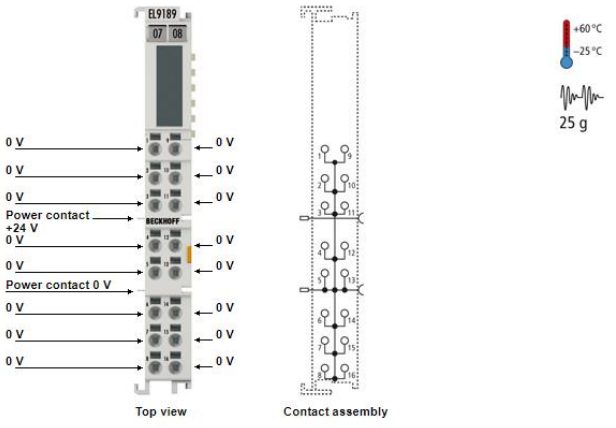

Figure 11- EL9189 module

– EL1008, 8 digital input terminal with 3ms input filter. Of this type, three identical terminals will be used (Figure 12).

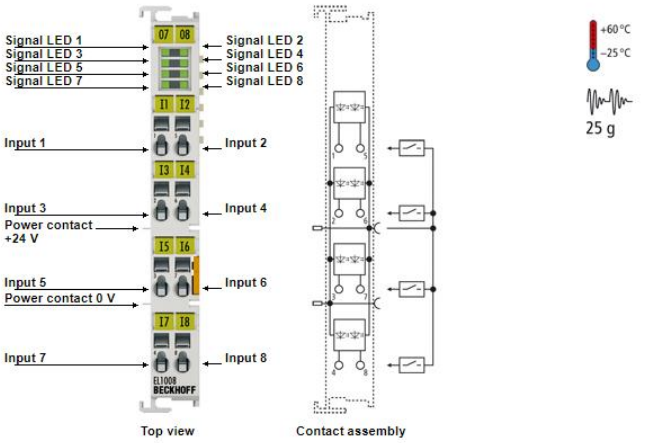

Figure 12-EL 1008 module

– EL2002, terminal with 2 digital output channels. Two of these will be used (Figure 13).

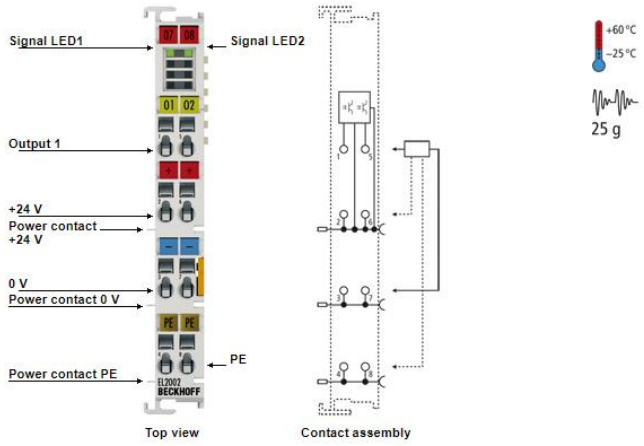

Figure 13- EL 2002 module

– EL2004, terminal with 4 digital output channels. Two of these will be used (Figure 14).

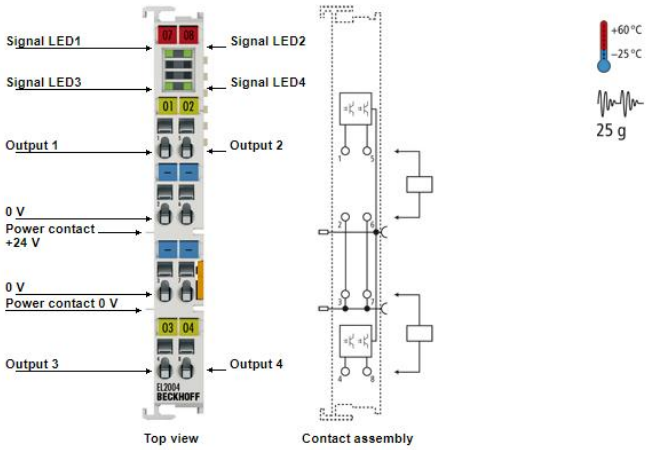

Figure 14- EL2004 module

– EL3054, terminal with 4 analog inputs channels of 4 to 20 mA (Figure 15).

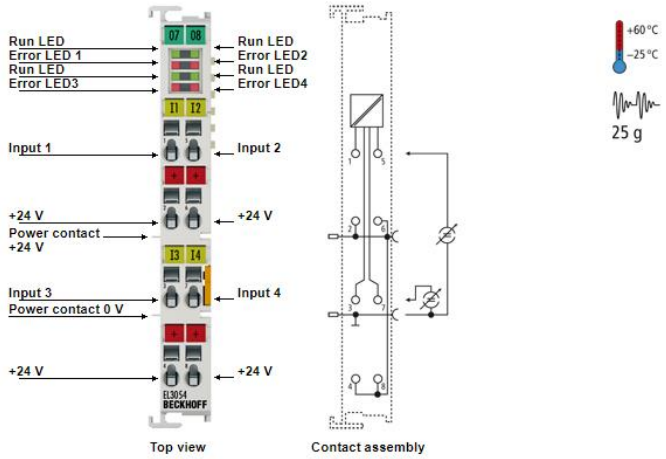

Figure 15- EL3054 module

– EL7332, terminal with 2 outputs channels of 24V and 1A for the control of two DC motors (Figure 16).

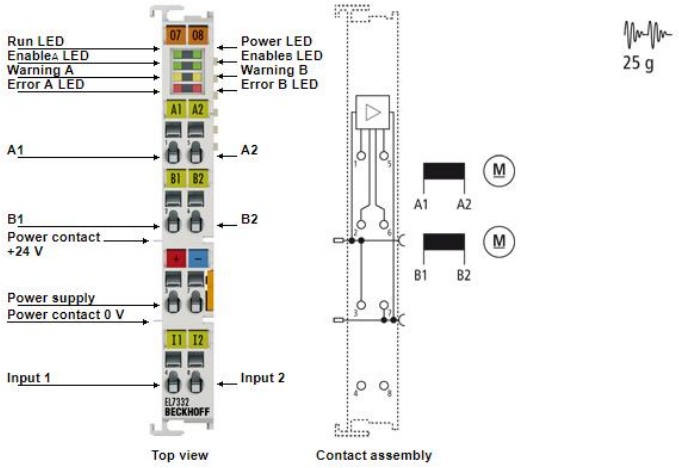

Figure 16- EL7332 module

– EL7031, terminal for the control of a 24V and 1,5A stepper motor. We will need one for each engine, that is, two in total (Figure 17).

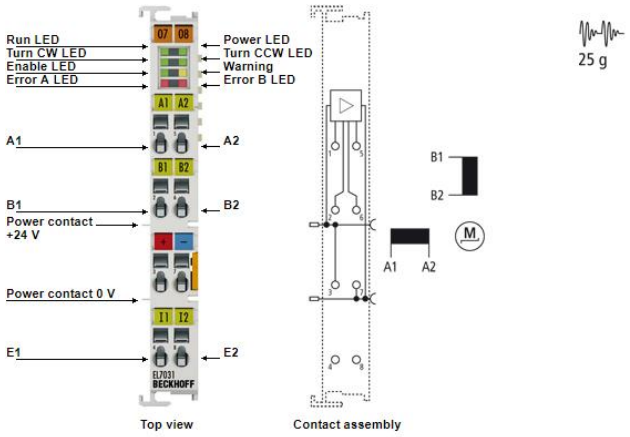

Figure 17- EL7031 module

3.4 **Motors**

The machine will have two motors for the movement of the conveyor belts, as it is a continuous movement, two continuous motors will be used. On the other hand it will have two stepper motors for the vertical and horizontal movement of the gripper.
Two different brands will be used for the DC motors to take advantage of the material currently in stock, so the following models have been chosen:

- One of the DC motors shall be of the Nidec brand with a rated voltage of 24V and a rated current of 0.5A (Figure 18).

Figure 18 – DC Motor Nidec GMAG 402 781

- The other motor will be of the brand Micromotors with a nominal voltage of 24V and a nominal current of 0.34A (Figure 19).

Figure 19 – DC Motor Micromotors RH158-24-75

The stepper motors will be both of the Beckhoff brand AS1030-0000, with a rated current of 1.5A and a voltage ranging from 24V to 50V (Figure 20).

Figure 20 – Stepper Motor Beckhoff AS 1030-0000

The connector of this type of motor is of the pre-assembled M12 type and in order to connect it correctly to the EL7031 terminal mentioned above, we must use a cable of the type ZK4000-6700-2XXX type (Figure 21).

Figure 21 – Beckhoff cable ZK4000-6700-2XXX

All the characteristics of each of the engines can be found in the data sheets in Annex 4.

3.5 Electro-valves and Pneumatic control

In order to control all the possible aspects of the pneumatic part of the machine, a manual control panel will be built with a switch that allows pressure to be introduced into the circuit or to be cut off depending on its position, a pressure regulator to select the bars that we want to have in our circuit, it will also have two exhaust air regulators and a manometer or pressure gauge. There will also be 4 buttons for manual activation of each of the solenoid valves.
The solenoid valves shall be 3/2-way solenoid actuating valves with a multiple tube design as we can see in figure 22, acting in a direction with spring-return. They must be connected to a voltage of 24 V and allow a maximum of 8 bar, but we will set the limit into 6 bar to avoid danger and damage to the circuit. The rest of the characteristics of these valves can be found in their data sheet in Annex 4.

Figure 22-Festo Valves BMFH-2-3-M5

3.6 **Manual control panel**

A manual control panel for the machine itself must be built so that it can be used in case of failure of the touch screen and for safety reasons. First of all, a main or general switch will be placed to switch the machine on and off (Figure 23).

Figure 23-General switch

It will also contain 3 buttons with LEDs, of Schneider electric brand (Figure 24):

- A green flush button that will activate the cycle.
- A red one flush button to stop the car.
- A yellow push button that will reset the whole process to start again.

Figure 24- Schneider electric buttons

In addition, an emergency safety button will be inserted to stop the entire process automatically (Figure 25).

Figure 25- Emergency safety button

4 DESIGN

4.1 Mechanical design

The mechanical design is one of the most important parts of the project, as it will determine how to make the rest of the designs. In engineering, mechanical design is not only the process of sizing and shaping a machine, but also involves other aspects such as the choice of materials to be used in manufacturing and operating technology so that it is able to perform its functions correctly.

To do that in as much detail as possible, the Autodesk Inventor program has been used. With this program we can create 3D models by making different pieces separately and then joining them together in the same work plane. This is the procedure followed to obtain the final design. Below are each of the pieces separately and then the final result as a whole.

First, the design of the conveyor belts has been carried out (figure 26), which will be made up of various parts, such as the metal structure, the motors and the belt, among others.

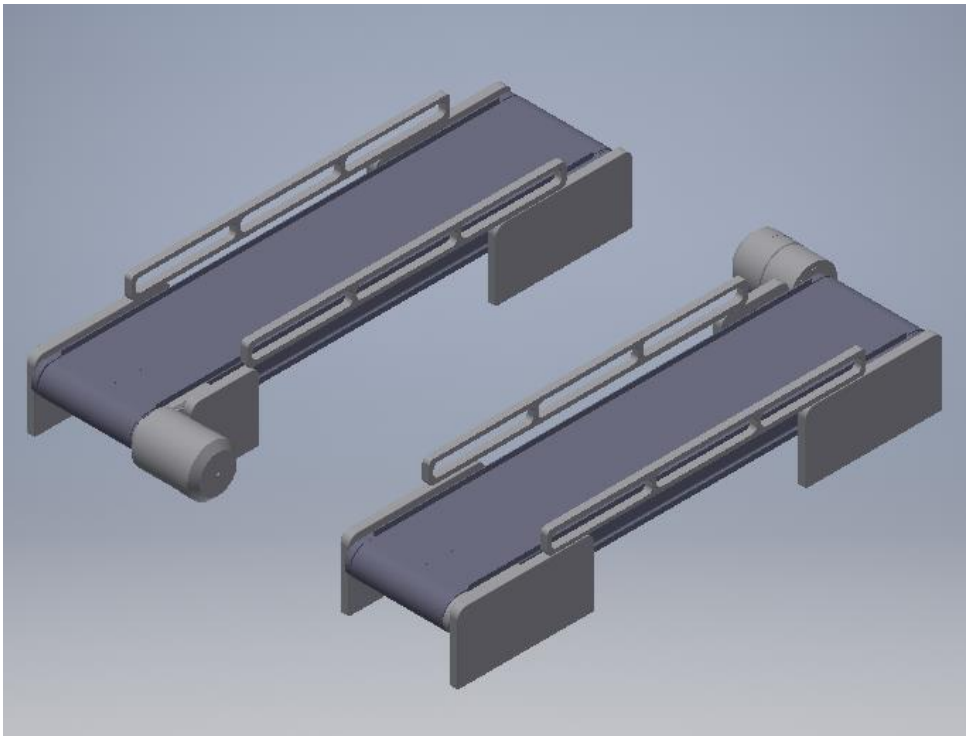

Figure 26 – Design of the conveyor belts in AutoCad Inventor

As we can see in the drawing, the conveyor belts will be placed in parallel, with the DC motors on the inside part to take up as little space as possible. We can also see that each conveyor has 4 metal supports, two on each side to raise it from the ground level. Finally, it is worth

mentioning the inclusion of two lanes, one on each side of the conveyor belt, to be able to connect the detectors we are going to use.

Next we have to make the bridge that will support the grippers, responsible of taking the corresponding pieces and changing them from one conveyor belt to another. This bridge will contain two pillars joined by two metal bars on which the claw will slide. (Figure 27).

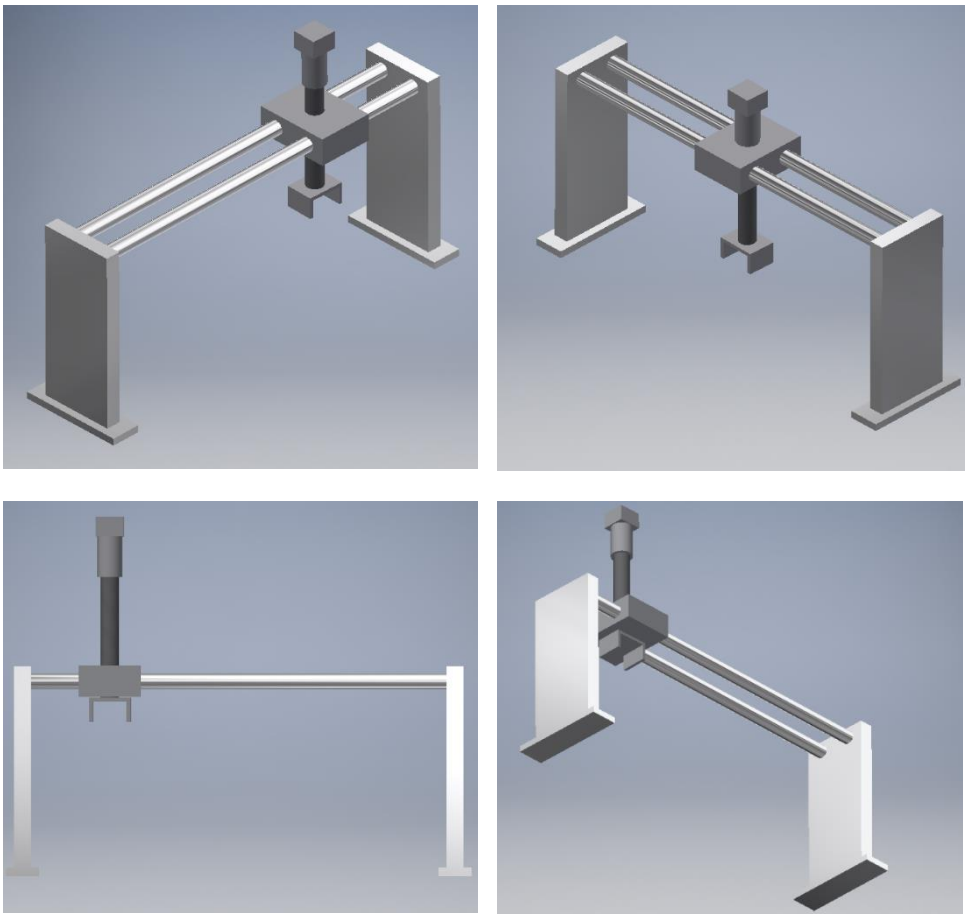

Figure 27- Design of the bridge with the grippers in AutoCad Inventor

In the previous figure you can see all the details of the gripper´s bridge. You can also see the horizontal movement of the gripper on the two bars, to move to one side or the other, and the vertical movement of the gripper, to approach the belt to pick up the object or leave it. These movements will be controlled by two step motors, one located above the gripper and the other on the side of the structure. The second is not included in the design as it can be placed on the side that best suits our design.

Subsequently, the design of another smaller bridge has been carried out, which will be located at the side of the previous gripper´s bridge. This will recirculate the part or discard it if it is not valid. It will be composed of two pillars, smaller than the previous ones, and a connecting bar on which the piece collector will slide (Figure 28).

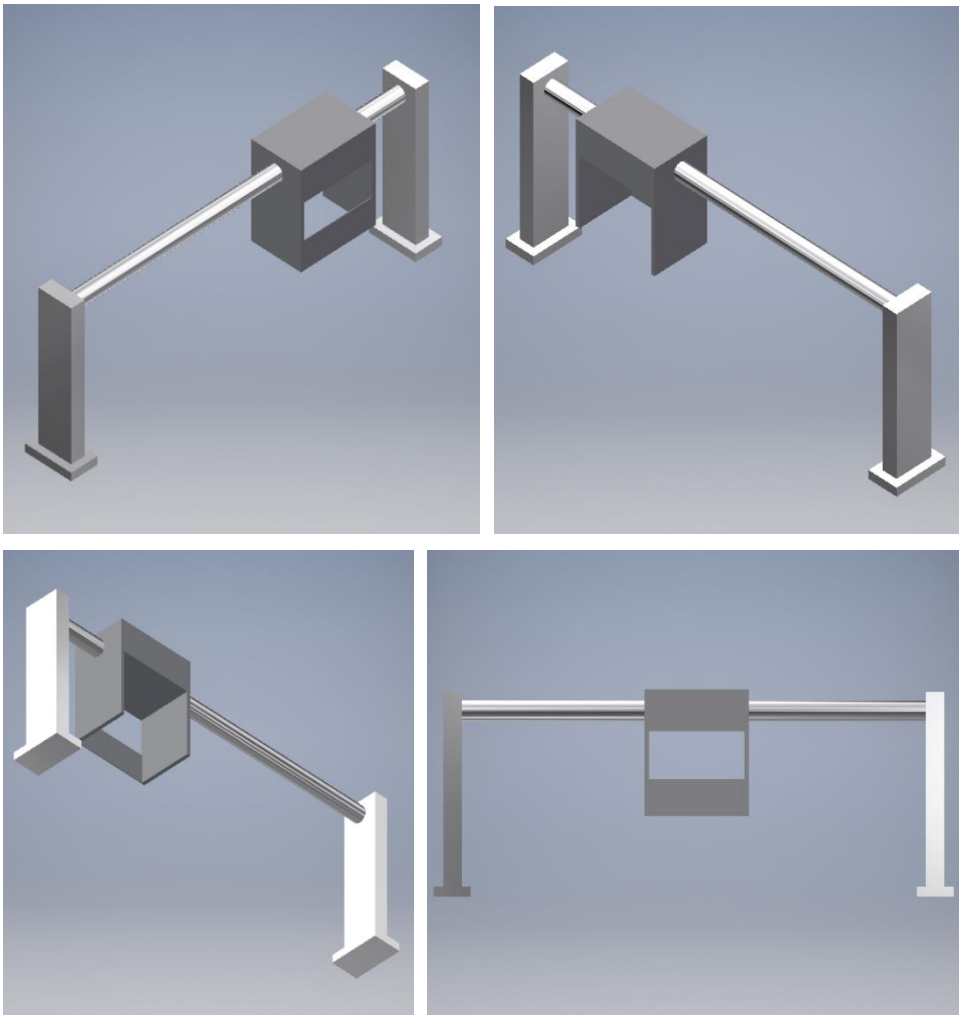

Figure 28- Design of the re-circulator bridge in AutoCad Inventor

In the figure 28 we can see that the model corresponding to the collector has two openings, one in the front part to allow to collect the piece and the other in the back part to allow the user to make the appropriate checks, in addition it can be seen that it has no base, because it will simply drag the piece on the base of the belts and another base that will be placed as a way of union between them.

Finally, two shelves have been created (Figure 29). They will be located at the end of each conveyor and will be where the pieces already ordered will be placed. In this way the pieces will be classified in the corresponding shelve, allowing the user to move them to any other place.

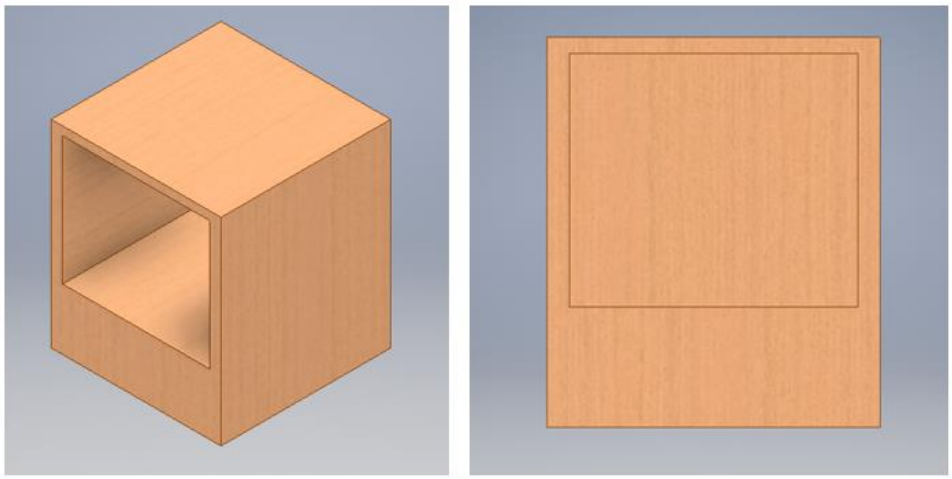

Figure 29- Design of the shelves in AutoCad Inventor

It should be noted that at the beginning it was thought to be made of wood, although it is possible to print them with a 3D printer.

The final system would look as shown in images 30, 31, 32.

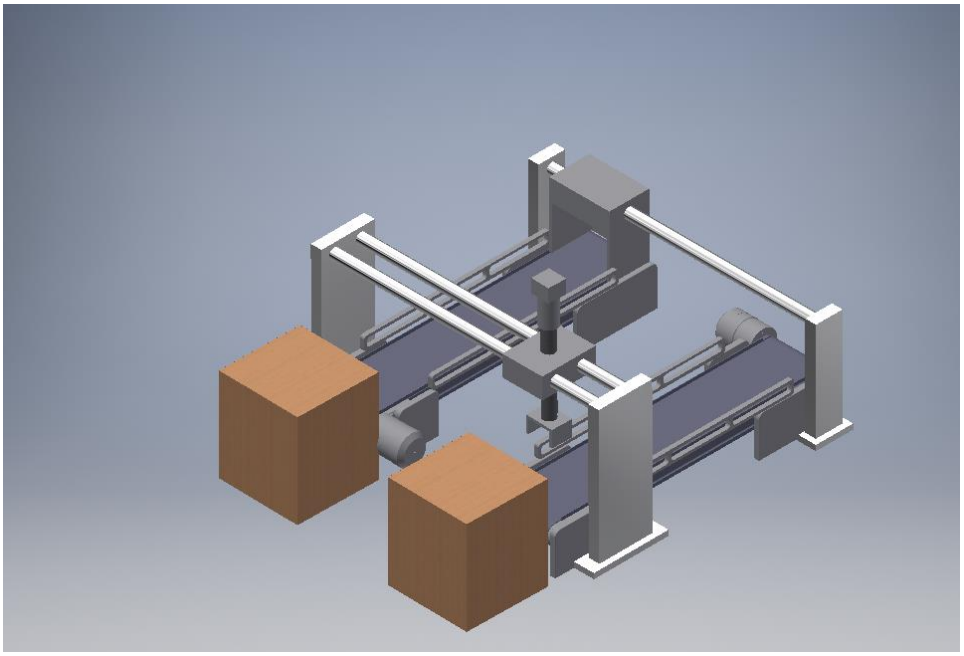

Figure 30- Prototype design of the machine in AutoCad Inventor.Back view

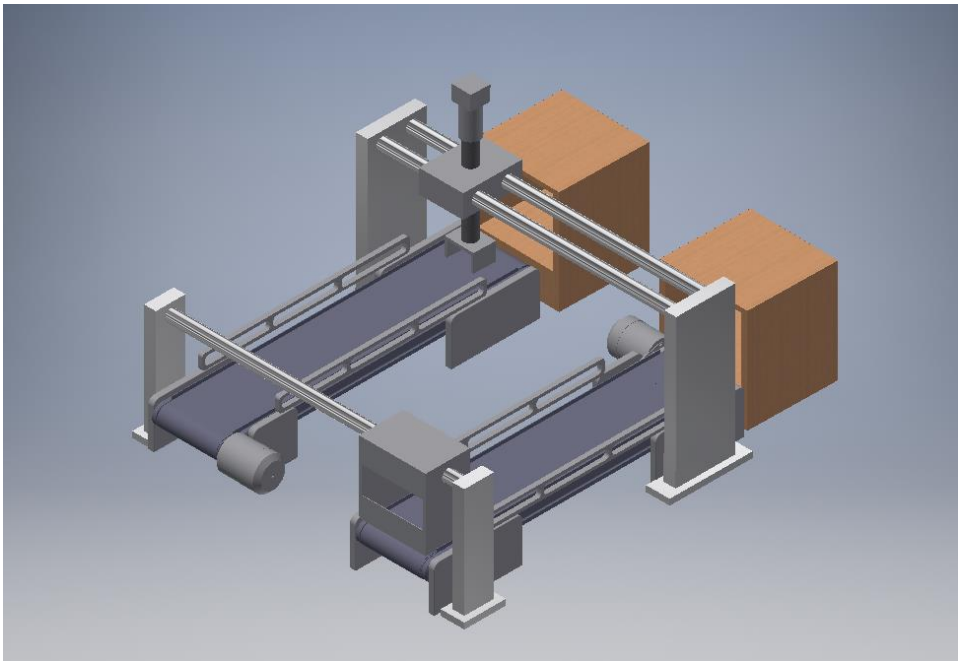

Figure 31 Prototype design of the machine in AutoCad Inventor. Side view

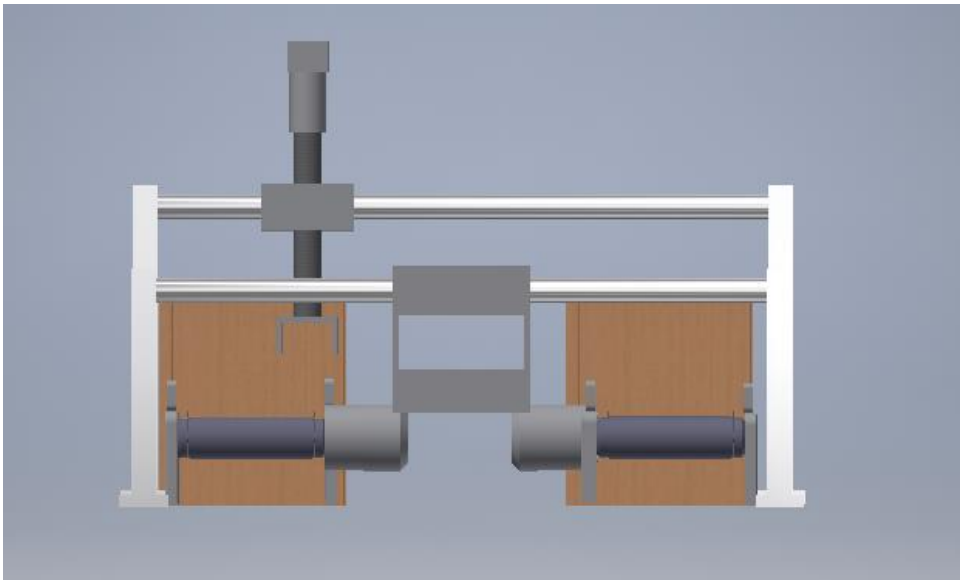

Figure 32- Prototype design of the machine in AutoCad Inventor. Front view

It was necessary to use metal supports, some of which were manually mechanized and others bought, for the correct fastening of the sensors to the structure (Figure 33).

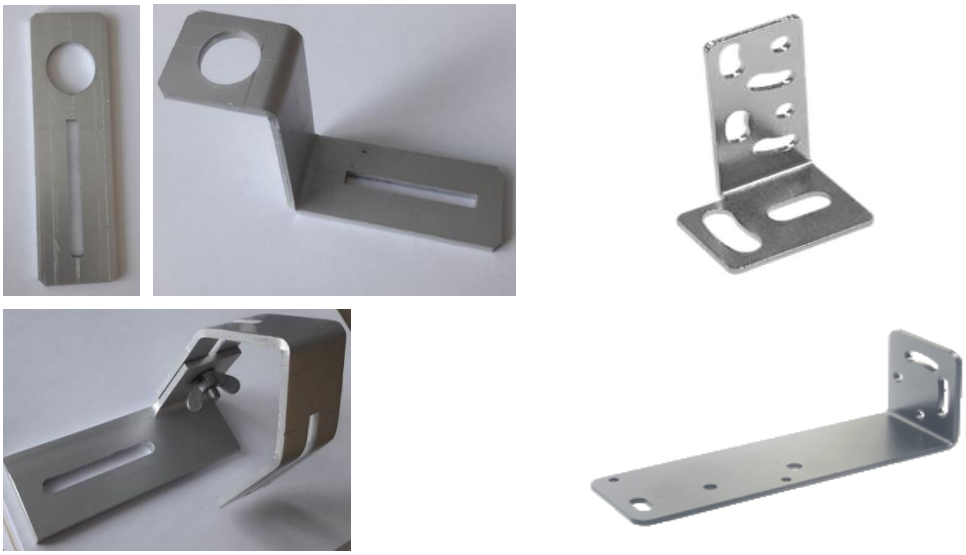

Figure 33- Metal supports

4.2 **Electrical and Pneumatic design**

The AutoCad Electrical program has been used to make both designs. The electrical and pneumatic schemes that will be installed in the machine have been drawn. The starting point is a 24V input current, which is achieved from 220V using a transformer. The pressure tap will have a regulator with which we can control the bars in the circuit, being 6 bars the maximum allowed. It should be noted that the PLC and touch panel will have their own power supply and will only be connected to the machine via an Ethernet cable. This will allow the PLC to be used for other applications without having to disassemble part of the machine installation.
The wires will be numbered according to the electrical schemes and they will have different pin colours:

- White pins for the wires that come from the sensors and step motors.
- Yellow pins for the wires of the limit switches.
- Red for the wires of the DC-Motors and the buttons.

All the diagrams can be found in Annex 2 of this document.

5 MANUFACTURE, CONSTRUCTION AND IMPLEMENTATION

For the mechanical construction of the machine, the starting point has been a model already built similar to the one initially designed, so the assembly process has been relatively simple since only the necessary modifications and adaptations have had to be made. Initially the model we have is the one shown in the image 34.

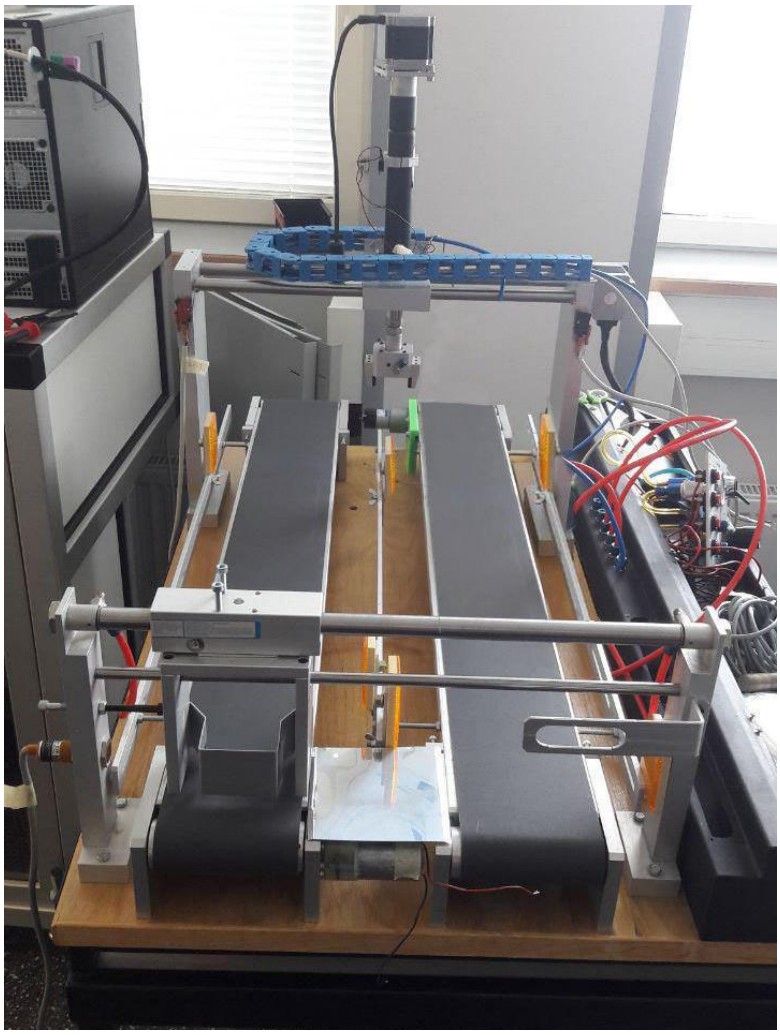

Figure 34- Initial model

The sensors must be installed, the retro-reflectors must be ordered and any unused parts must be removed. In addition, the entire wiring of the control box on the right-hand side of the figure 34 has been removed, as well as the pneumatic tubes, so that the new cables can be installed and all connections can be made. The electrical wiring has been done according to the diagrams present in the electrical design and the pneumatic connections according to the schemes (Annex 2). The complete bus station, consisting of the input and output modules, will be placed inside the control box and pressed onto a 35 mm DIN

mounting rail. In addition, the modules will be connected to each other by means of a tongue and groove system. (Figure 35).

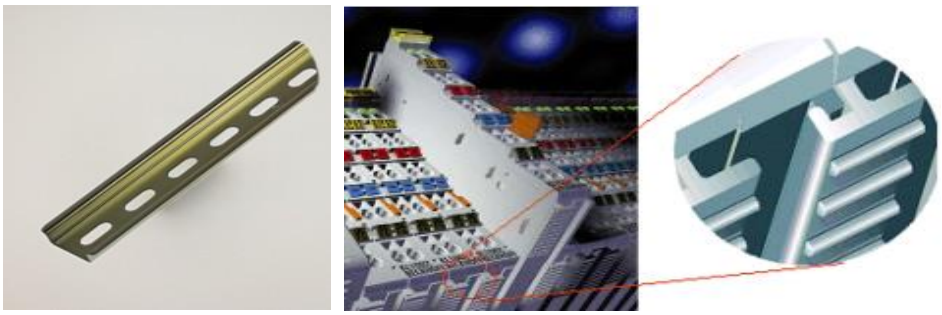

Figure 35 - Bus station assembling

In the next figure (Figure 36) we can see the complete bus station with all the connections.

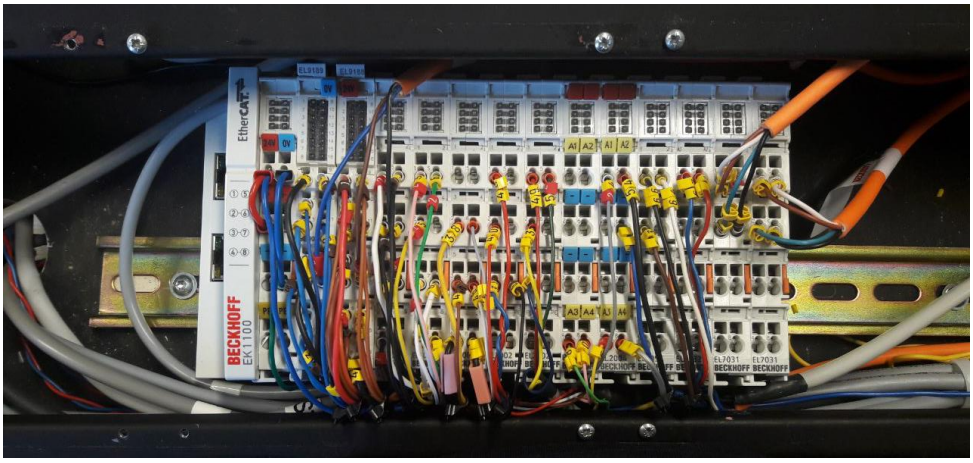

Figure 36 – Bus station with all the connections

The 4 solenoid valves will also be placed inside this control box, which will be connected to external adapters or connectors. You can see on the left side of the image 37 that there are 6 external connectors, although we only have 4 solenoid valves, this is due to the fact that we leave the option of adding two new valves if necessary. (Figure 37).

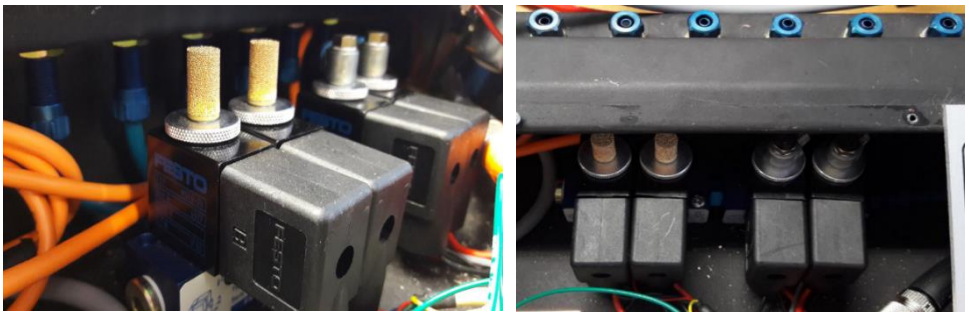

Figure 37- Valve details

Finally, there will be a manual control panel and a pneumatic control panel with all the elements explained in the choice of materials (2.1.5. Electro-Valves and Pneumatic control and 2.1.6. Manual control panel). (Figure 38).

Figure 38- Manual control panel of the machine

In the following images (Figure 39, 40, 41) we can see the machine already finished.

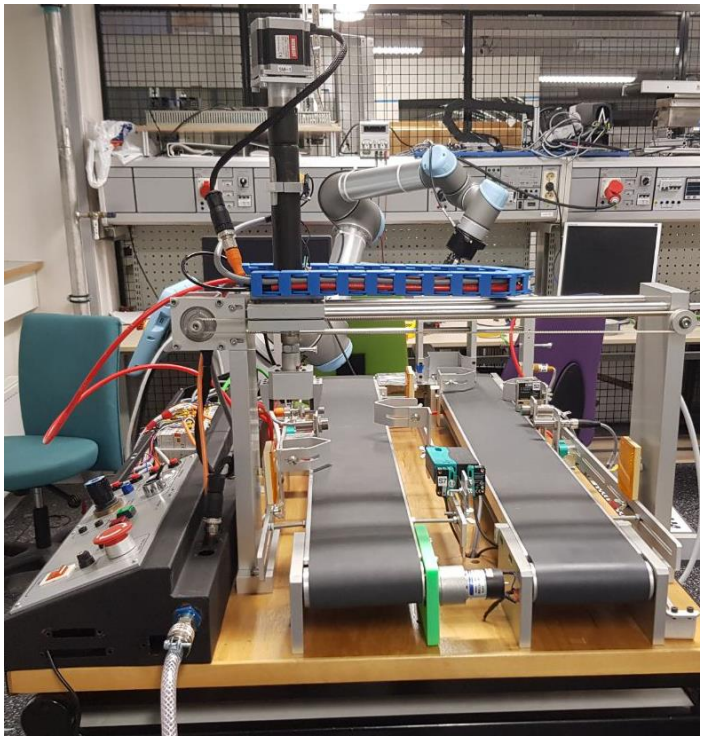

Figure 39-Left side view of the machine

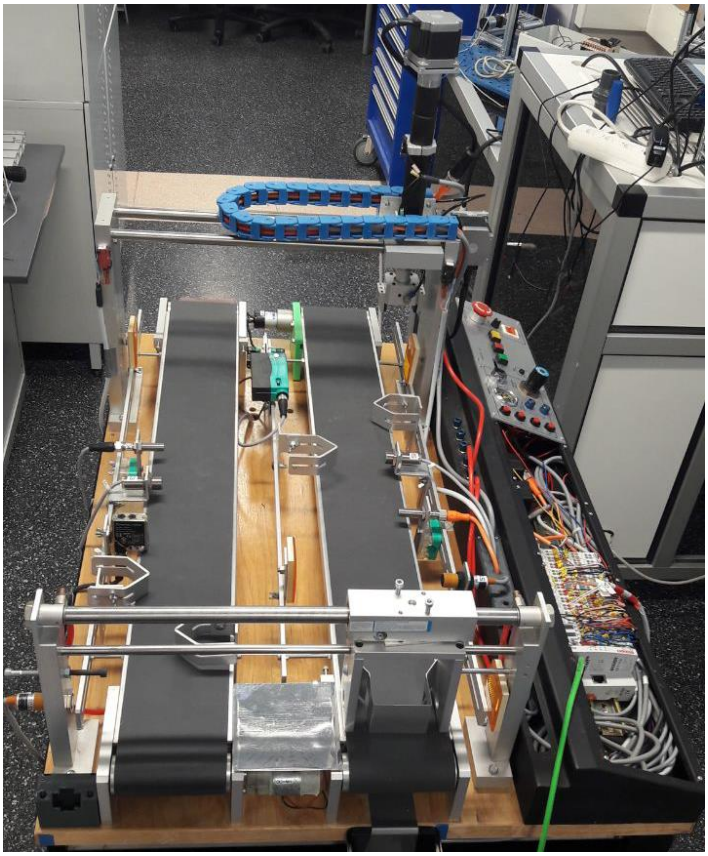

Figure 40-Upper view of the machine

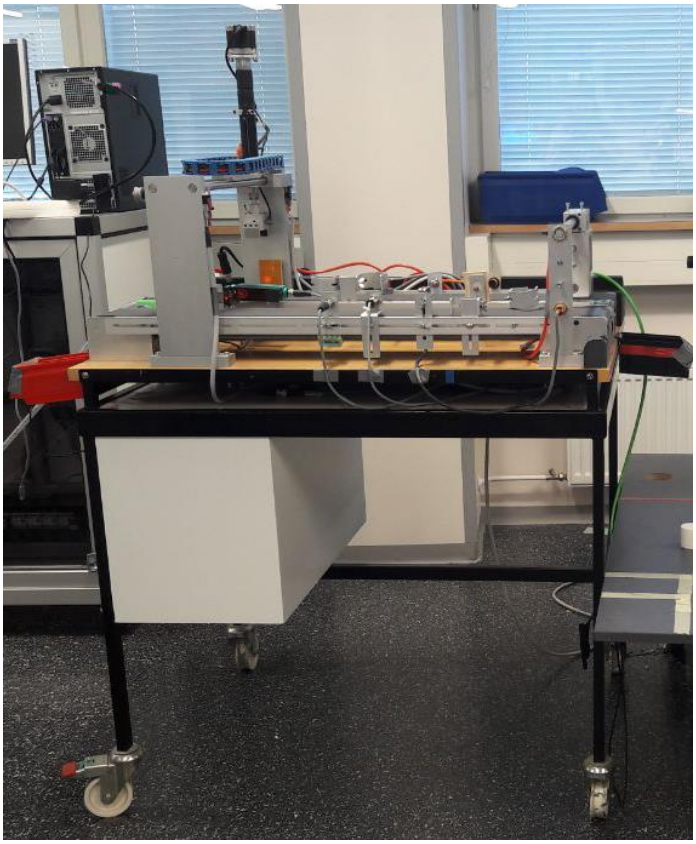

Figure 41-Machine working with the Robot

6 PROGRAMMING

6.1 Distance sensor

The distance sensor will provide an analogue output which must be configured via the IO-link system using PactWare4.1 software. First we must connect the sensor and when the program is started, add the devices we are using, in this case will be (Figure 42):

- VDM28-8-L (sensor de distancia)
- IO-Link USB Master 2.0

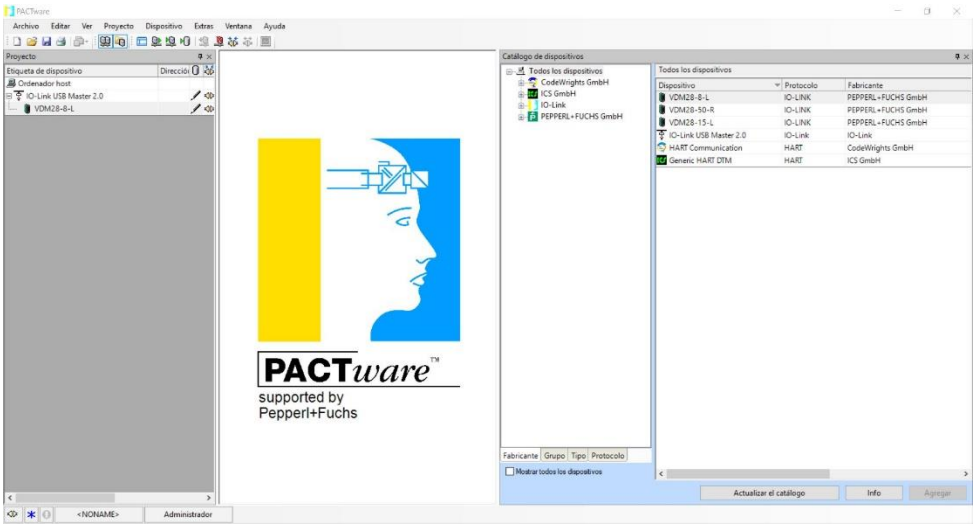

Figure 42 – Pact Ware interface. Adding the devices

Once we have been able to connect to the device through the program, we will have access to all the possible configurations and settings of its parameters.

We must know that this sensor has two output channels, we are only going to use one of them so we will disable the other one (Figure 43).

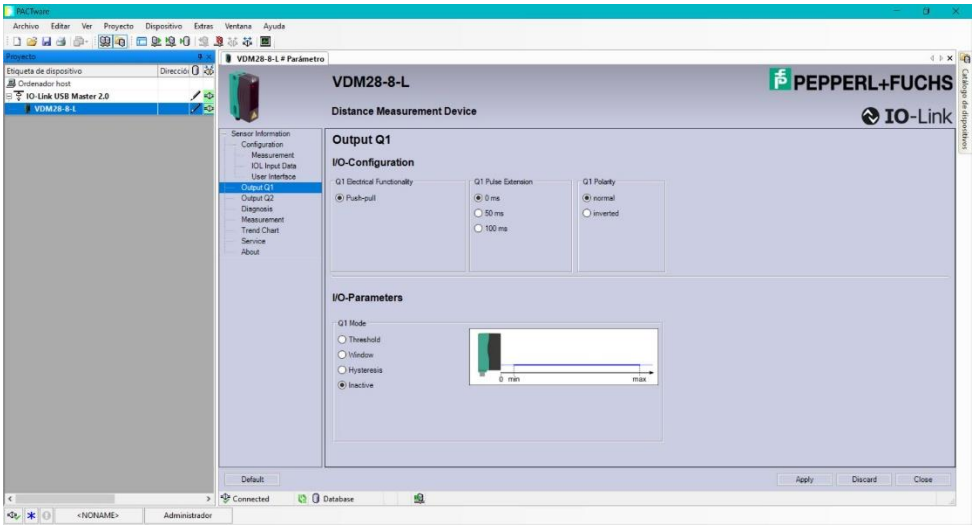

Figure 43 - Pact Ware interface. Distance Sensor parameters channel 1

Output channel 2 will be used as it is the only one that allows us to set an analog output between 4 and 20 mA. We will set the minimum distance at 5cm and the maximum distance we can obtain at 50cm corresponding respectively to the lowest and highest 4 and 20 mA output value. (Figure 44).

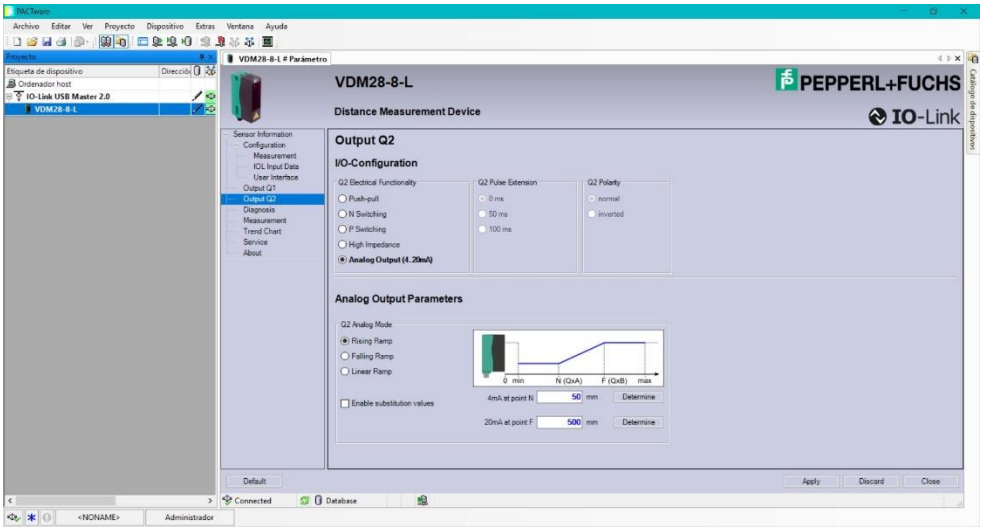

Figure 44 - Pact Ware interface. Distance Sensor parameters channel 2

Once all the parameters have been set, the distance sensor can be connected to the analog input module EL3054 and the values obtained can be checked. The module itself, according to the voltage received, will send a determined value to the PLC, which will be in charge of managing it. To do this, it is necessary to perform a conversion to obtain the measurement in the unit we are interested in, cm.

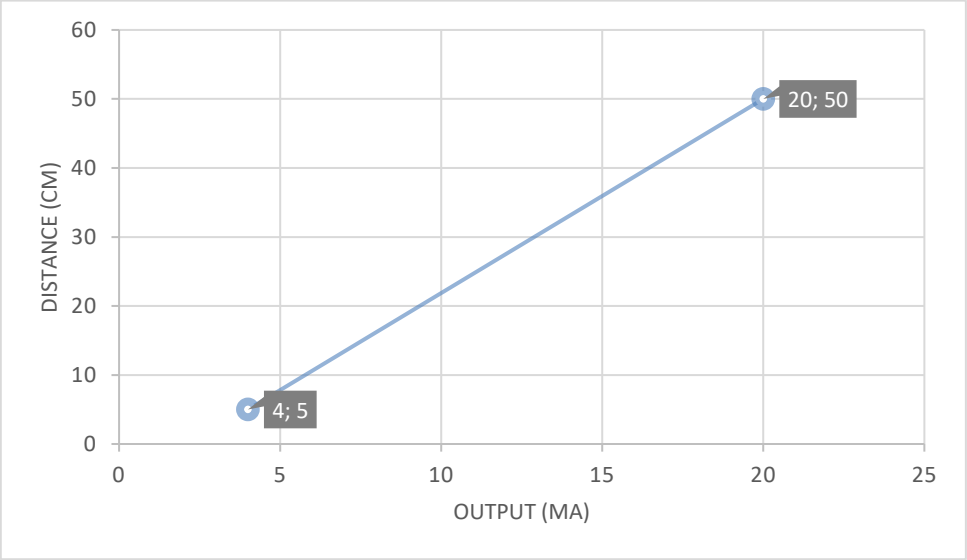

Figure 45- Graphic to get the equivalence of the data obtained

$$4\ mA \rightarrow 5cm \rightarrow 0\ (value\ in\ twincat) \quad (1)$$

$$20mA \rightarrow 50cm \rightarrow 32767\ (value\ in\ twincat) \quad (2)$$

Therefore we calculate the equation of the line using the values received in Twincat and the distance in cm:

$$y = \frac{45}{32767}x + 5 \quad (3)$$

x: value obtained in twincat
y: distance calculated in cm

With this equation and the values obtained in Twincat, we can calculate the distance in cm from the position of the distance sensor to the edge of the piece. We will have to add the radius of the piece because we need the exact distance to its centre. The calculations have been implemented in the program as we can see in image 46.

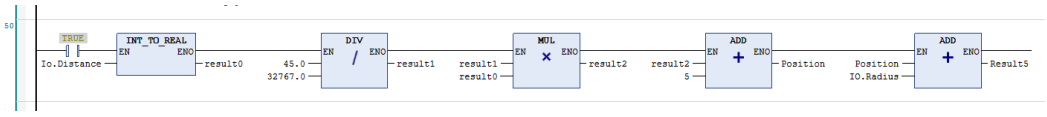

Figure 46 – Calculations implemented in Twincat

6.2 **PLC**

6.2.1 Twincat 3

As has already been justified at the beginning, the PLC that is going to be used is of Beckhoff brand, so we will have to use the Twincat 3 software for its programming. First of all we must download this software. To do this it is necessary to know that it is an extension of Visual Studio so it would be better to have it installed previously, although if you do not have it, it will be installed automatically Visual Studio Shell. The software is free, only registration is required, and can be downloaded from:

http://www.beckhoff.com/english.asp?download/tc3downloads.htm.

For its installation is not necessary to know anything, just follow the instructions that appear on the screen.
After successful installation, the program will start from the taskbar (Figure 47).

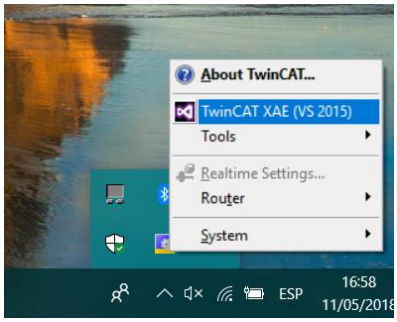

Figure 47- Open Twincat from the taskbar

The Visual Studio home page will then appear, where you can create a new program or open an existing one (Figure 48).

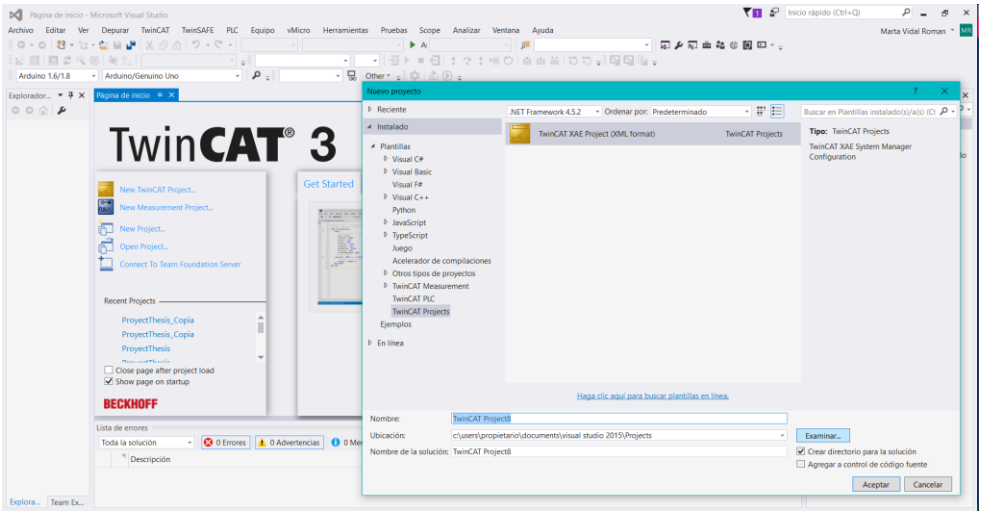

Figure 48 – Creation of a new program in Twincat

Once the new program has been created, the screen in image 49 will appear, where all the files in the project will be organized in the file explorer on the left side. The files are arranged in a tree with the solution or project at the top, followed by all its parts. This organization allows several solutions or projects to be opened at the same time. The main parts of a project are:

- System, is in charge of managing the runtime including the licenses.
- Motion, takes care of the motion control tasks and assigns it to the axes.
- PLC, where the PLC projects are created
- Safety, takes care of runtime safety, although it is not always possible to modify it.
- C+++, where you can write the code in C+++ and run it directly at the runtime.
- I/O, where the input and output network and the maps between all the modules will be configured.

In this case it will only be necessary to use the System, Motion, PLC and I/O parts.

Located at the bottom of the screen is the list of errors and warnings and on the right side is the toolbox and properties, which will be useful when making the program.

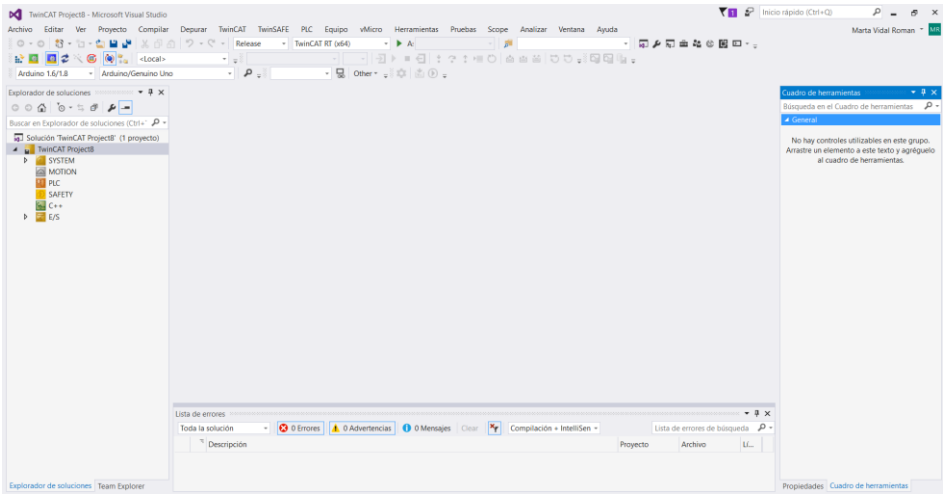

Figure 49 – Twincat interface. Main screen

6.2.2 PLC project

To create a PLC project we only have to right-click and add a new element. You can then choose to create a standard or an empty project. The standard will contain the default template as we can see in figure 50.

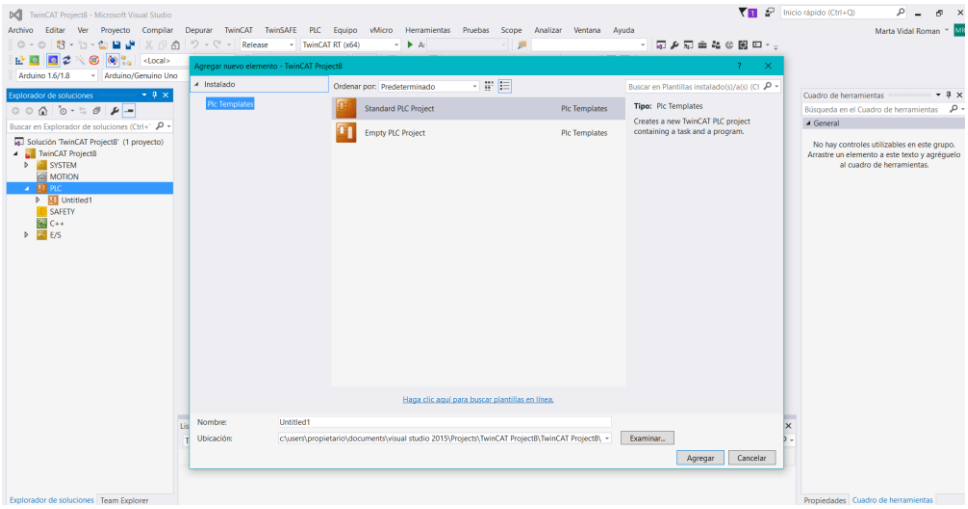

Figure 50- Creating a new PLC program

To create a Standard PLC project we will have the internal structure that we can see in the image 51.

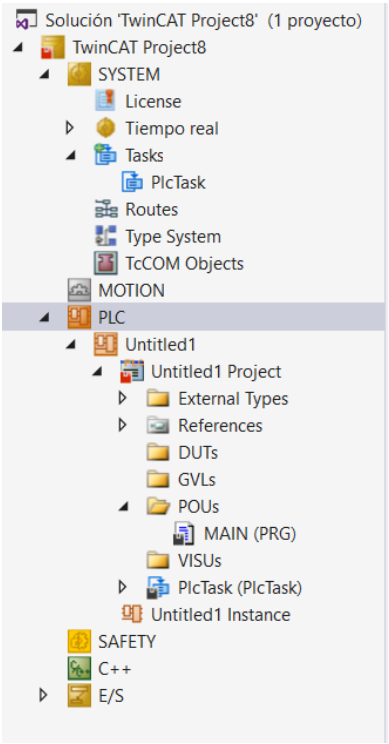

Figure 51- Internal structure of a project

Initially we will only have a POU or Program Organization Unit, which will be the MAIN, from where we will establish the order of execution of the cycle. In the Tasks section included in System, you can modify aspects of the execution. You can add as many POUs as you require. Only local variables may be declared there. The folder called GVLs will host the lists of global variables that we want to include in the project. The References contain all the libraries that are included and can be used in the current project, being able to add new ones if required. Finally, there is the VISUs folder that will contain everything related to the touch panel.

To start programming we must first choose which type of POUs we are going to use, being able to choose between program, function or function block. We will also have to determine which language to implement: contact diagram (LD), functional block diagram (FBD), continuous function diagram (CFC), sequential functional diagram (SFC), structured text (ST) or UML stratechart (SC).

Our program will contain program-type POUs and we will use contact diagrams for their programming (LD). Three text lists will also be used for display purposes. The global variables will be organized in different lists according to their characteristics. It should also be noted that different libraries have been added as necessary.

The PLC project tree looks as shown in figure 52:

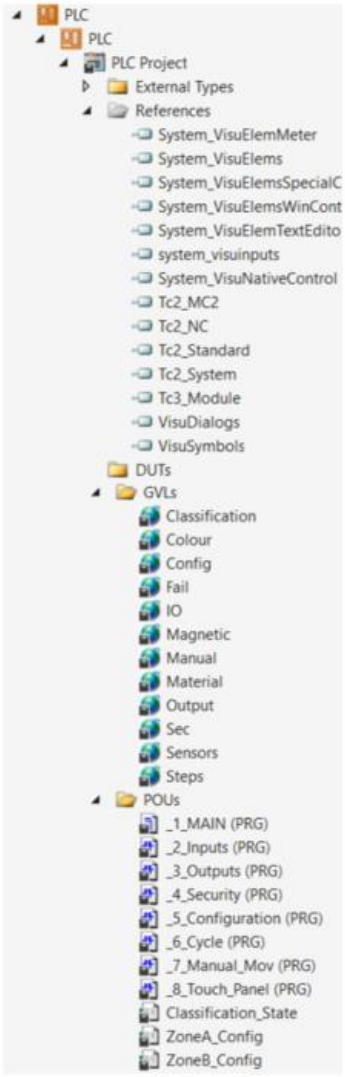

Figure 52 – Internal structure of our PLC

The POU number 1 is the MAIN, which will be in charge of cyclically executing each of the POUs in the order we have established.

Next we have the Inputs and Outputs POUs, where the connection is established between the input and output variables that we are going to use in our program and the variables assigned to physical digital inputs or outputs. It should be noted that not all input and output variables have been assigned in this way, some have been used directly without prior assignment. This assignment has been made because there are some times that an input is required to remain on for a while or because the same output cannot be activated from several points as it can cause execution conflicts. An example of an input assignment is shown in figure 53. For example, in segment 4, when the digital input variable IO.S3, associated with the digital input corresponding to the inductive sensor, is activated or set to 1, the variable Sensors.S3 will be permanently activated.

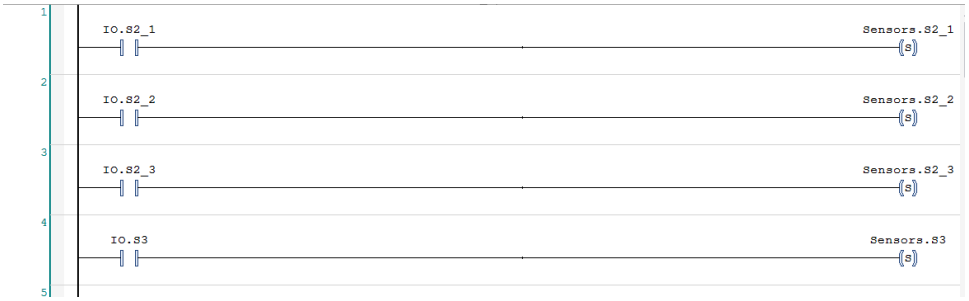

Figure 53- Fragment of the POU 2-Inputs

An example of the outputs is shown in figure 54. In segment number 7 we see how the variable IO.ER_2, which is assigned to the physical output that corresponds to the solenoid valve number 3, can be activated through two variables, when one of them is set to 1.

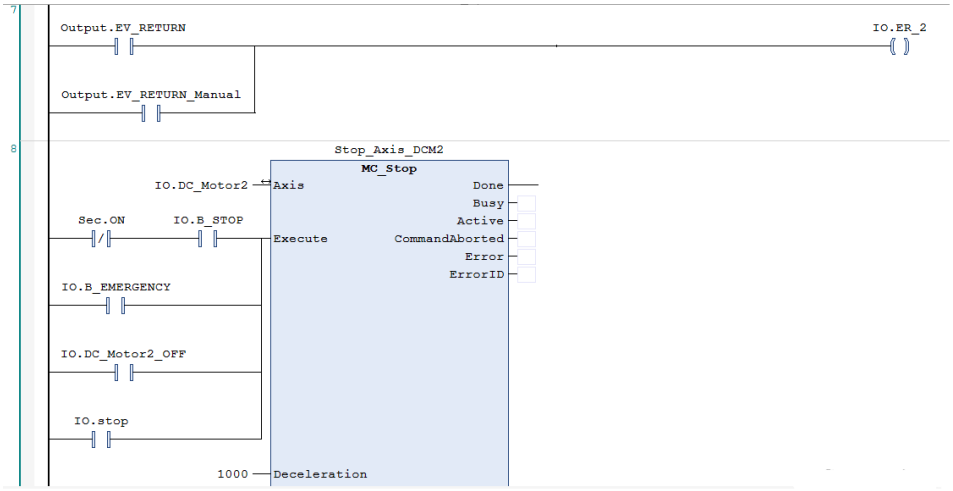

Figure 54- Fragment of the POU 3-Outputs

Then there is the POU for safety, that is, where everything related to emergency stops is located, when they must be activated and what happens when they are activated. The figure 55 shows that the safety devices are correct when the emergency stop button and the emergency stop button are not activated. In addition, the start button must be pressed at least once, from the manual control panel or from the display, so that we are aware that we are activating the securities and consequently the machine.

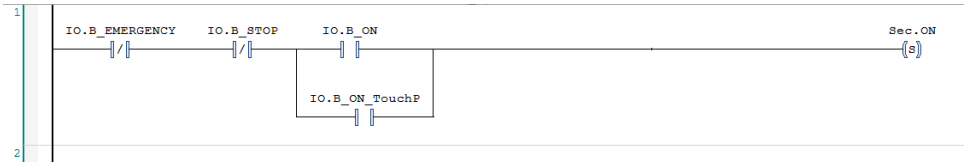

Figure 55- Fragment of the POU 4-Seccurity

The next POU that we can see is "Configuration", it will be in charge of establishing the configuration that the user has introduced and activating one of the processes. For a better understanding of how to make this configuration, figure 56 has been included as an example. When the user chooses through the touch screen whether the material in zone A is metal or not, it is written in the variable MaterialA, or B according to the zone we are configuring, a 1 or a 2. This way, after checking what value is written in this variable and validating the zone configuration, the type of material will be activated. It is the same with colour and the characteristic of magnetism. When we validate the configuration of a zone, we simultaneously activate a type of process, for example in the case in which we want to classify in zone A the metal, magnetic and blue pieces, the process Config.First_A will be activated. We can see this example reflected in segments 3 and 4 of figure 56. It should be noted that only two processes can be activated at a time, one for zone A and one for zone B.

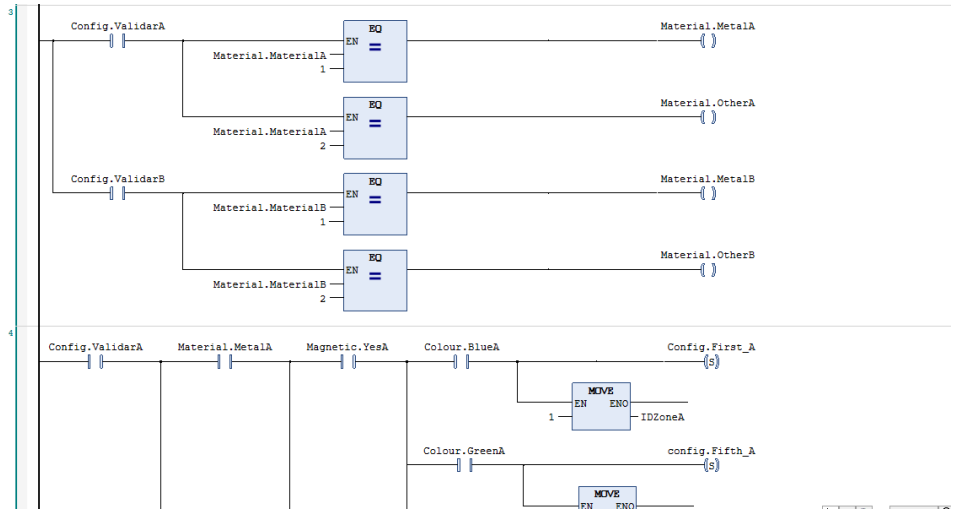

Figure 56- Fragment of the POU 5-Configuration

The Cycle program is the one that contains all the steps that each of the processes will follow in automatic mode. The first three stages will be common for all configurations and the rest will be specific for each type. Apart from the automatic or manual mode, you can also select to work with or without a robot. This is because initially it was thought to connect this project with a collaborative robot that is part of another project. The robot will communicate with our machine through digital inputs and outputs to place the part on the conveyor belt or pick it up. This configuration of working with or without robot has been included in the cycle because at each stage, depending on whether we have the robot or not, we will wait for some signals or others to continue.

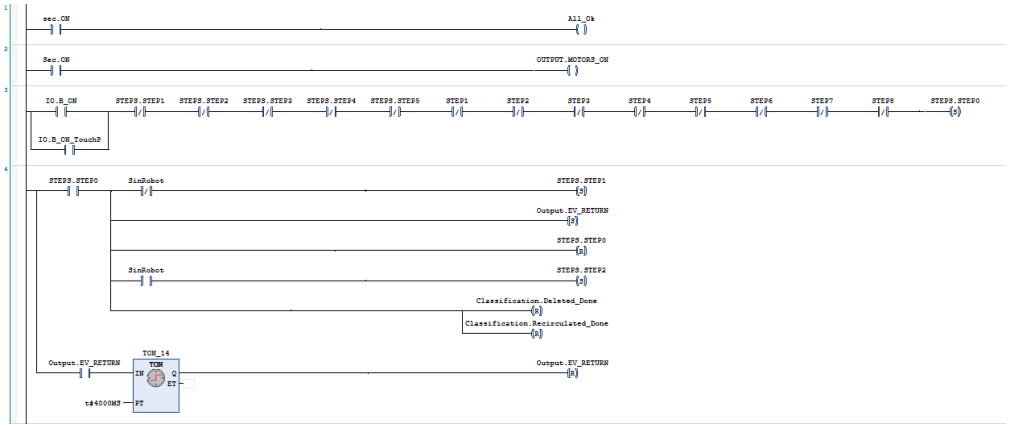

Figure 57- Fragment of the POU 6-Cycle

In the illustration above (Figure 57), we see the first stages of the process. Line 3 shows the initial stage, which will only be activated the first time the program is started by pressing the ON button and the "Stage 0" variable will be activated. Line 4 corresponds to stage 0, in which the return valve is activated, some other variables are reset and, if the robot is used, stage 1 is activated. On the other hand, if the robot is not included in the cycle, we will jump to stage number 2. This is an example of how the cycle has been implemented as a whole.

As mentioned above, the machine has two operating modes: manual or automatic. The automatic mode operates continuously without any human intervention and has been explained in the Cycle program. The manual mode has been incorporated so that the solenoid valves can be operated independently, either to set them in a certain position or to carry out the process manually. In figure 58, in line 1, we can see the manual activation of the DC motor that moves the first conveyor belt and in line 3 the activation of the DC motor number 2, in charge of the movement of the second conveyor belt. We can see in the image that different ways have been used to start these motors, this is because motor number 2 has been connected to the EL7332 module and is treated as an axis, as we are interested in controlling both its speed and direction, so it is controlled by Motion. It is not the same with the DC motor 1, which has been connected to a digital output that will activate or deactivate it, since it will only move in one direction and the speed will always be the same. Motion will be explained later.

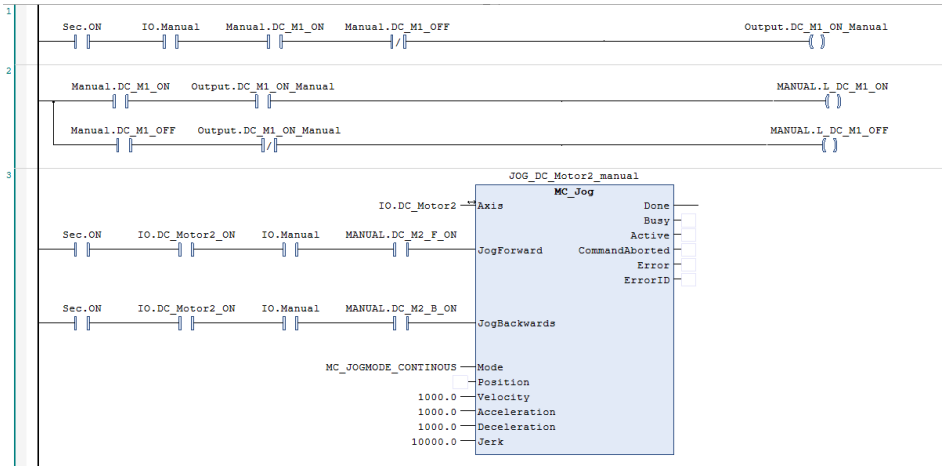

Figure 58 - Fragment of the POU 6-Manual Movements

Finally we have a last POU called "Touch_Panel" in which we manage things related to the screen, for example the activation of variables through it or the display of the cycle status by means of lights. In the following image we can see in segment 1 how the light indicating that the system is activated, will switch on when we press the ON button either from the manual or tactile control panel. The second segment will be activated to indicate that the settings have been made correctly when both zones settings are validated. (Figure 59)

Figure 59 - Fragment of the POU 8-Touch Panel

6.2.3 Cycle

As explained above, the cycle the machine will follow has been programmed in a POU called "Cycle". This cycle will be explained in more detail below.

1º.The desired configuration is entered and validated

2º. Press the start button. When this occurs, the SM1 and SM2 motors will move to the home position, and the solenoid valves will move the recirculator to the home position above the second conveyor belt.

3º.The piece is placed at the beginning of the machine, cutting off the detection of sensor 1. This will then be started up by moving the piece toward the different sensors.

4º.Case 1: The piece will be classified in zone A. The piece will be moved along the conveyor it is on until it reaches the end of it.
Case 2: The piece must be classified in zone B. When it reaches sensor number 6, the belt will stop, the SM1 and SM2 motors will move to the position where the piece is located and with the help of the solenoid valve that controls the grippers, the piece will be taken to be moved to the other conveyor belt. Once the S7 sensor has detected that the piece is correctly positioned, the DCM2 motor will run in reverse direction for the time necessary for the piece to reach the end position in zone B.
Case 3: The piece will be removed. In the same way as in case 2, the piece will be transferred to the conveyor belt number 2. When the S7 sensor detects the presence of it on the belt, the DCM2 motor will start up moving forward and will transport the piece through other sensors. When it reaches sensor number 10, the machine will make a decision:

- Remove the piece, in which case it will activate solenoid valve number 1 to move the recirculator away and the DCM2 motor will continue to run until the piece is removed.
- Recirculate the piece if there is any doubt about its classification due to a possible failure or defect in the detection of any sensor and the piece has not been previously recirculated. To do this, the piece will be moved until it is inserted in the recirculator, then activate the solenoid valve number 1 to move it to the belt number 1 and once it is in it, we will return to the 3rd stage.

6.2.4 Motion

As mentioned above we will have 3 axes:

- Axis 1: DC motor 2
- Axis 3: Stepper motor 1 (vertical movement)
- Axis 4: Stepper motor 2 (horizontal movement)

When we connect the input and output modules to our PLC and load them into our program through the "scan" tool located in the input and output section, the number of axes available for our system is automatically created. For this reason we have 4 axes created, the first two belonging to the EL7332 module for DC motors and the last two coming from the EL7031 modules for stepper motors. (Figure 60).

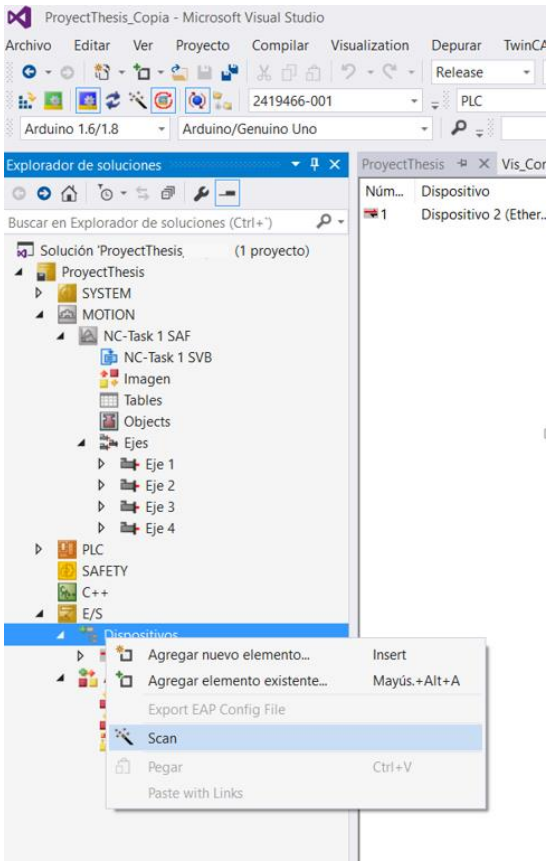

Figure 60 – Scanning the connected devices

The configuration and parameters of DC motor number 2 are shown in the picture below (Figure 61):

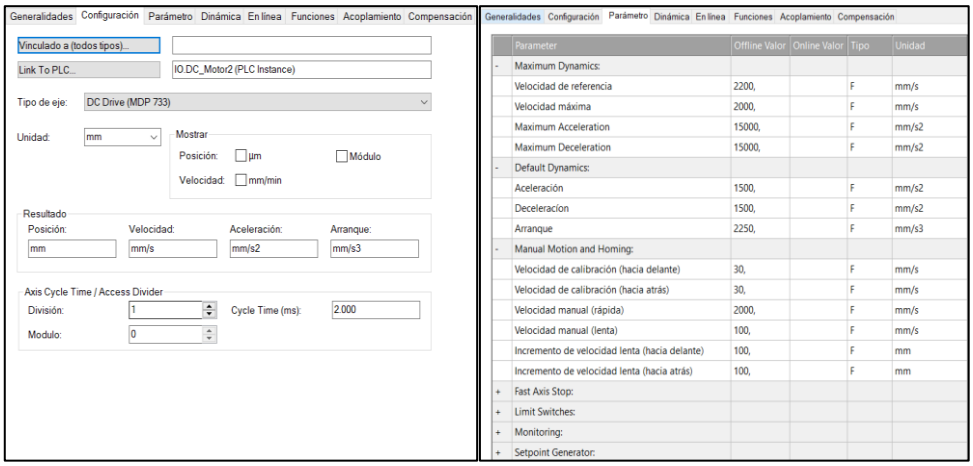

Figure 61 – Configuration and parameters of the DC Motor 2

Only parameters that have been modified and adjusted to the engine requirements are displayed. The axis has been linked to the PLC through the global variable *"IO.DC_Motor2* ".
As this motor will not have an encoder we will have to establish a simulation one and adjust the parameters of the proportion factor, module factor, filter times and homing (Figure 62). These parameters have been established according to the data and references provided by Beckhoff's documentation.

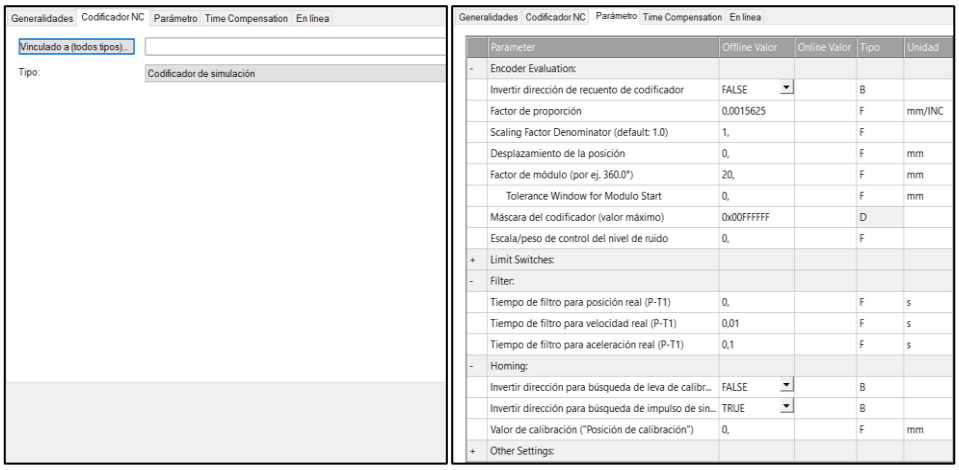

Figure 62 – Encoder configuration and parameters of the DC Motor2

The controller of this motor will be a position controller type and its drive will be linked to the EL7332 driver.

Finally, once we have loaded all the settings made, and entered in online mode into our program, we can adjust the voltage and current

parameters of the EL7332 module (Figure 63) according to the data-sheet of this module that can be found in Annex 4.

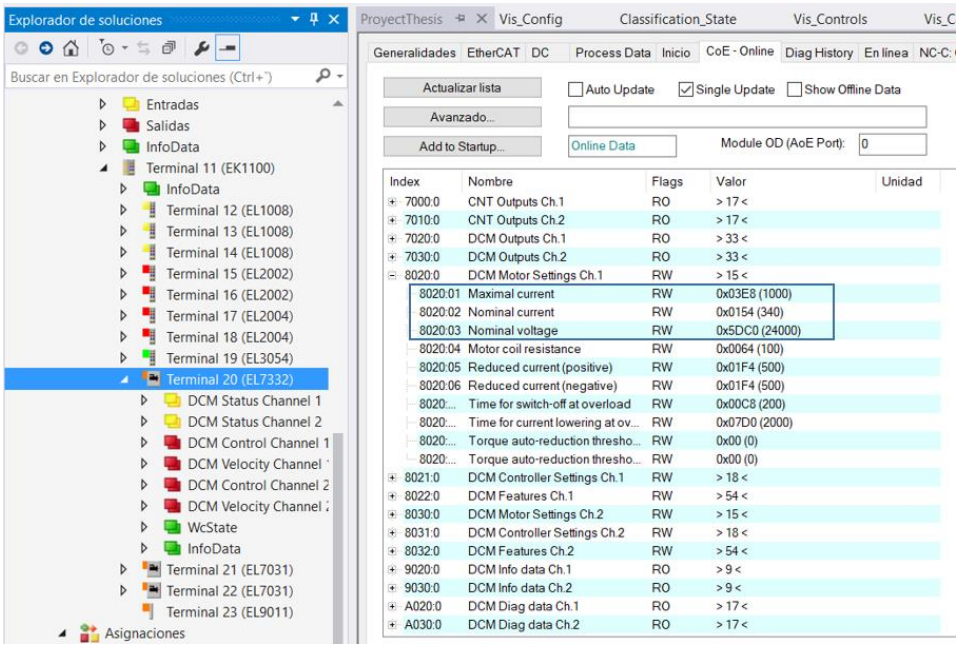

Figure 63 - Parameters of the EL7332

The stepper motor configurations have been carried out following the same steps as for the DC motor. These axes will be linked to the PLC via the global variables *"IO.Axis_SM1"* and *"IO.Axis_SM2"*. (Figure 64)

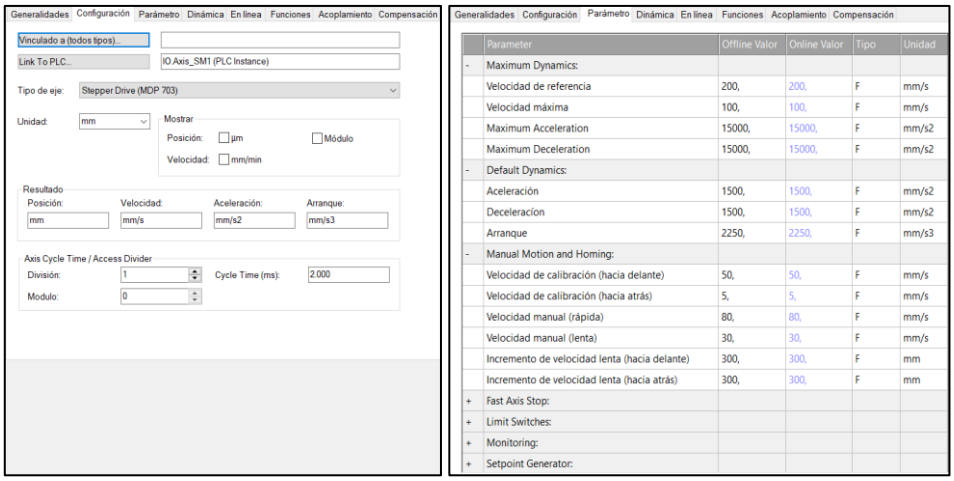

Figure 64 - Configuration and parameters of the Step Motor 1

These motors will not have an encoder either, so their configuration is identical to that of the DC motor as shown in the figure 62. They will also be position controlled and the driver will be linked to their respective EL7031 driver from terminal 21 or 22 depending on whether it is stepper motor number 1 or 2 respectively. Finally, the

nominal voltage and current of the module must be configured online, which will be the same for both terminals.

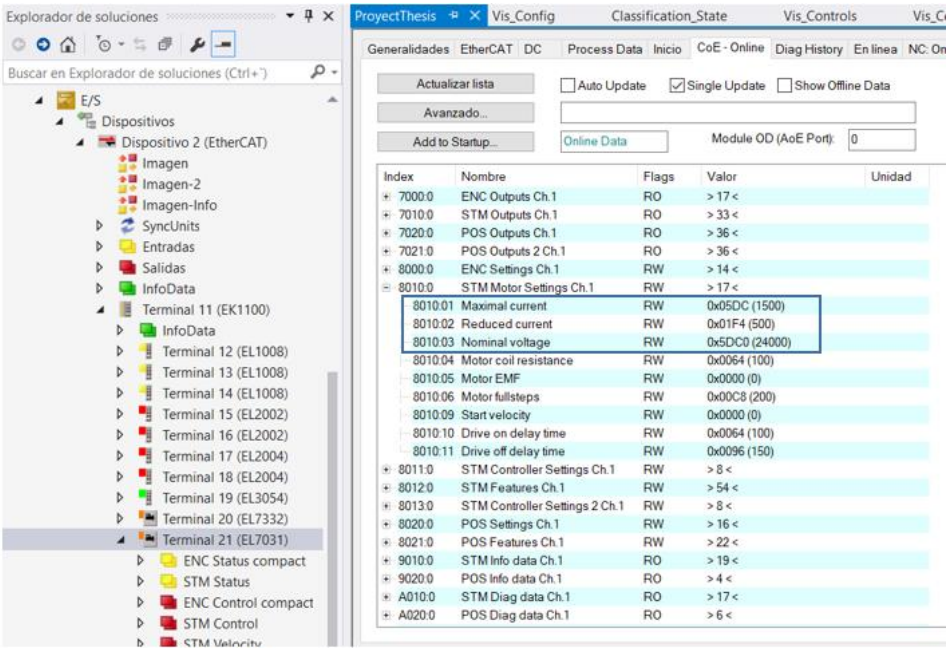

Figure 65 - Parameters of the EL7031

To control the axes is necessary to use the *"TC2_MC2"* and *"TC2_NC"* libraries. First, the axis must be enabled via the "MC_Power" function block. It is recommended that this command always remains on, as the motor can be stopped with other modules, so we set an input signal that is always kept on. (Figure 66).

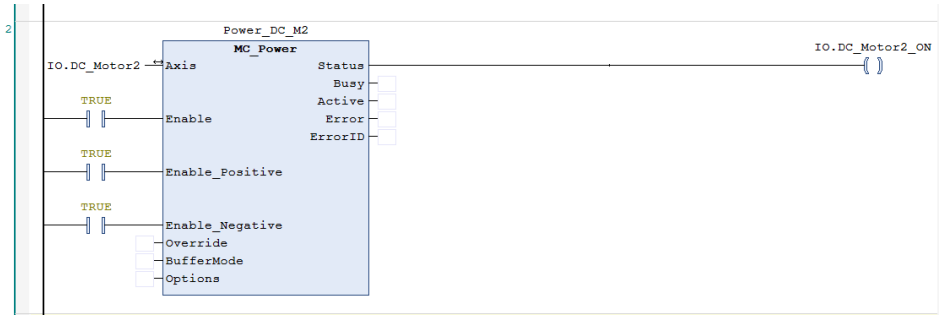

Figure 66 – Power block

We will place the stepper motors at the home position using the *"MC_Home"* function block. The motor will start to move up and to the right until a positive signal is detected from the corresponding limit switches, then the motors will stop and start to move in the opposite direction until the positive signal from the limit switches is lost, which is when they stop and we will set this position as point 0. It´s very

important to be sure that the directions that the axis would use to reach the calibration point and the position 0.0 are opposite in the parameters of the axis. (Figure 67).

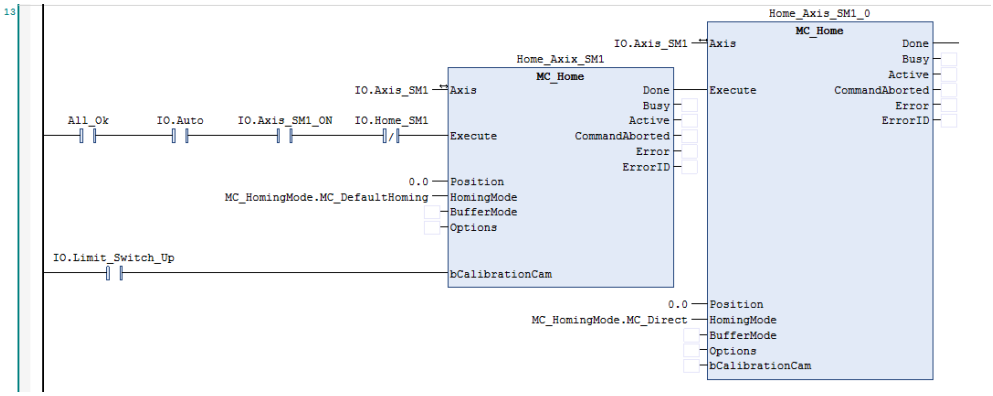

Figure 67 – Homing blocks

Later, we can set a run command in one direction or another, with the *"MC_Jog"* block, depending on the conditions that are met, although it is not necessary to use both drives. This block has several modes. In the following image we can see the continuous mode, which is the one we are going to use in our program, in which when the JogForward or JogBackward inputs are activated it will rotate in one direction or the other, and when they are deactivated it will stop automatically. (Figure 68).

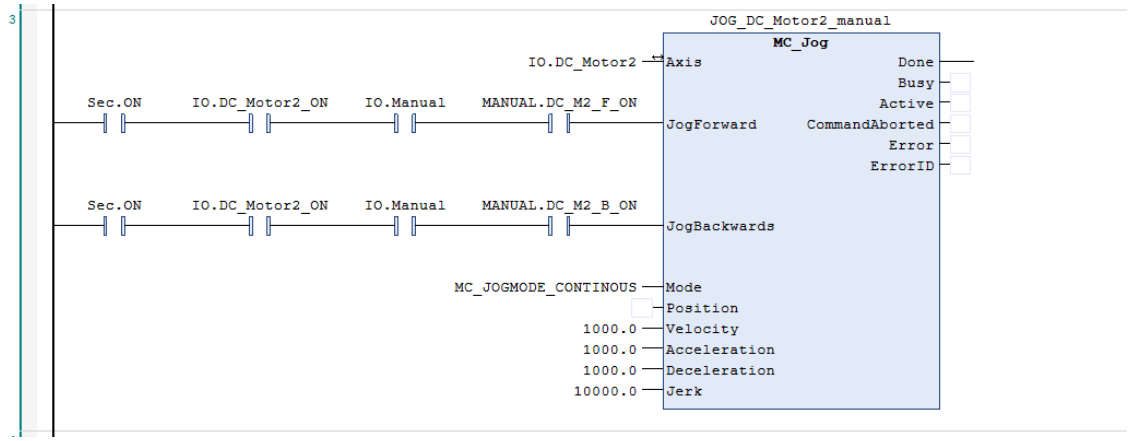

Figure 68 - Jog block

Another option that we have use to move a motor is through the *"MC_MoveAbsolute"* block with which we can move the motor to a certain position. (Figure 69).

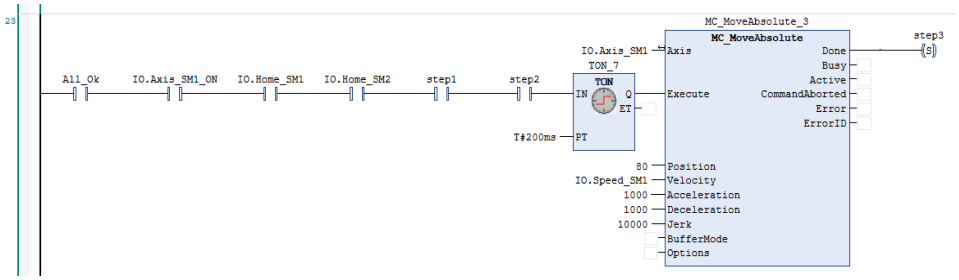

Figure 69 – Move Absolute block

To move to a certain position we must know or calculate the equivalence between the number of revolutions and the distance travelled.

First of all, the calculation has been carried out for the step motor number 2 which is responsible for the horizontal displacement (Figure 70).

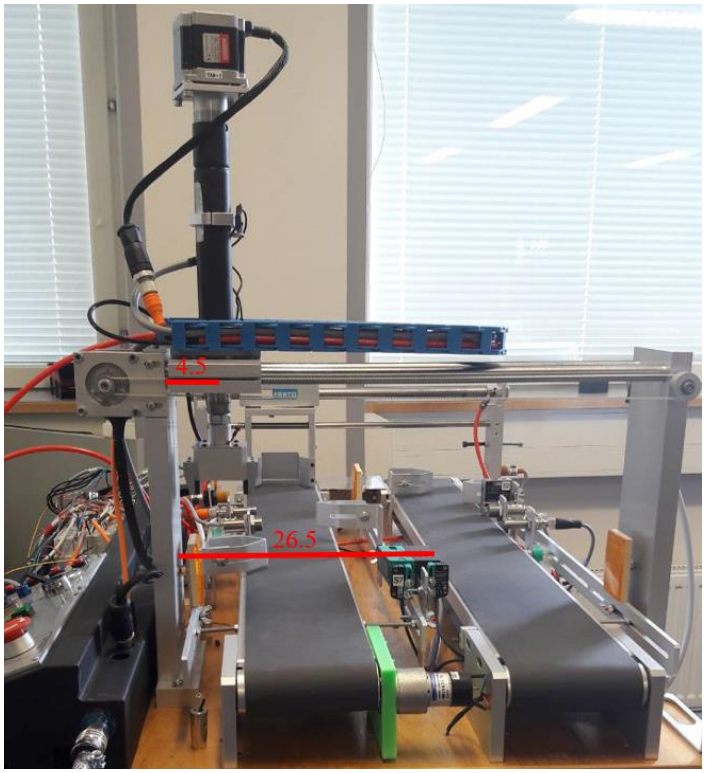

Figure 70 – Horizontal measurements

We move the motor 100 steps manually and measure the distance travelled, in this case 27 cm, to be able to perform the next conversion:

$$100\ steps \rightarrow (27 - 4.5) = 22.5cm \quad (4)$$

$$x\ steps \rightarrow (26 - 4.5) = 22cm \quad (5)$$

$$x = \frac{100 * 22}{22.5} = 97.78\ steps \tag{6}$$

The 97.78 steps, will be what motor 2 has to be moved to be just above the distance sensor. Now we only have to add to these steps the distance measured by the sensor to the piece:

$$\frac{100 * a}{22.5} + 97.78 \tag{7}$$

a: measured distance to the part.

The distance "a" is obtained through the distance sensor after the corresponding transformation as described in section 6.2. Distance sensor.

In figure 71 we can see how we have implemented all the previous formulas.

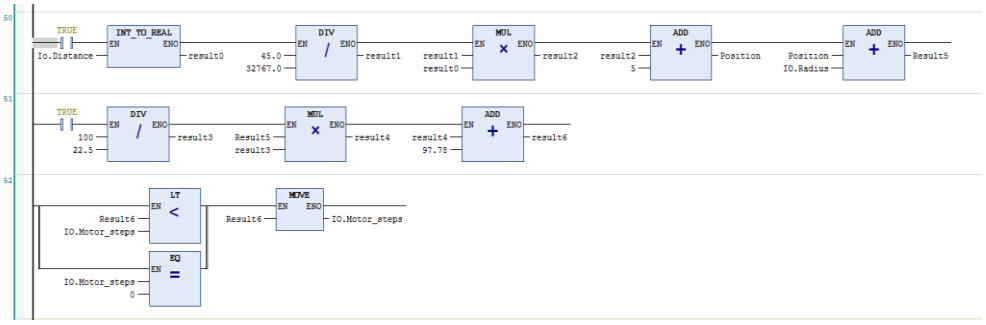

Figure 71 – Implementation of all the calculations

It should be noted that the distance sensor measures continuously, so we will only keep the minimum measurement obtained as it will correspond to the exact distance to the piece.
The calculations for step motor number 1 have been carried out in a similar way (figure 72):

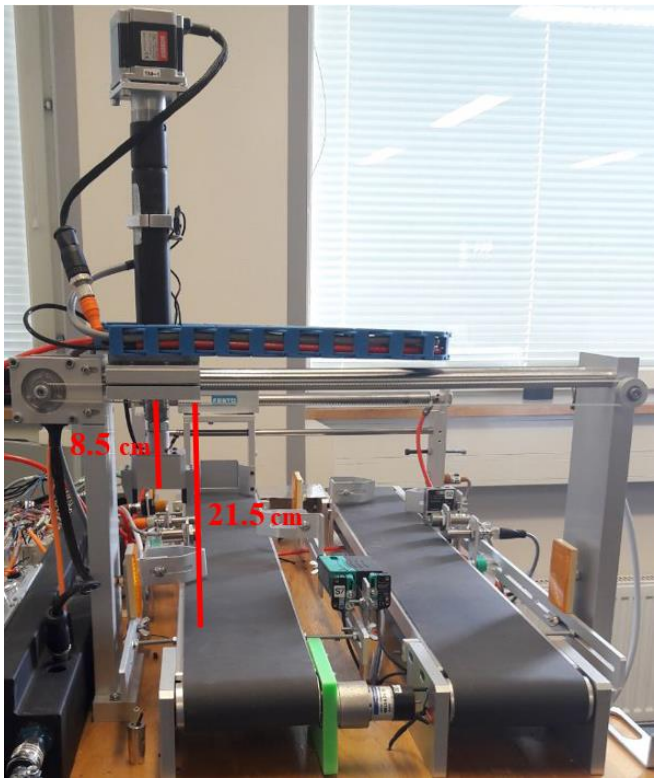

Figure 72 – Vertical measurements

We need some data to have as reference, so we will move the motor manually until we place the gripper 3mm from the surface of a piece of 4cm high, and this corresponds to 435 steps from the home position. We will take into account an error of +0.3cm for security.

$$(21.5 - (4 + 0.3) - 8.5) = 8.7\ cm \rightarrow 435\ steps \tag{8}$$

$$21.5 - (x + 0.3) - 8.5 \rightarrow y\ steps \tag{9}$$

So, therefore:

$$y = \frac{435 * (21.5 - (x + 03) - 8.5)}{8.7} \tag{10}$$

x: height of the piece; y: number of steps

To stop the motor we can do it in two ways, disabling the signal that starts it, although this option is not valid when using a movement of the type *"MC_MoveAbsolute"* as it will not stop until it reaches the indicated position unless we stop it using the function block "*MC_Stop"*. (Figure 73).

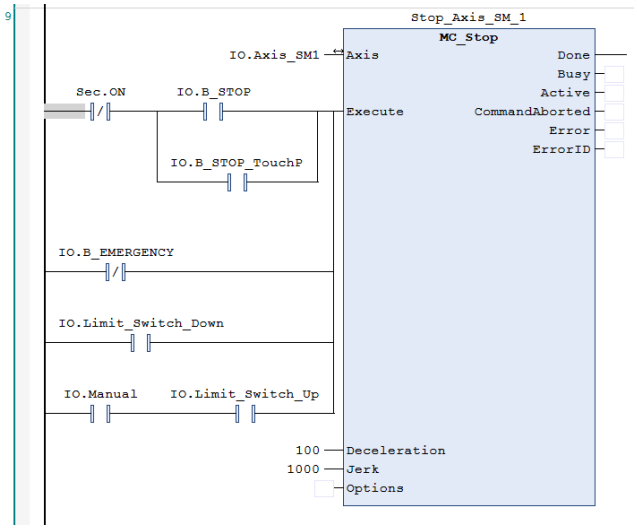

Figure 73 – Stop block

When the motors stop quickly or there is a fault in any of them, we will get an error signal and therefore we will not be able to start them even when we solve the problem. To remove this error signal, we use the *"MC_Reset"* block, which will reset all the existing faults in the motor, and if they have been solved previously, we can restart it. (Figure 74).

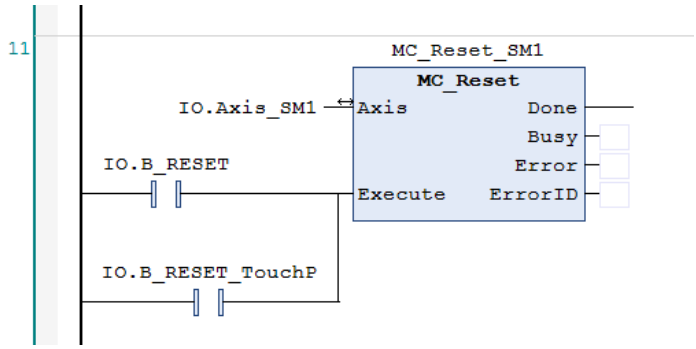

Figure 74 – Reset block

6.2.5 Connection to the PLC

To connect our computer to the PLC we need to set the Ethernet connection, through which we will establish the connection. The settings to be made are shown in the following image. Be sure that the IP address is got automatically. (Figure 75).

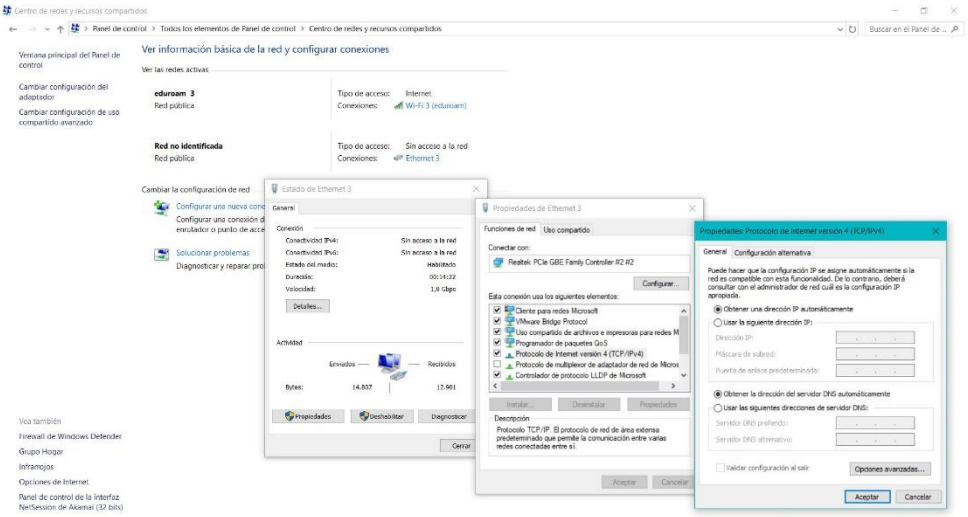

Figure 75 – Network configurations on our PC

Now we have to install the EtherCAT driver on the PLC if it's new or if it doesn't have it yet and the EhterCAT protocol. We can do it both things following the instructions from Beckhoff:

- Driver instalator:
  https://infosys.beckhoff.com/content/1033/fc900x/html/fc900x_driver_manual.htm
- EtherCAT protocol installation:
  https://infosys.beckhoff.com/content/1033/fc900x/html/fc900x_tc-etherprotactivate.htm

Then from the "System" section we will create a new target of a local type and we will search until we obtain the IP address of the device that corresponds with our PLC. It is important to check that the MAC address also matches. When it appears we will add it as a route, so we will be creating the connection. (Figure 76).

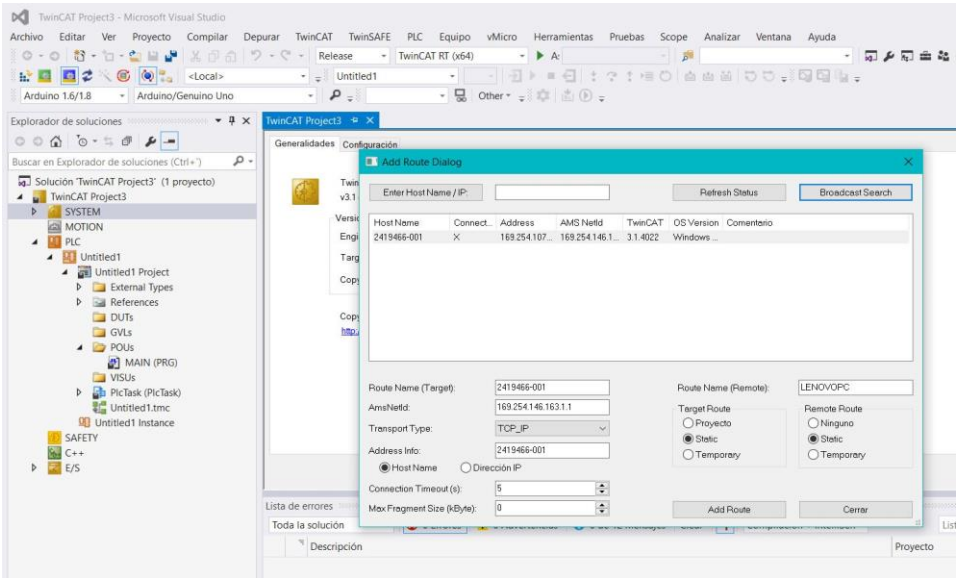

Figure 76 – Linking the PLC project to the real PLC

To check that the connection has been made correctly we can do it through the system console as shown in the figure 76. If the connection is correct we will see that packets have been sent and received correctly. (Figure 77).

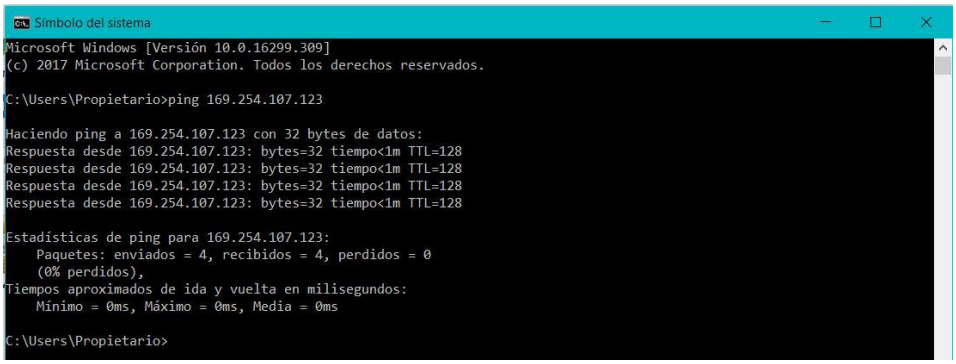

Figure 77 – System console test

All above will be useful because is need to be do it each time we have a new PLC.

6.3 **Touch Panel**

Once the program has been completed, we proceed to create the touch screens that we will have. A total of 6 different screens have been created, all of them in English, although it is possible to translate them into other languages if necessary.

To create a screen, simply add a new display and the display manager and other tools will be created automatically. In the visualization manager we will have to create a new task or target, which will be the file that will be loaded in the touch screen. (Figure 78).

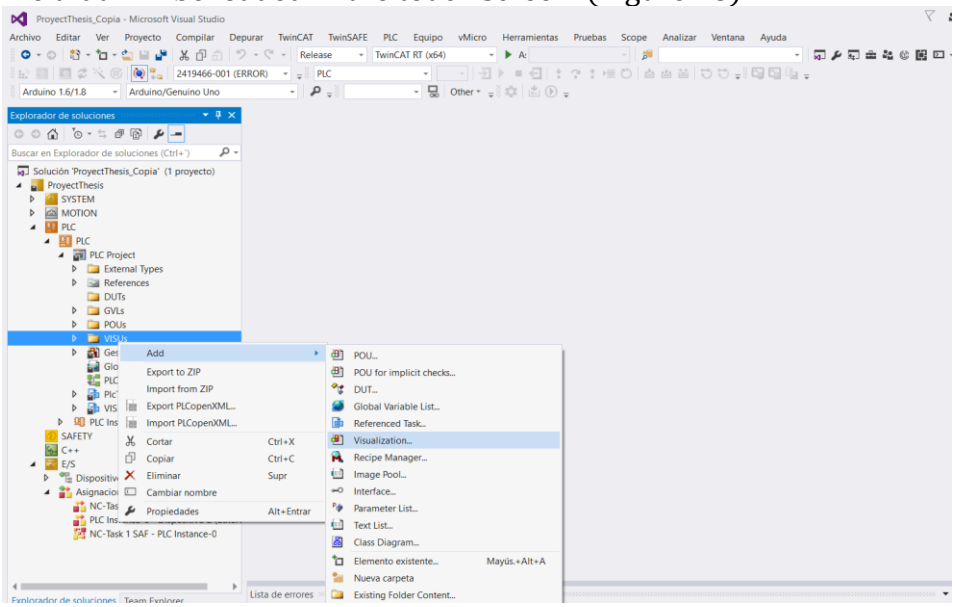

Figure 78 – Creation of a visualization

The main menu is the main panel from which all machine and system controls can be accessed. (Figure 79).

Figure 79 – Main screen display

To log in with your username and password, go from the initial menu to the LOG IN/OUT screen. In this screen you will find all the controls related to the users. (Figure 80).

Figure 80 – Log in/ Log out screen display

We find a viewer located at the top, where the user who is currently logged in will appear in case there is one.
At the top we can log in or log out. The users that have initially been configured are:

- User: Student. Password: studenthamk
- User: Teacher. Password: teacherhamk
- User: Admin. Password: admin

The first two belong to the HAMK user group that will be able to access all the controls, except the modification, deletion or user creation, located at the bottom of this screen, which can only be accessed if we log in as an administrator.

All the screens will have a series of buttons at the bottom with which you can navigate through the different screens, in this case you can only return to the initial menu.

Once we have started the session, we will be able to access, from the main menu again, to the configuration screen (Figure 81), in which we will be able to decide which type of pieces we want to be classified in zone A and which in zone B. The characteristics we can choose from are:

- Colour: red, blue or green
- Material: metal or other
- Magnetism: magnetic part or not

The buttons on the right side are used to validate the configuration entered.

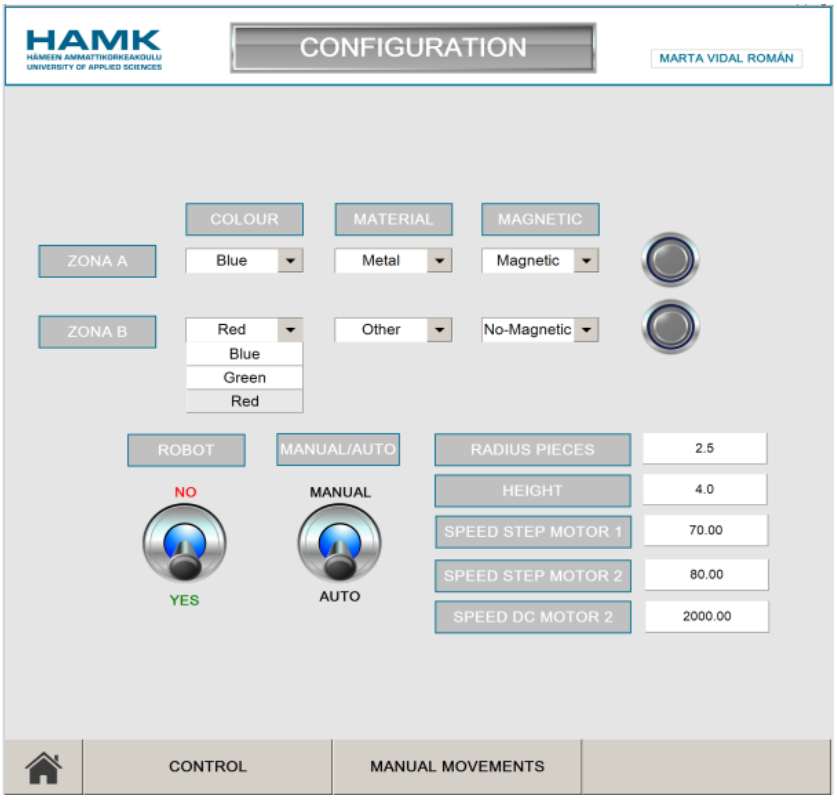

Figure 81 - Configuration screen display

In the central part we can configure the work modes: with or without robot, and manual or automatic. In addition we must introduce the radius of the pieces we are going to classify and their height, as well as other aspects such as the speed of the motors. If none of these parameters have been entered, the default values will be used:

- Radius of the pieces: 2,5cm
- Height of the pieces: 4 cm
- Stepper motor speed 1: 70
- Stepper motor speed 2: 80
- DC motor speed 2: 1500

Finally, as mentioned above, you can scroll between the different screens using the buttons situated at the bottom.

Another of the most important screens is where we find all the controls of the machine. (Figure 82).

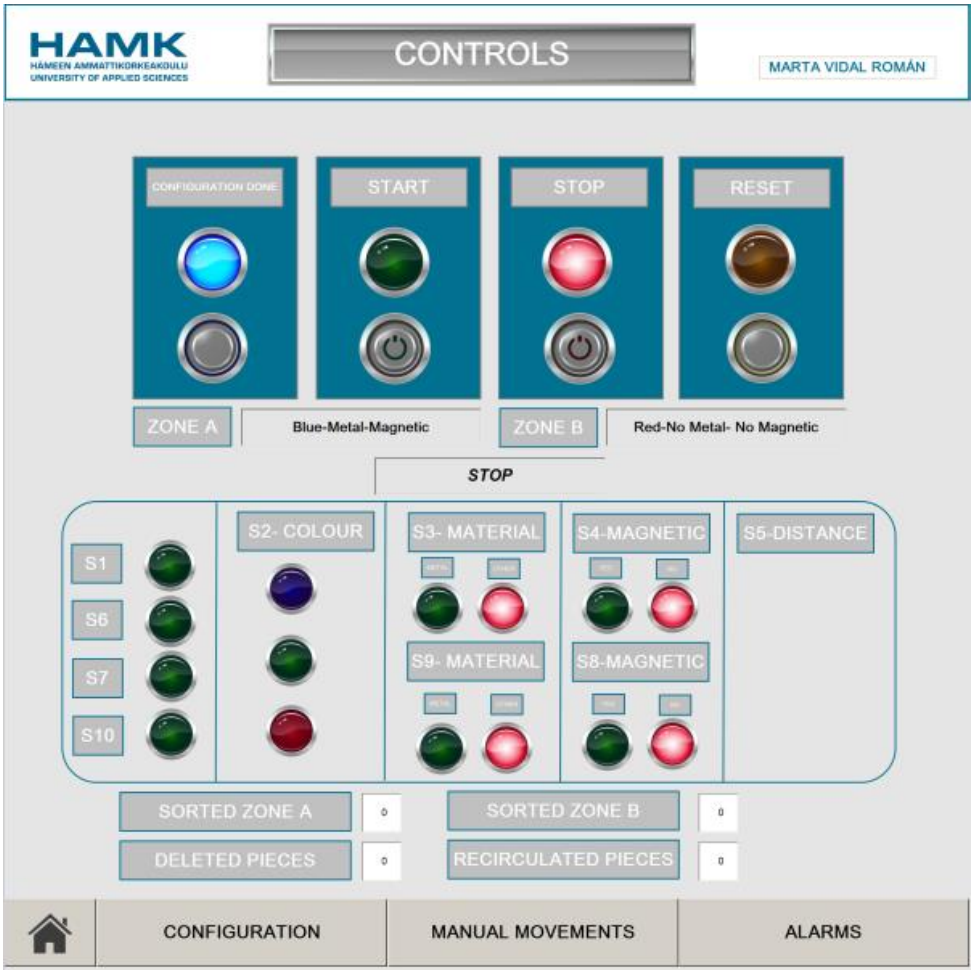

Figure 82 - Controls screen display

At the top are the buttons to validate configuration, start, stop and reset, that is, the main controls on which we can act, all of them will be push-buttons except the stop which will work as a switch. Just below we can see the configuration that has been entered and that the machine will follow as a condition of sorting the pieces. It should be noted that this configuration can only be displayed when it has been validated, and for this purpose the blue light must be kept on. After these displays, we find another one in which we can see the current status of the machine:

- Stopping
- Ready to go
- Security breach
- Classifying in zone A
- Classifying in zone B
- Removing part
- Recirculating part
- Engines at home

When we press the start button, if all the safety precautions are correct, the signal above the button will automatically turn green and the machine will be ready to start the cycle automatically when it receives the first piece. If we press the stop button during the cycle, it will stop until the user removes the stop signal and the start is resumed. Finally, there is the reset button with which we will be able to restart the process completely. In addition, a message will appear on the screen in case we want to reset the entered configuration as shown in figure 83.

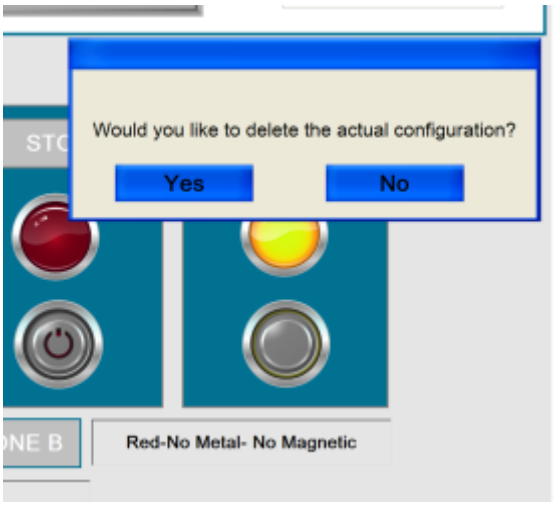

Figure 83 – Warning dialog

An important aspect to have in mind is that the same start, stop and reset controls can be carried out from the physical control panel that the machine has, although in the case of resetting from the physical panel, we must go to the touch screen to confirm or not the delete of the configuration.

In the central part of the screen you can see indicator lights related to the machine's sensors. They are only useful to check their current status in real time and know if there is any fault or defect in the operation of any of them.

At the bottom are the piece counters that have been sorted, removed or recirculated.

The last screen we can access is the manual movement screen (figure 84). From it we can control the movement of all motors and solenoid valves, in case we have previously selected the manual mode from the configuration screen.

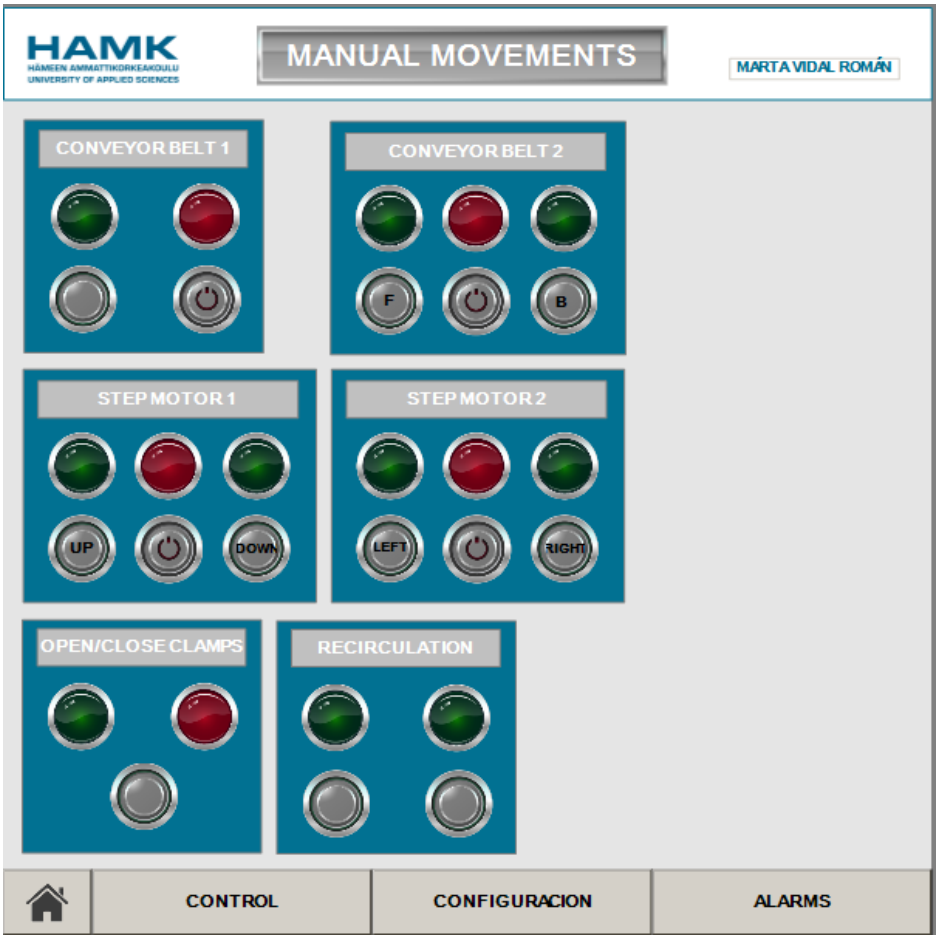

Figure 84 – Manual movement screen display

6.4 **Robot integration**

We have mentioned that the machine could work by its own or with the help of a robot. This is part of other project called "*Robot arm vision guided*" by Pablo Horno Pérez 2018. The robot will be the one that puts the pieces on the first conveyor belt and take the pieces from the second conveyor belt in case they were going to be deleted. To do that is necessary to have a communication between the PLC and the Robot. It has been used two digital inputs, two digital outputs and GND connection between them.
The first signal that the robot receive is a digital output to know that it can leave a piece on the initial point of the conveyor belt, then the robot will send the PLC a digital signal so that the PLC knows that the pieces is already on the conveyor and it can begins to work without any danger. At the end of the process if the piece is going to be deleted, the robot would be noticed and it would be the one that takes the piece from the second conveyor belt. Finally when it has picked and take out the piece from the conveyor, it would send a signal of work done and the process would start again. If there is not piece to be deleted, the robot would be waiting till the next signal to puta new piece in the beginning. The connection between the robot and the Machine is done as the figure 85 shows.

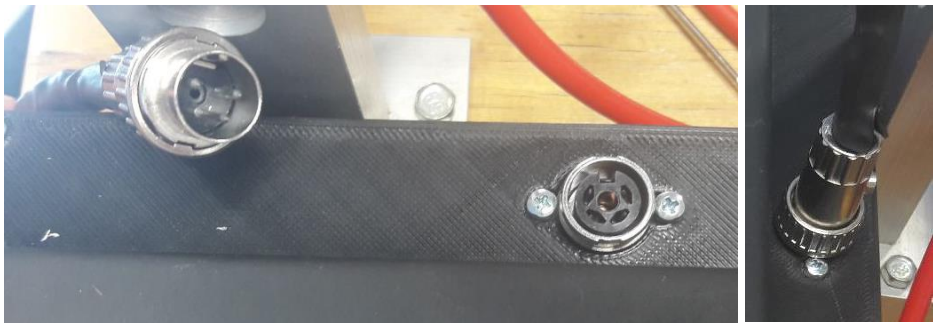

Figure 85-Cable connection

The work of the machine with the robot it is shown in the following image (figure 86).

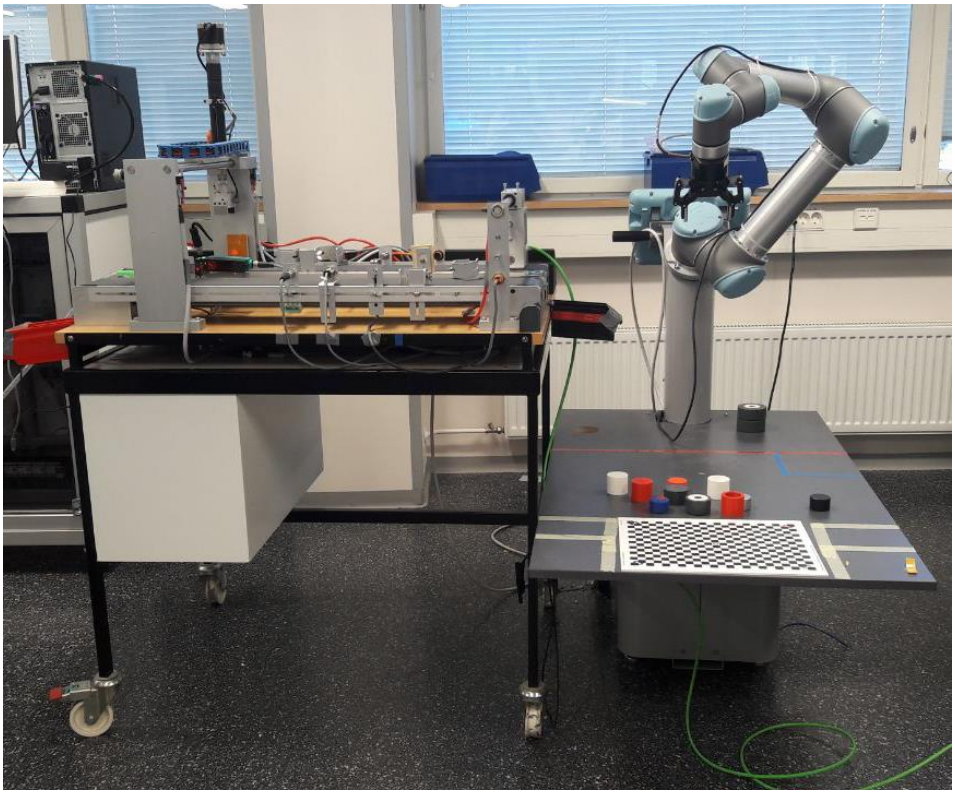

Figure 86- Robot and classification machine working together

This has been done to simulate a real industrial automatic production line.

7 START UP OF THE MACHINE

A 24V power supply and a pressure tap were required for the start up. Before explaining its operation we must know that we have to pay attention to all the indicator lights, and that there are several ways to stop the machine if necessary:

- Through an emergency mushroom located on the physical panel of the machine. If we use this stop, we won´t be able to restart the engines again until a reset is carried out. Recommended for use in emergencies.

- One stop button on the physical panel and one on the touch screen. With this type of stop, you can resume the cycle from the point where it left off.

Once the machine and the PLC are turned on, we will proceed as follows:

1). On the touch screen you will be able to log in by entering your username and password.

2). We open the configuration screen where we must select which types of piece we are going to classify in each zone. Validate each of the settings using the buttons to the right. We select the type of work, whether it is with a robot or not and whether it is manual or automatic. We introduce the dimensions of the pieces we are going to classify. We adjust the motor speeds if necessary always taking into account the minimum and maximum values (it is recommended to leave the default values).

3). We open the control screen and we will see that the stop sign is on and if we have validated the settings correctly, they will appear in the central part of the display, and the blue configuration sign will also be on. We check that the sensors are in their idle state and that there are no obstacles in the circuit. The machine will be ready to start.

4). We start the machine by pressing the green start button from the touch screen or from the physical control panel and wait until the display indicates that the machine is ready to receive a piece.

5). The piece is placed at the beginning of the machine. If we do it manually we will have to place it in the sensor S1 cut-off point. If the piece is placed by the robot, the machine itself will manage the communication with it through signals. The cycle will begin. During the machine cycle, we should not perform any complementary actions.

6). When the piece has been classified or eliminated we will repeat actions from the 5th step.

If the machine stops or fails at any part of the process for any unknown reason, it is recommended to reset it completely and perform all the machine start up steps again. We can also reset it if we want to change the entered configuration.
In case the screen is locked, turn off the whole system and restart it.

To make easier the work and setup of the machine, a user manual will be include so that you can follow step by step the start-up, the reset or even the stop process.

8 CONCLUSIONS

In this final thesis the mechanical, electrical and pneumatic design, programming of the programmable logic controller, manufacture and assembly of a first prototype of the classification machine have been carried out.

The main objective was that it could be used in the university as a learning method for students. It will be a good method of learning as it contains some of the basic elements that we can find in an automated production line, such as motors, solenoid valves and different types of sensors and the latest technology in terms of programmable logic controllers.

This project has been programmed for the joint control and operation of all the integral elements, although many other options are possible. This gives the machine a flexible programming feature. An intensive study has also been carried out on the programming with ladder diagrams in Twincat 3, mentioning the most important parts to take them into account. This study and programming has been carried out intensively and successfully and will be of great help to others, as many of the aspects covered are not currently incorporated in the documentation of the device and software manufacturer.

The mechanical design has been designed so that the sensors can be positioned along the two conveyor belts. In addition, the parts can be dismantled and rearranged. This feature allows new sensors or elements to be removed, repositioned or added and incorporated into the programming. It is therefore a modular machine, as its various components can be relocated in many other ways as well as being able to add new ones.

The motivation that has led me to carry out this project in the field of automation has been the need to bring a small part of the field of industrial automation to engineering students, as it is one of the things most demanded by factories and companies nowadays. This will allow us to get a little closer to the industrial world.

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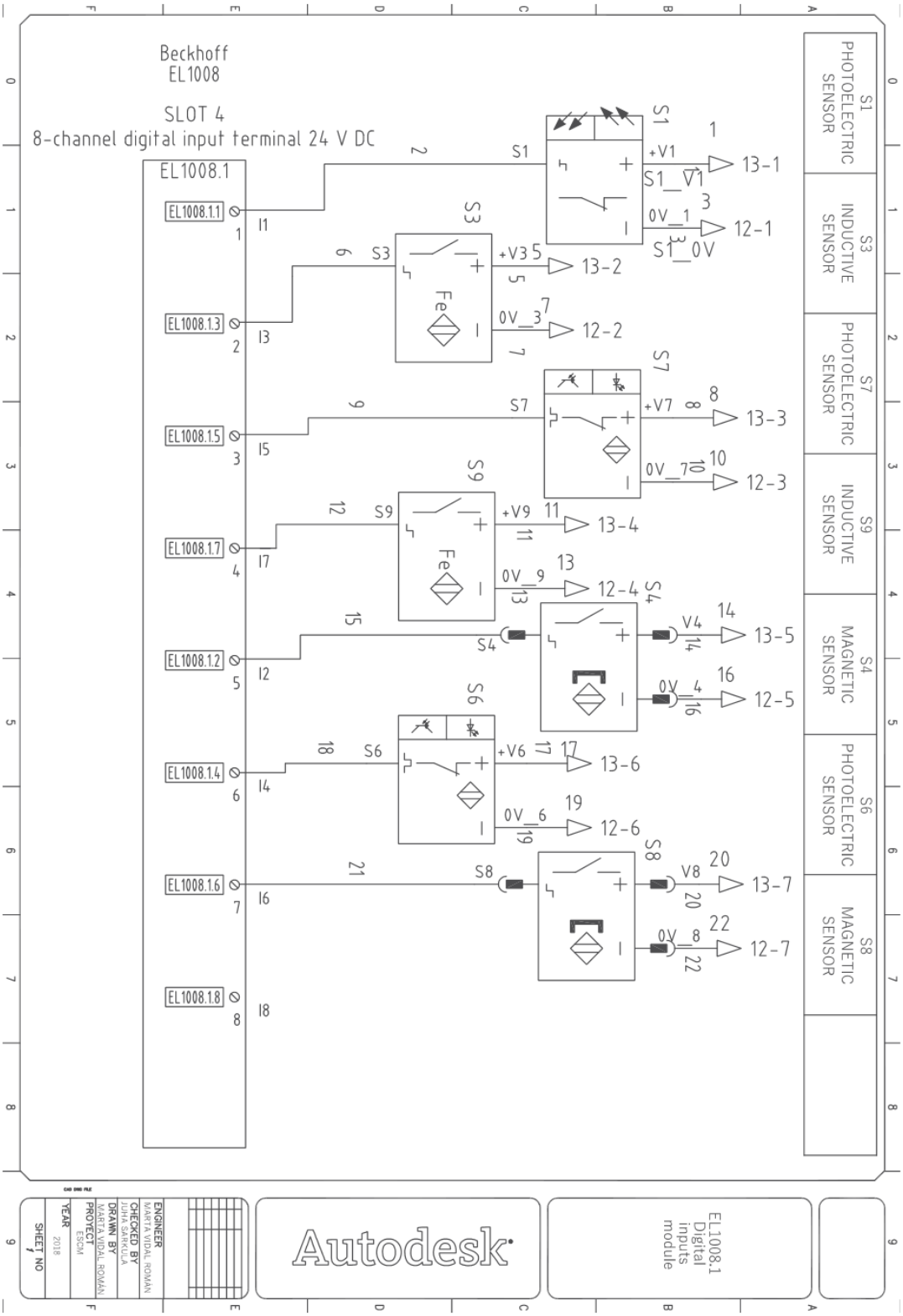
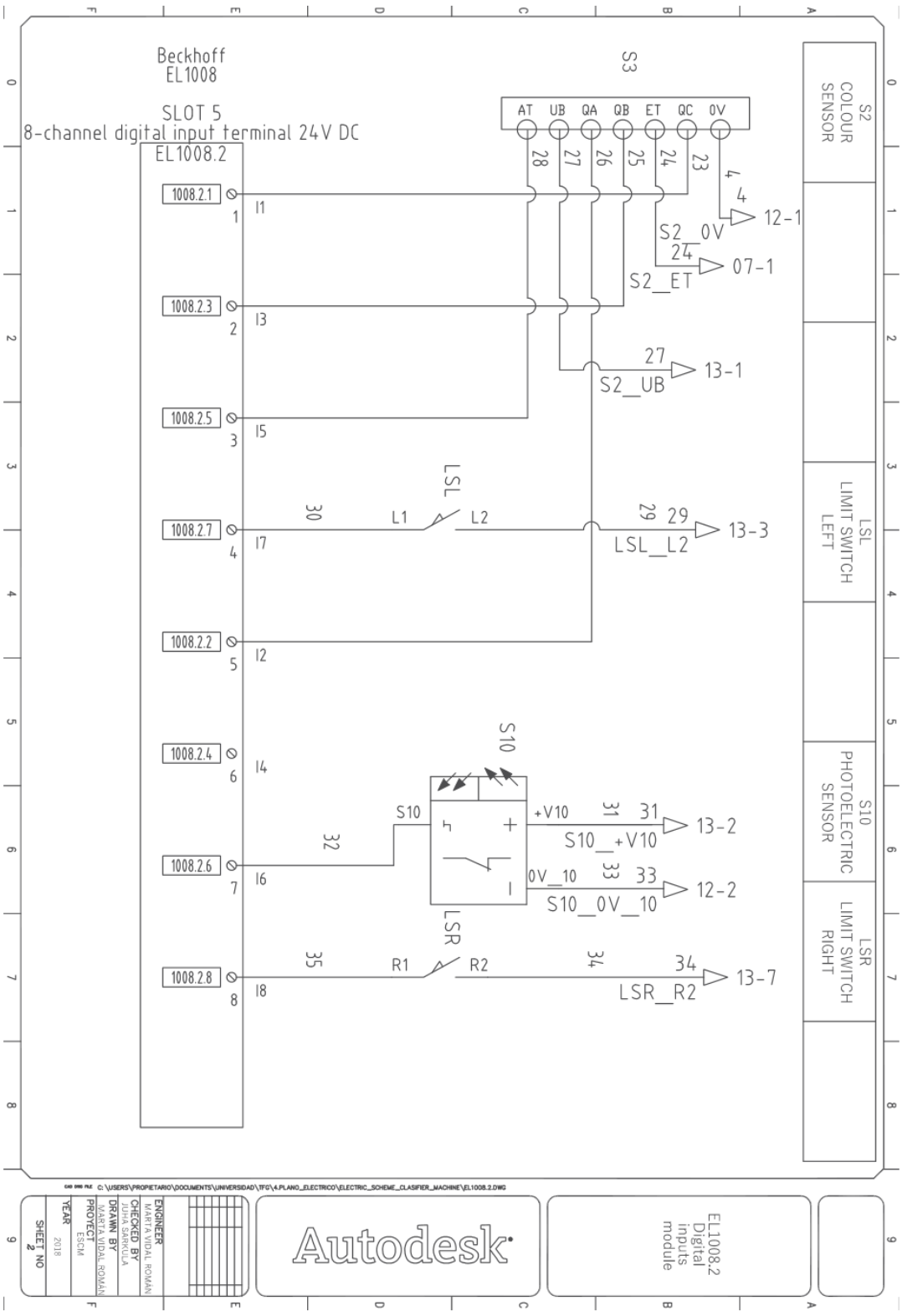
Appendix 1

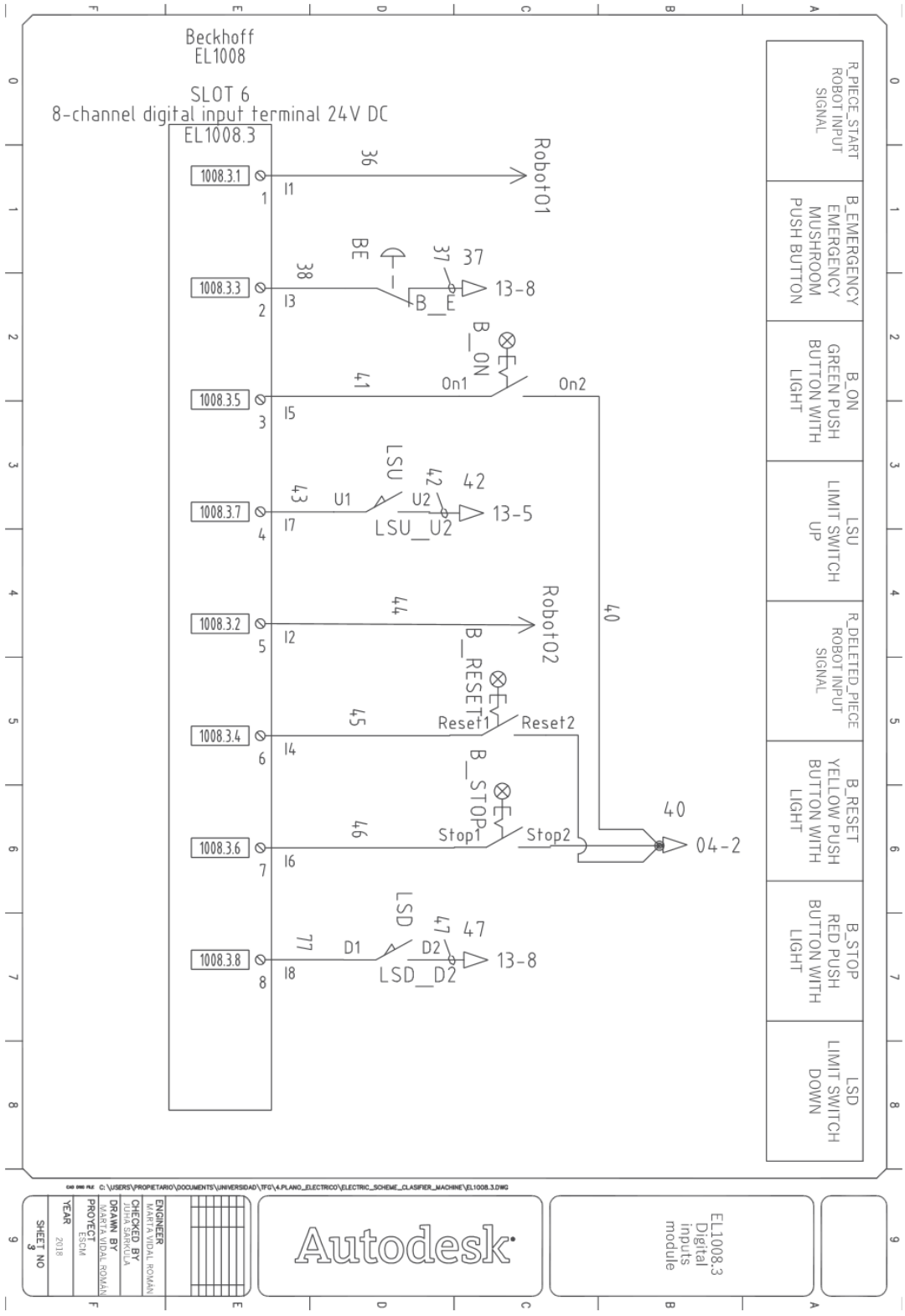
CODE

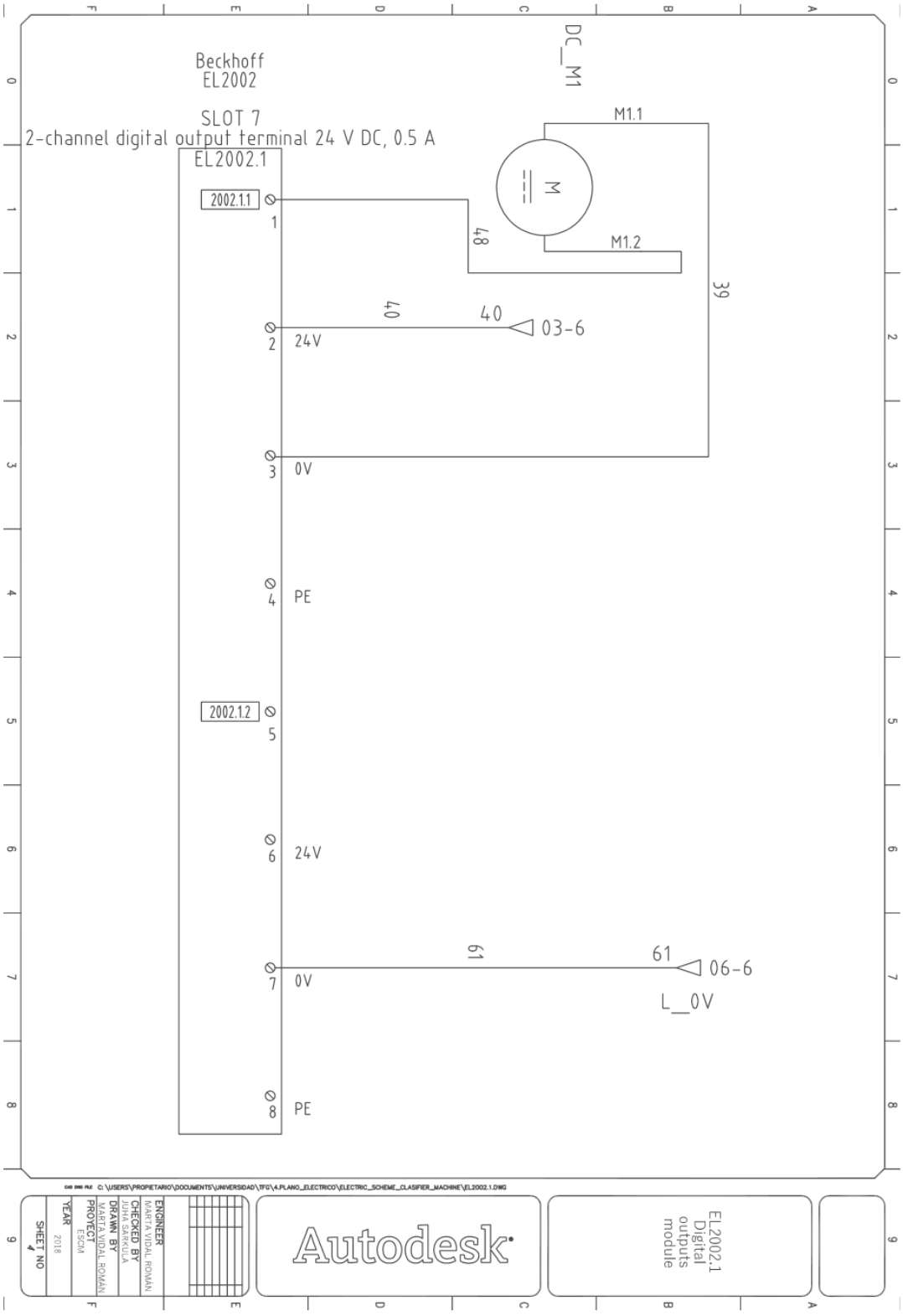
Included in digital format (Incluido en formato digital)

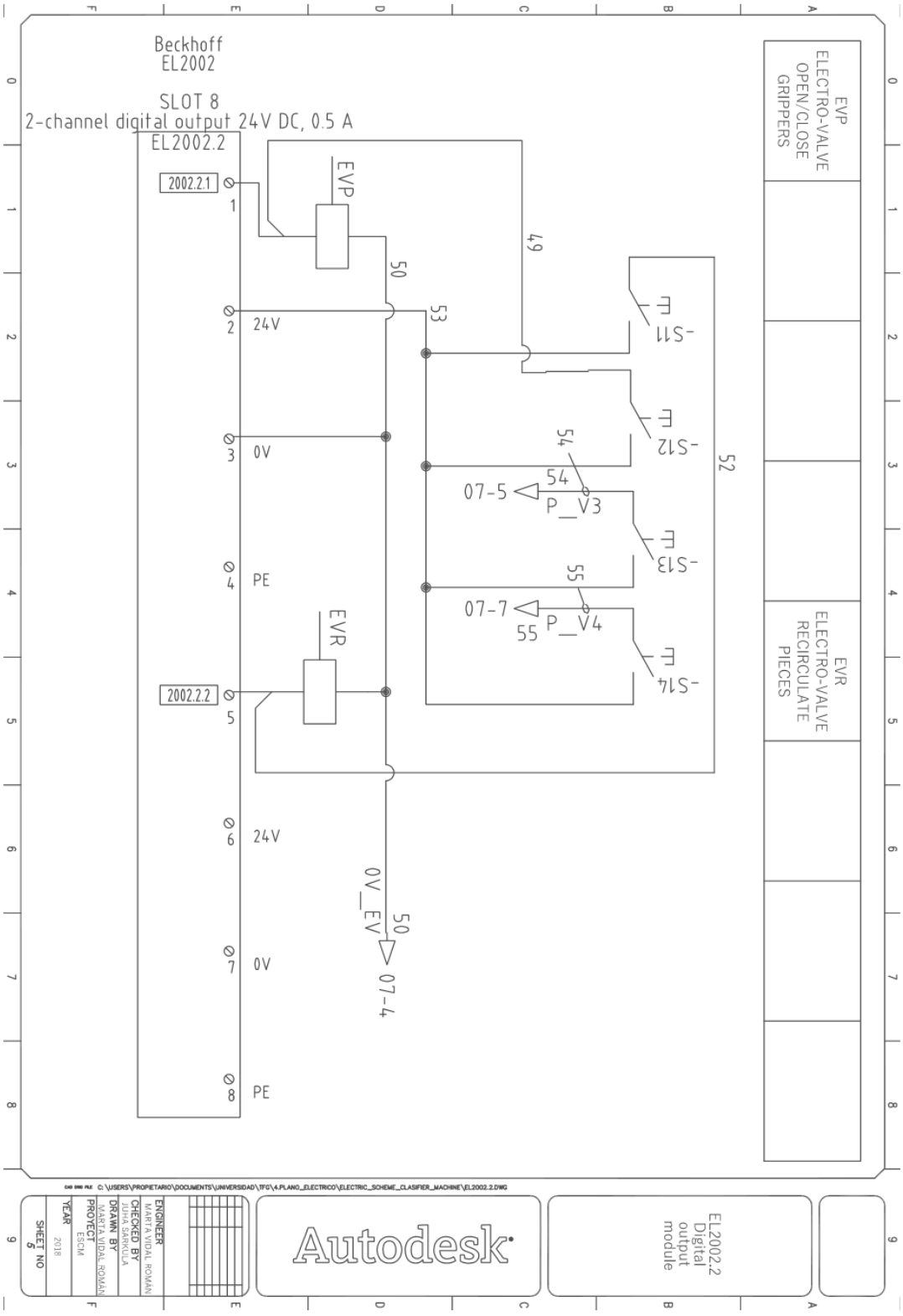
ELECTRICAL AND PNEUMATIC SCHEMES Appendix 2

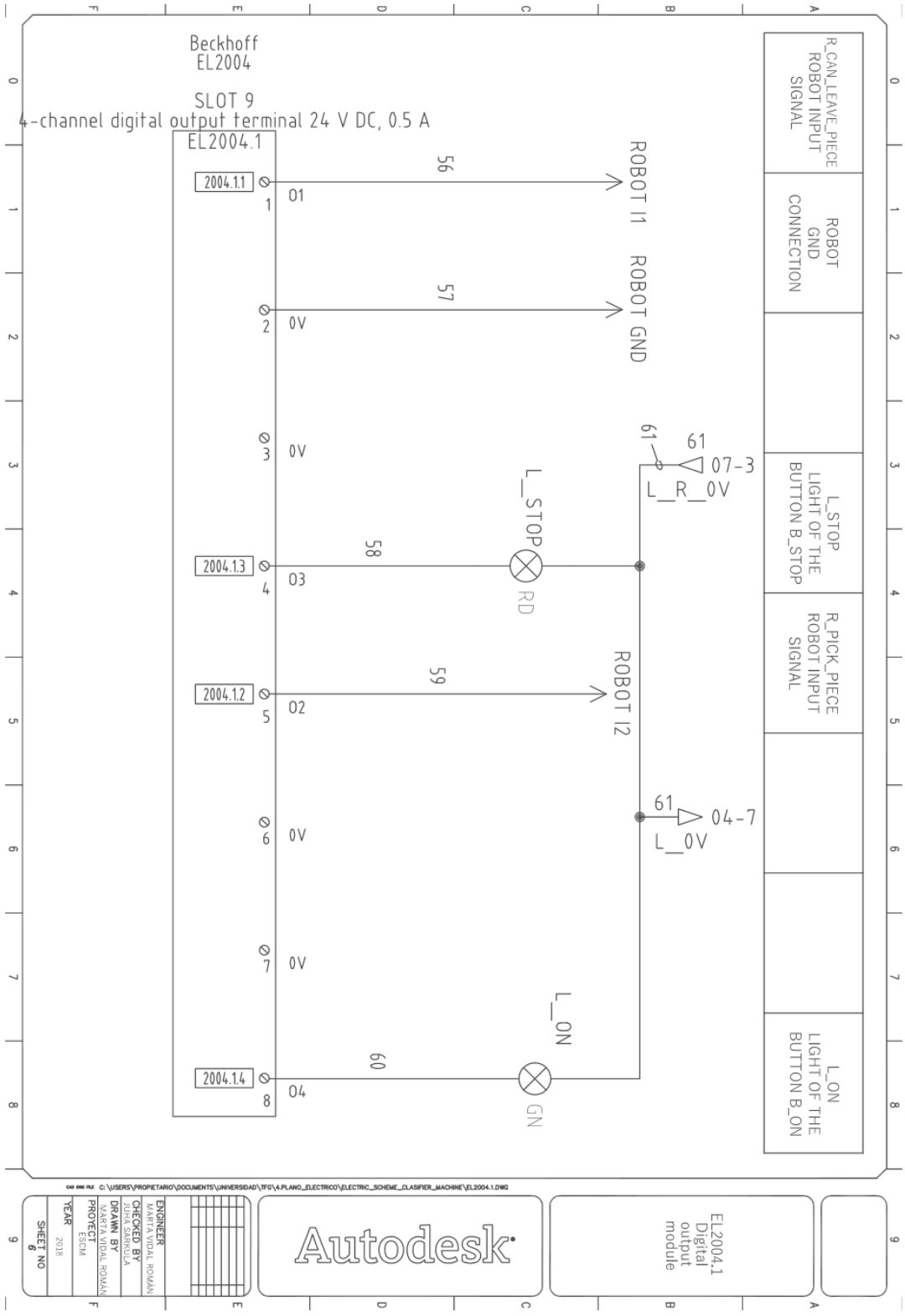


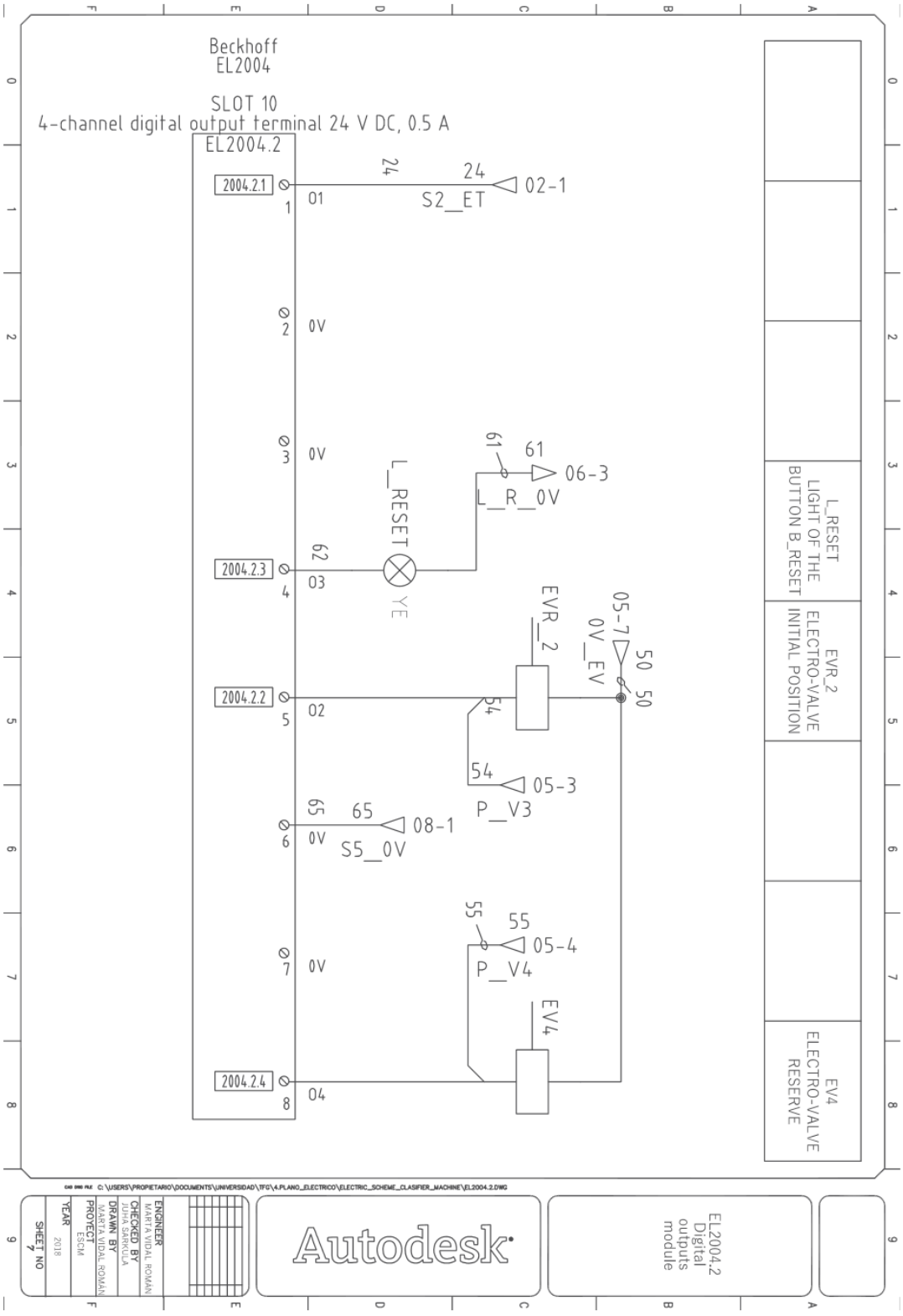

Beckhoff
EL1008
SLOT 5
8-channel digital input terminal 24V DC
EL1008.2
S3
AT UB QA QB ET QC 0V
28 27 26 25 24 23 4
S2_0V
S2_ET
S2_UB
12-1
07-1
13-1
1008.2.1
1008.2.3
1008.2.5
1008.2.7
1008.2.2
1008.2.4
1008.2.6
1008.2.8
I1
I3
I5
I7
I2
I4
I6
I8
LSL
L1
L2
LSL_L2
13-3
S10
+V10
S10_+V10
13-2
0V_10
S10_0V_10
12-2
LSR
R1
R2
LSR_R2
13-7
S2 COLOUR SENSOR
LSL LIMIT SWITCH LEFT
S10 PHOTOELECTRIC SENSOR
LSR LIMIT SWITCH RIGHT
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL1008.2.DWG
ENGINEER MARTA VIDAL ROMÁN
CHECKED BY JUHA SARKKILA
DRAWN BY MARTA VIDAL ROMÁN
PROYECT ESCM
YEAR 2018
SHEET NO 2
Autodesk
EL1008.2 Digital inputs module

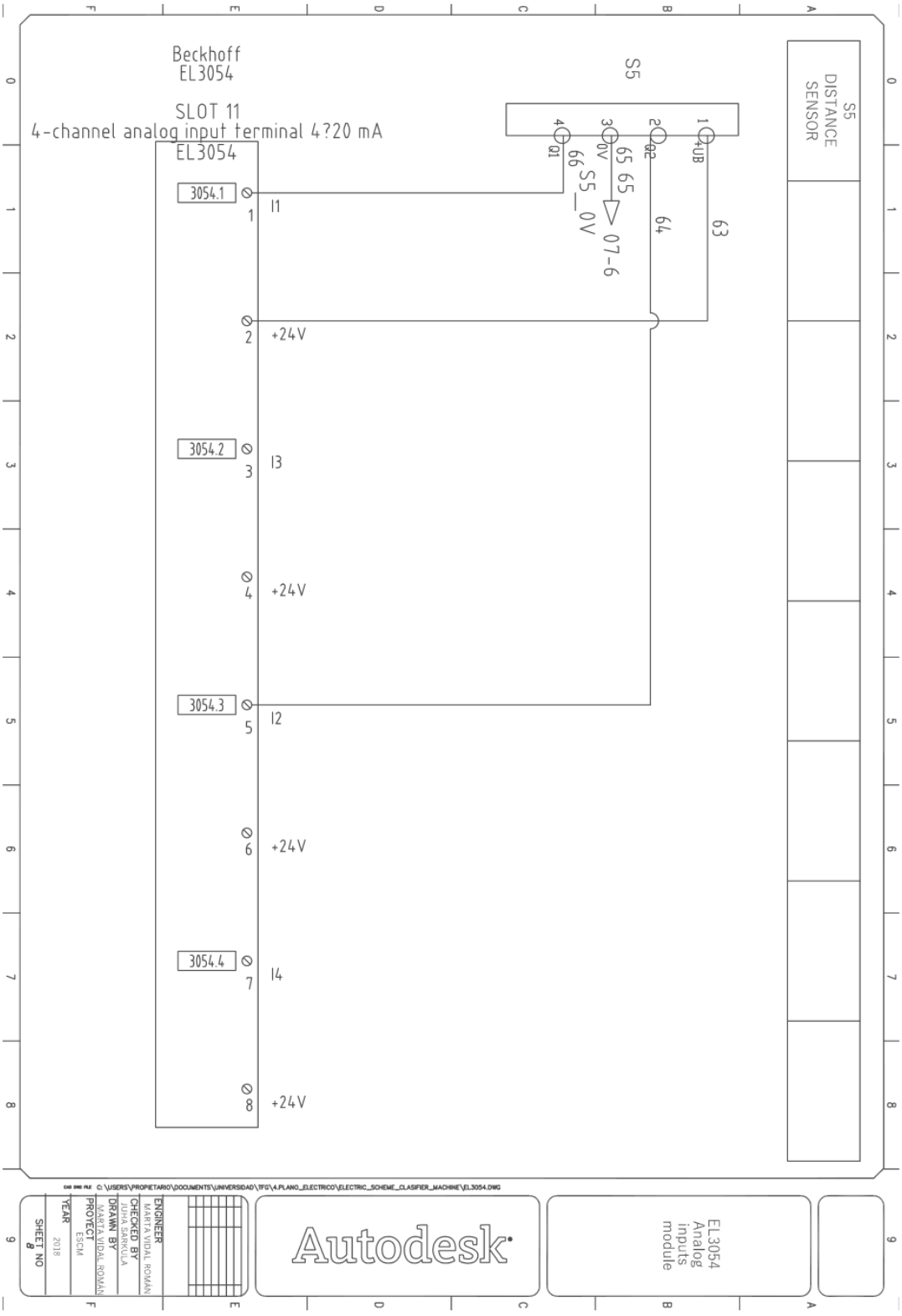

Beckhoff
EL1008
SLOT 6
8-channel digital input terminal 24V DC
EL1008.3
1008.3.1
1008.3.3
1008.3.5
1008.3.7
1008.3.2
1008.3.4
1008.3.6
1008.3.8
Robot01
Robot02
B_E
B_ON
LSU
B_RESET
B_STOP
LSD
LSU_U2
LSD_D2
On1
On2
Reset1
Reset2
Stop1
Stop2
13-8
13-5
04-2
R_PIECE_START ROBOT INPUT SIGNAL
B_EMERGENCY EMERGENCY MUSHROOM PUSH BUTTON
B_ON GREEN PUSH BUTTON WITH LIGHT
LSU LIMIT SWITCH UP
R_DELETED_PIECE ROBOT INPUT SIGNAL
B_RESET YELLOW PUSH BUTTON WITH LIGHT
B_STOP RED PUSH BUTTON WITH LIGHT
LSD LIMIT SWITCH DOWN
ENGINEER MARTA VIDAL ROMÁN
CHECKED BY JUHA SARKKILA
DRAWN BY MARTA VIDAL-ROMÁN
PROYECT ESCM
YEAR 2018
SHEET NO 3
Autodesk
EL1008.3 Digital inputs module

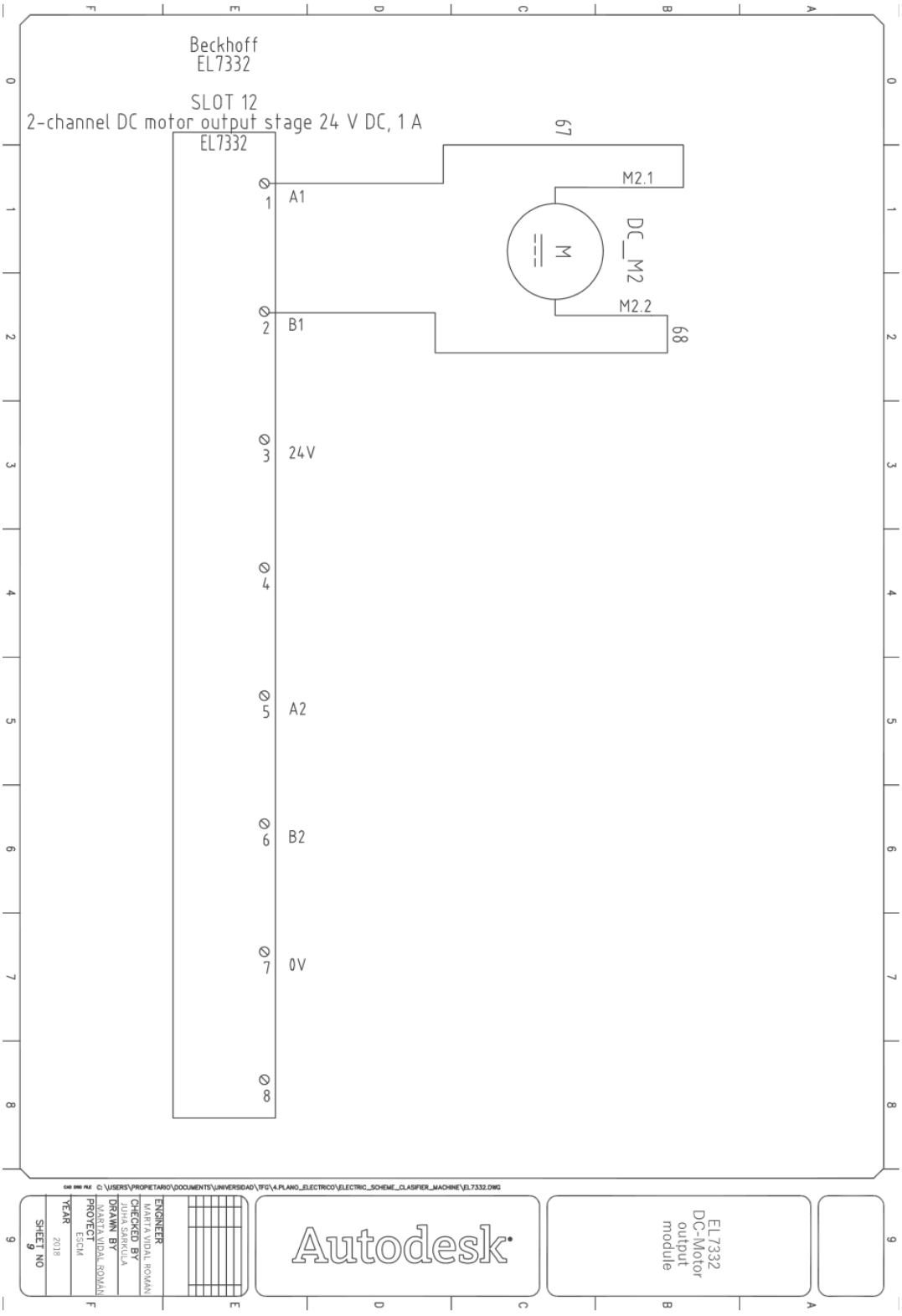

Beckhoff
EL2002
SLOT 7
2-channel digital output terminal 24 V DC, 0.5 A
EL2002.1
DC_M1
M1.1
M1.2
M
48
39
40
40
03-6
2002.1.1
1
2
24V
3
0V
4
PE
2002.1.2
5
6
24V
61
61
06-6
7
0V
L_0V
8
PE
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL2002.1.DWG
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKKIJA
DRAWN BY
MARTA VIDAL ROMÁN
PROYECT
ESOM
YEAR
2018
SHEET NO
4
Autodesk
EL2002.1
Digital
outputs
module

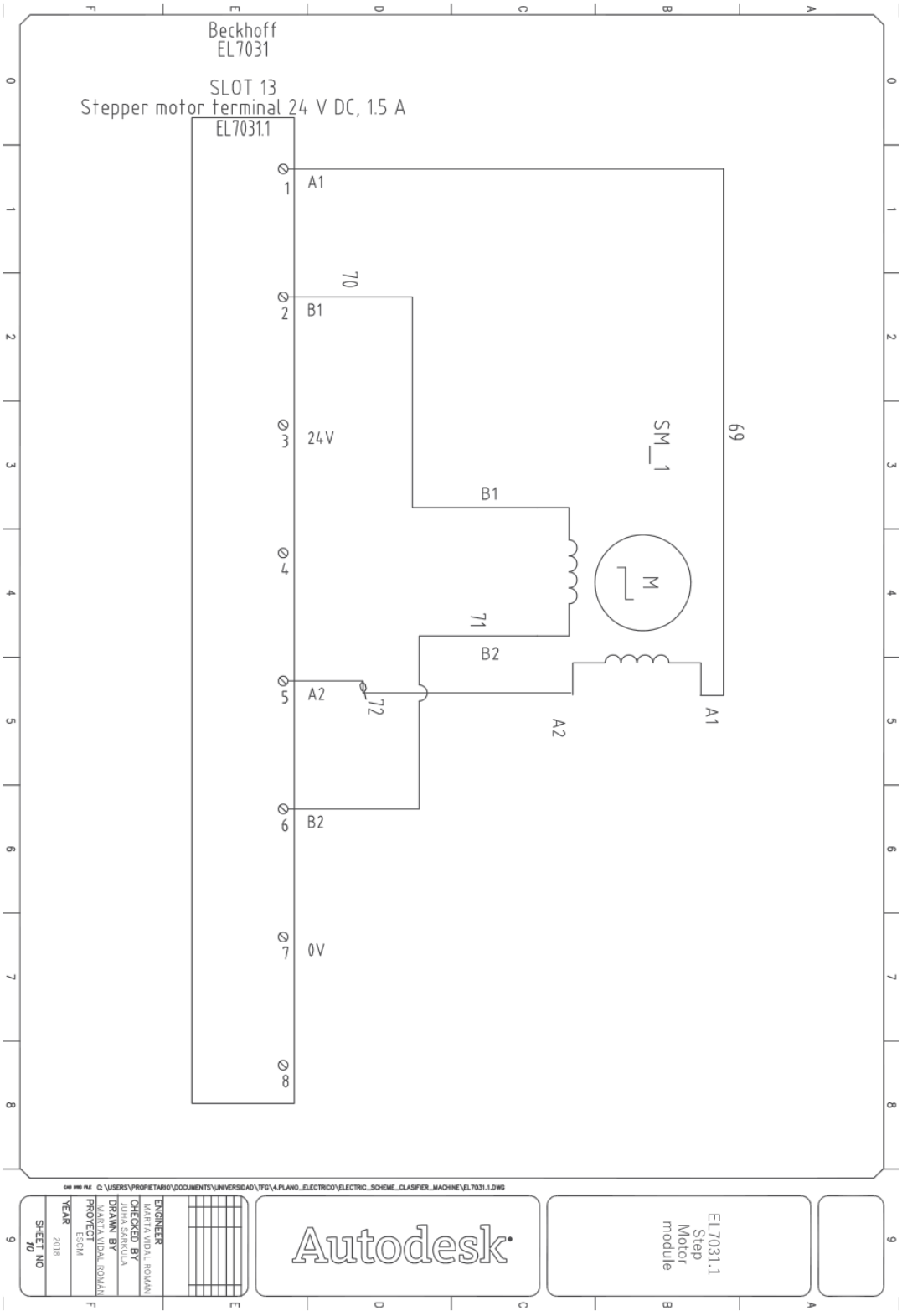

Beckhoff
EL2002
SLOT 8
2-channel digital output 24V DC, 0.5 A
EL2002.2
2002.2.1
2002.2.2
EVP
EVR
24V
0V
PE
24V
0V
PE
49
50
53
52
54
55
-S11
-S12
-S13
-S14
07-5
07-7
P_V3
P_V4
0V_EV
07-4
EVP ELECTRO-VALVE OPEN/CLOSE GRIPPERS
EVR ELECTRO-VALVE RECIRCULATE PIECES
EL2002.2 Digital output module
Autodesk
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKKILA
DRAWN BY
MARTA VIDAL ROMÁN
PROYECT
ESCM
YEAR
2018
SHEET NO
6

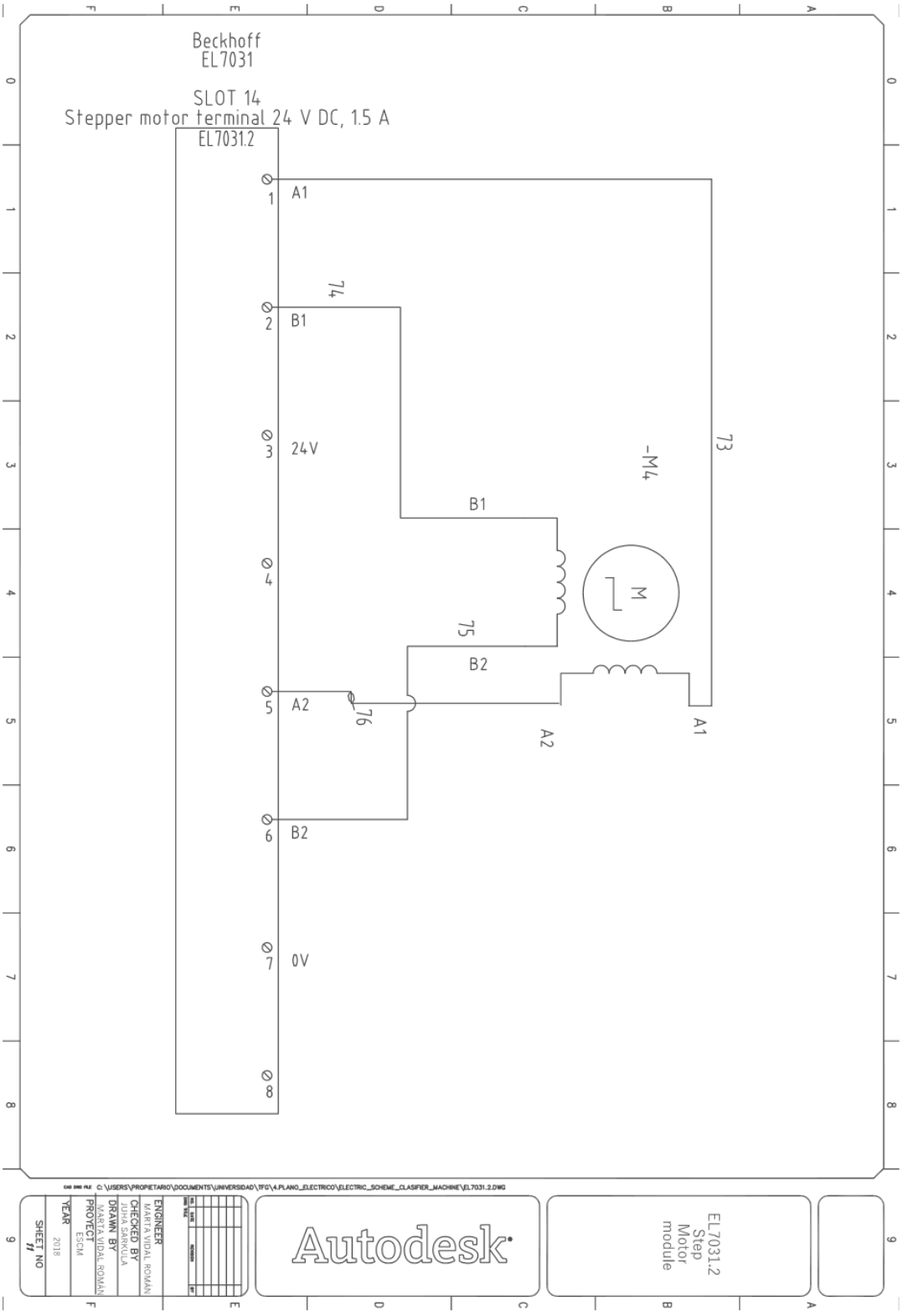

Beckhoff
EL2004
SLOT 9
4-channel digital output terminal 24 V DC, 0.5 A
EL2004.1
2004.1.1
2004.1.3
2004.1.2
2004.1.4
01
02
03
04
0V
ROBOT I1
ROBOT I2
ROBOT GND
L_STOP
L_ON
RD
GN
07-3
04-7
L_R_0V
L_0V
R_CAN_LEAVE_PIECE ROBOT INPUT SIGNAL
ROBOT GND CONNECTION
L_STOP LIGHT OF THE BUTTON B_STOP
R_PICK_PIECE ROBOT INPUT SIGNAL
L_ON LIGHT OF THE BUTTON B_ON
EL2004.1 Digital output module
Autodesk
ENGINEER MARTA VIDAL ROMÁN
CHECKED BY JUHA SARKKULA
DRAWN BY MARTA VIDAL ROMÁN
PROYECT ESCM
YEAR 2018
SHEET NO 6

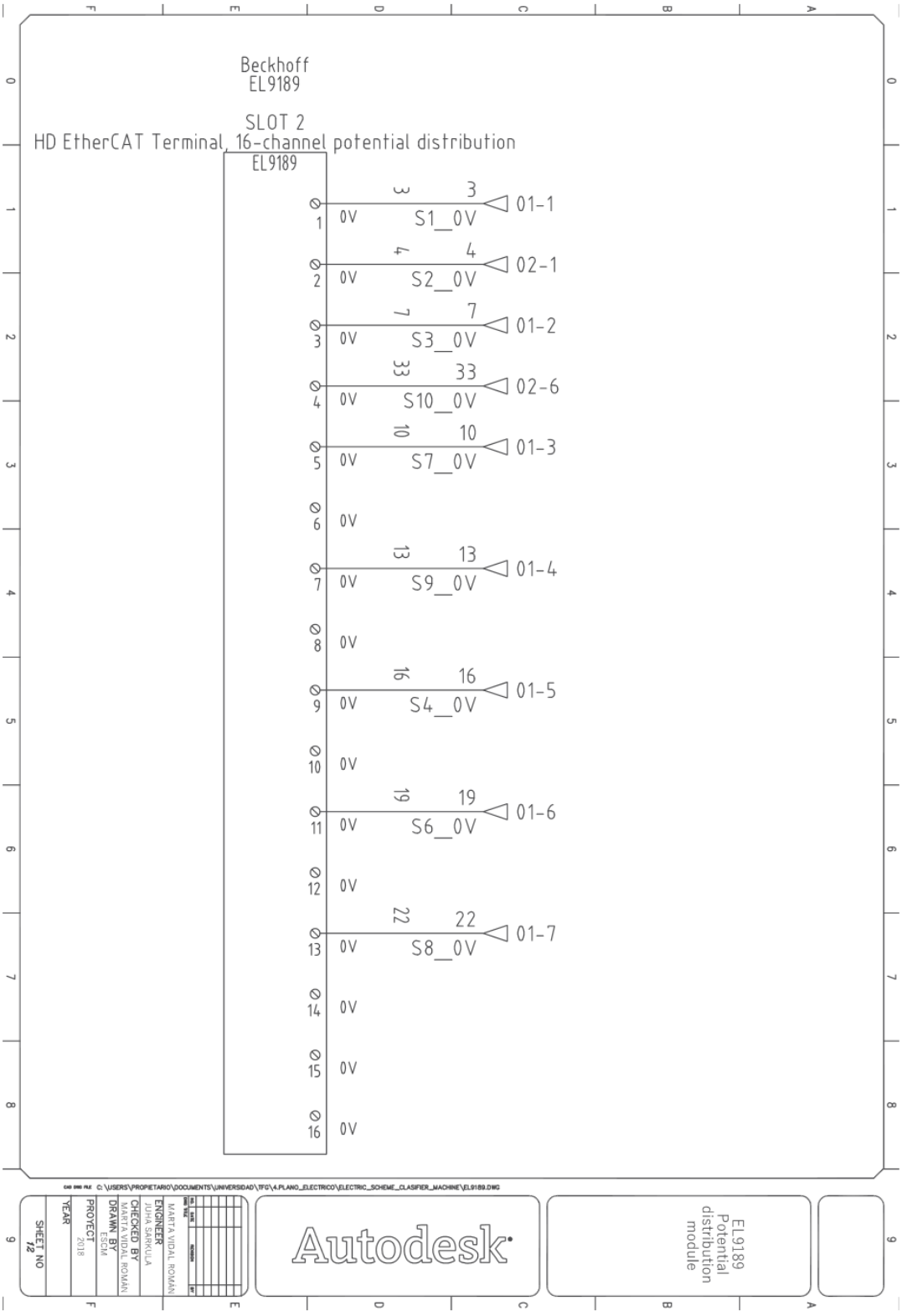

Beckhoff
EL2004
SLOT 10
4-channel digital output terminal 24 V DC, 0.5 A
EL2004.2
2004.2.1
01
24
24
S2_ET
02-1
0V
2004.2.3
03
61
61
06-3
L_R_0V
L_RESET
62
YE
2004.2.2
02
EVR_2
05-7
0V_EV
50
50
54
54
05-3
P_V3
2004.2.4
04
65
65
08-1
S5_0V
55
55
05-4
P_V4
EV4
L_RESET
LIGHT OF THE
BUTTON B_RESET
EVR_2
ELECTRO-VALVE
INITIAL POSITION
EV4
ELECTRO-VALVE
RESERVE
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL2004.2.DWG
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKKULA
DRAWN BY
MARTA VIDAL ROMÁN
PROYECT
ESCM
YEAR
2018
SHEET NO
Autodesk
EL2004.2
Digital
outputs
module

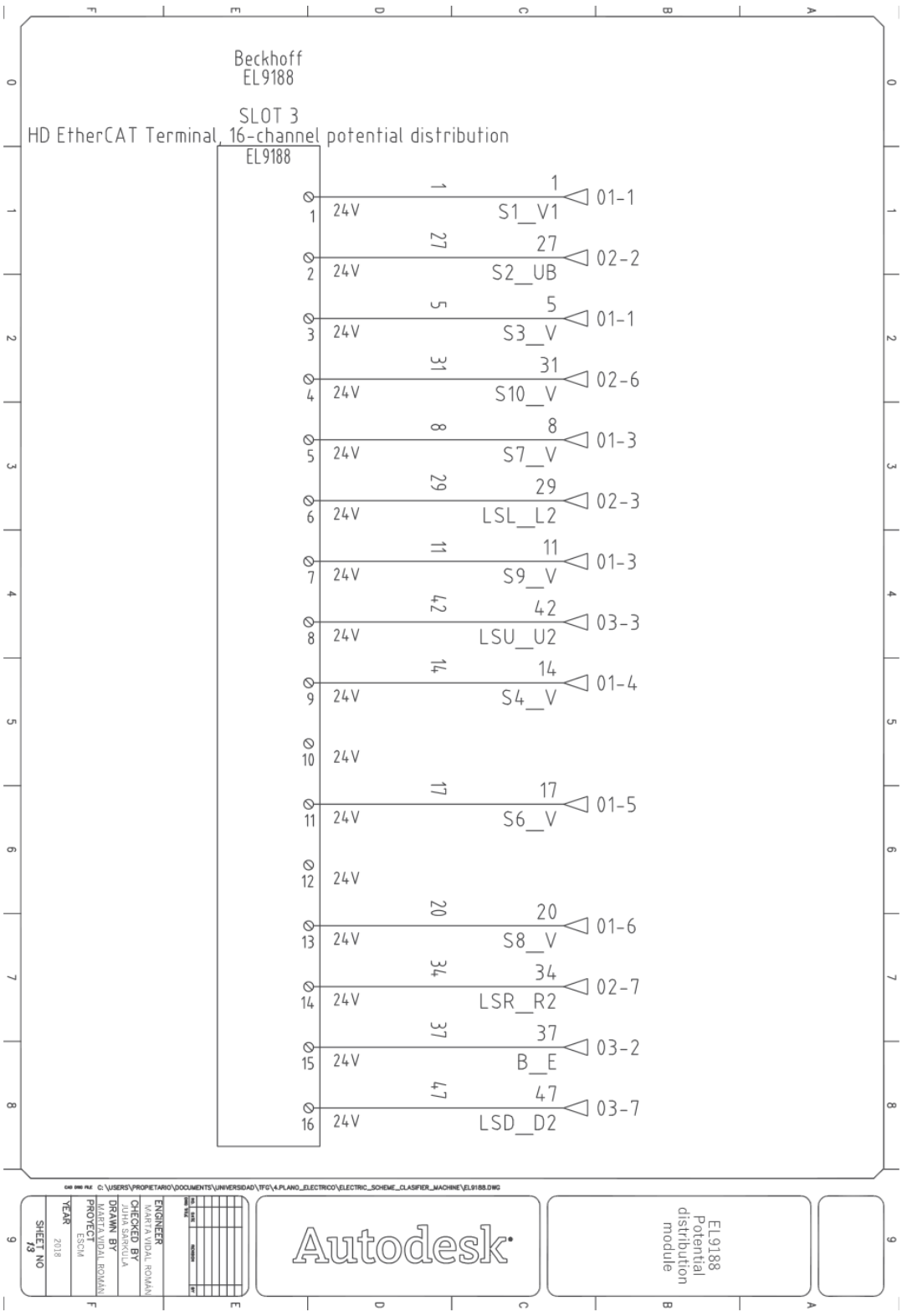

Beckhoff
EL3054
SLOT 11
4-channel analog input terminal 4?20 mA
EL3054
3054.1
1
I1
2
+24V
3054.2
3
I3
4
+24V
3054.3
5
I2
6
+24V
3054.4
7
I4
8
+24V
S5
4
3
2
1
Q1
0V
Q2
+UB
66
S5_0V
65
65
07-6
64
63
S5
DISTANCE
SENSOR
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL3054.DWG
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKULA
DRAWN BY
MARTA VIDAL ROMÁN
PROTECT
ESCM
YEAR
2018
SHEET NO
8
Autodesk
EL3054
Analog
inputs
module

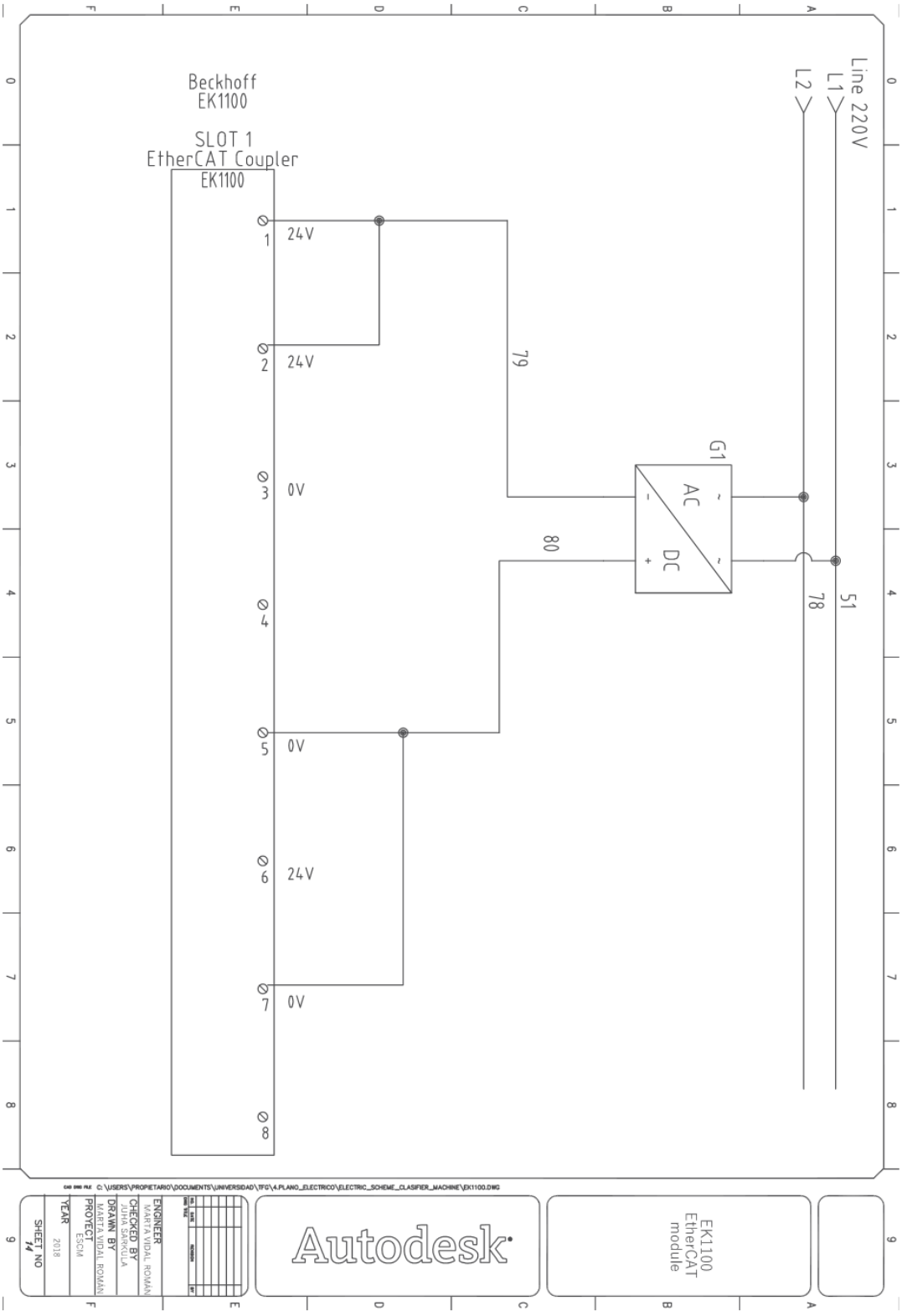

Beckhoff
EL7332
SLOT 12
2-channel DC motor output stage 24 V DC, 1 A
EL7332
67
M2.1
1
A1
M
DC_M2
M2.2
2
B1
68
3
24V
4
5
A2
6
B2
7
0V
8
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL7332.DWG
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKOLA
DRAWN BY
MARTA VIDAL ROMÁN
PROTECT
ESCM
YEAR
2018
SHEET NO
9
Autodesk
EL7332
DC-Motor
output
module

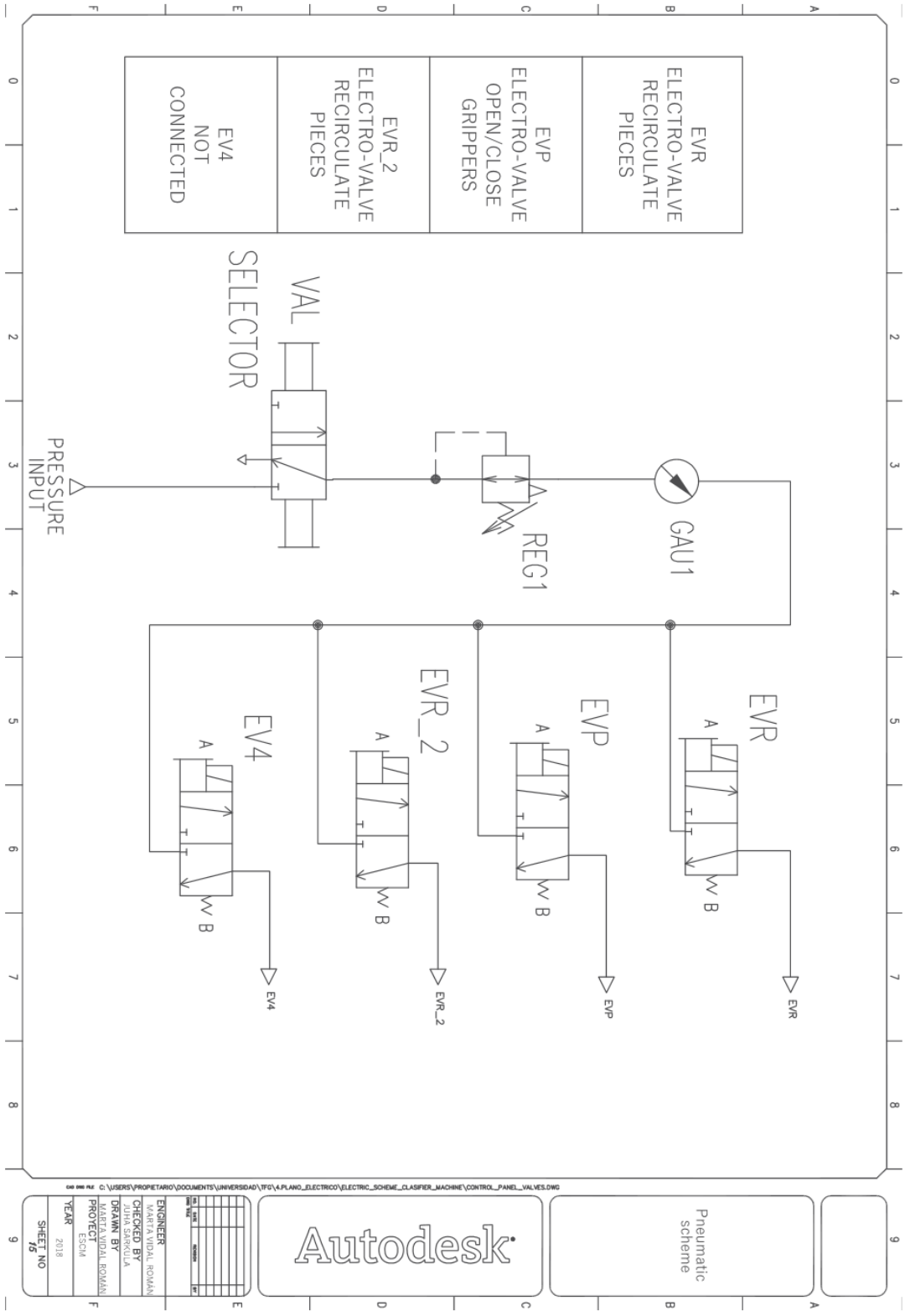

Beckhoff
EL7031
SLOT 13
Stepper motor terminal 24 V DC, 1.5 A
EL7031.1
1 A1
2 B1
3 24V
4
5 A2
6 B2
7 0V
8
70
71
72
69
B1
B2
A2
A1
SM_1
M
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL7031.1.DWG
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKKILA
DRAWN BY
MARTA VIDAL ROMÁN
PROYECT
ESCM
YEAR
2018
SHEET NO
10
Autodesk
EL7031.1
Step
Motor
module


Beckhoff
EL7031
SLOT 14
Stepper motor terminal 24 V DC, 1.5 A
EL7031.2
1 A1
2 B1
3 24V
4
5 A2
6 B2
7 0V
8
74
73
75
76
-M4
M
B1
B2
A2
A1
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL7031.2.DWG
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKOLA
DRAWN BY
MARTA VIDAL ROMÁN
PROYECT
ESCM
YEAR
2018
SHEET NO
11
Autodesk
EL7031.2
Step
Motor
module


Beckhoff
EL9189
SLOT 2
HD EtherCAT Terminal, 16-channel potential distribution
EL9189
1 0V
2 0V
3 0V
4 0V
5 0V
6 0V
7 0V
8 0V
9 0V
10 0V
11 0V
12 0V
13 0V
14 0V
15 0V
16 0V
3 3 S1_0V 01-1
4 4 S2_0V 02-1
7 7 S3_0V 01-2
33 33 S10_0V 02-6
10 10 S7_0V 01-3
13 13 S9_0V 01-4
16 16 S4_0V 01-5
19 19 S6_0V 01-6
22 22 S8_0V 01-7
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL9189.DWG
SHEET NO 12
YEAR
PROYECT 2018
DRAWN BY CSM
CHECKED BY MARTA VIDAL ROMÁN
ENGINEER JUHA SARKULA MARTA VIDAL ROMÁN
Autodesk
EL9189 Potential distribution module


Beckhoff
EL9188
SLOT 3
HD EtherCAT Terminal, 16-channel potential distribution
EL9188
1 24V 1 S1_V1 1 01-1
2 24V 27 S2_UB 27 02-2
3 24V 5 S3_V 5 01-1
4 24V 31 S10_V 31 02-6
5 24V 8 S7_V 8 01-3
6 24V 29 LSL_L2 29 02-3
7 24V 11 S9_V 11 01-3
8 24V 42 LSU_U2 42 03-3
9 24V 14 S4_V 14 01-4
10 24V
11 24V 17 S6_V 17 01-5
12 24V
13 24V 20 S8_V 20 01-6
14 24V 34 LSR_R2 34 02-7
15 24V B_E 37 37 03-2
16 24V LSD_D2 47 47 03-7
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EL9188.DWG
ENGINEER MARTA VIDAL ROMÁN
CHECKED BY JUHA SARKKILA
DRAWN BY MARTA VIDAL ROMÁN
PROYECT ESCM
YEAR 2018
SHEET NO 13
Autodesk
EL9188 Potential distribution module


Beckhoff
EK1100
SLOT 1
EtherCAT Coupler
EK1100
1
24V
2
24V
3
0V
4
5
0V
6
24V
7
0V
8
79
80
G1
AC
DC
L2
L1
Line 220V
78
51
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\EK1100.DWG
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKKULA
DRAWN BY
MARTA VIDAL ROMÁN
PROYECT
ESCM
YEAR
2018
SHEET NO
14
Autodesk
EK1100
EtherCAT
module


EVR
ELECTRO-VALVE
RECIRCULATE
PIECES
EVP
ELECTRO-VALVE
OPEN/CLOSE
GRIPPERS
EVR_2
ELECTRO-VALVE
RECIRCULATE
PIECES
EV4
NOT
CONNECTED
VAL
SELECTOR
PRESSURE
INPUT
REG1
GAU1
EVR
EVP
EVR_2
EV4
A
B
EVR
EVP
EVR_2
EV4
C:\USERS\PROPIETARIO\DOCUMENTS\UNIVERSIDAD\TFG\4.PLANO_ELECTRICO\ELECTRIC_SCHEME_CLASIFIER_MACHINE\CONTROL_PANEL_VALVES.DWG
Autodesk
Pneumatic
scheme
ENGINEER
MARTA VIDAL ROMÁN
CHECKED BY
JUHA SARKKULA
DRAWN BY
MARTA VIDAL ROMÁN
PROYECT
ESIGM
YEAR
2018
SHEET NO
15

NAME	QUANT	SUB	CATALOGUE	BRAND	DESCRIPTION
-M4 -SM_1	2		AS1030-0000	BECKHOFF	
-LSD -LSL -LSR -LSU	4		ZC-W2155-MR	OMRON	LIMIT SWITCH - ENCLOSED SPRING RETURN HINGE ROLLER LEVER 1 FORM C
-M1 -M2	2		GMAG402_781	NIDEC	
-S11 -S12 -S13 -S14	4		IEMPUL0010025	A-ELECTRONICS	
-B_ON -B_RESET -B_STOP	3		XB6ECF3B2P	SCHNEIDER ELECTRIC	
-BE	1		XAL K178F	SCHNEIDER ELECTRIC	EMERGENCY STOP MUSHROOM HEAD PUSHBUTTON, TURN TO RELEASE 40mm RED 2 NC TRIGGER ACTION
-S1 -S10	2		E3F2-R2B4	OMRON	PHOTOSWITCH - E3F2 THREADED CYLINDRICAL PHOTOELECTRIC SENSOR RETROREFLECTIVE 10-30VDC DC-SWITCHING, 2M SENS RANGE, PNP OUTPUT PRE-WIRED (2M), 2.5MS RESPONSE TIME, INFRARED LED
-S6 -S7	2		OBR7500-R100-2EP-IO-0,3M-V1	PEPPERL FUCHS	
-EL9189	1		EL9189	Beckhoff	
-EK1100	1		EK1100	Beckhoff	
-EL9188	1		EL9188	Beckhoff	
-EL2002.1 -EL2002.2	2		EL2002	Beckhoff	
-EL7031.1 -EL7031.2	2		EL7031	Beckhoff	
-EL7332	1		EL7332	Beckhoff	
-EL3054	1		EL3054	Beckhoff	
-EL2004.1 -EL2004.2	2		EL2004	Beckhoff	
-EL1008.1 -EL1008.2 -EL1008.3	3		EL1008	Beckhoff	
-S4 -S8	2		MMB60-12GH50-E2-V1	PEPPERL FUCHS	
-S3 -S9	2		NBB8-18GM50-E2	PEPPERL FUCHS	Inductive sensor NBB8-18GM50-E2 INDUCTIVE 10 … 30 V DC 106378
-G1	1		TR31501	NERLED	
-EVR -EVP -EVR_2 -EV4	4		BMFH-2-3-M5	FESTO	Solenoid actuated valves 3/2 way, M5
-VAL	1		6817	FESTO	Selector
-REG	1		LR-1/8-F-7	FESTO	Pressure Regulator
-G1	1		159596	FESTO	Pressure Gauge

Material List

Autodesk

ENGINEER
MARTA VIDAL ROMÁN

CHECKED BY
JUHA SARKULA

DRAWN BY
MARTA VIDAL ROMÁN

PROYECT
ESCM

YEAR
2018

SHEET NO
16

MATERIAL BUDGET Appendix 3

"Classification Machine"

Material Budget

Date	28-05-18
Made by	Marta Vidal
Client	HAMK
Payment	
Order number	1

Requested by: HAMK

Producto	Cantidad	Descripción	Vendor	Unidades	Precio / unidad	Precio
1	1	CP2215-0020	Beckhoff	1	2.181,00 €	2.181,00 €
2	1	Delivery and packaging costs	Beckhoff	1	25,00 €	25,00 €
3	3	EL1008	Beckhoff	1	26,54 €	79,62 €
4	2	EL2002	Beckhoff	1	18,00 €	36,00 €
5	2	EL2004	Beckhoff	1	25,00 €	50,00 €
6	1	EL3054	Beckhoff	1	100,00 €	100,00 €
7	1	EL7332	Beckhoff	1	96,00 €	96,00 €
8	2	EL7031	Beckhoff	1	103,50 €	207,00 €
9	1	EL9189	Beckhoff	1	13,88 €	13,88 €
10	1	EL9188	Beckhoff	1	13,88 €	13,88 €
11	1	EK1100	Beckhoff	1	73,50 €	73,50 €
12	2	Inductive Sensor Pepperl NBB8-18GM50-E2	Pepperl+Fuchs	1	47,40 €	94,80 €
13	2	Magnetic Sensor MMB60-12GH50-E2-V1	Pepperl+Fuchs	1	64,80 €	129,60 €
14	2	Photoelectric Sensor OBR7500-R100-2EP-IO-0,3M-V1	Pepperl+Fuchs	1	46,80 €	93,60 €
15	1	Colour Sensor DF12-11-3K/145/151	Pepperl+Fuchs	1	381,60 €	381,60 €
16	1	Distance Sensor VDM28-8-L1-IO/73c/110/122	Pepperl+Fuchs	1	201,00 €	201,00 €
17	2	Photoelectric Sensor E3F-R2B4	OMRON	1	34,40 €	68,80 €
18	4	Final switch	Honneywell	1	0,50 €	2,00 €
19	2	Step Motors AS 1030-0000	Beckhoff	1	75,00 €	150,00 €
20	2	DC Motors GMAG 402 781	Nidec	1	39,99 €	79,98 €
21	2	Electrovalves BMFH-2-3-M5	Festo	2	53,50 €	107,00 €
22	1	Regulator LR 1/8 -F	Festo	1	58,17 €	58,17 €
23	1	Gauge MA-40-10-1/4-EN	Festo	1	36,03 €	36,03 €
24	1	Valve frontal pannel SV-3-M5	Festo	1	47,13 €	47,13 €
25	1	selector H-22-SW	Festo	1	26,95 €	26,95 €
26	1	Green illuminated button XB6ECF3B2P	Schneider	1	17,70 €	17,70 €
27	1	Red illuminated button XB6ECF4B2P	Schneider	1	17,70 €	17,70 €
28	1	Yellow illuminated button XB6EDW5B2P	Schneider	1	14,00 €	14,00 €
29	1	Emergency mushroom XB7NS8445	Schneider	1	71,02 €	71,02 €
30	4	Small red buttons		1	1,50 €	6,00 €
31	1	Orange switch		1	1,00 €	1,00 €
32	1	Connector V19-G-BK5M-PUR-U	Pepperl+Fuchs	1	16,80 €	16,80 €
33	4	Connector V1-G-5M-PUR	Pepperl+Fuchs	1	8,40 €	33,60 €
34	4	Connector DOL-1205-G0M3S 6027569	Sick	1	27,37 €	109,48 €
35	2	Ethernet cable 6XV18703RH60	Siemens	1	33,23 €	66,46 €
					Subtotal	4.706,30 €
				24,00%	IVA	1.129,51 €
					Total	**5.835,81 €**

DATA SHEETS Appendix 4

PLC Datasheet:
https://download.beckhoff.com/download/document/ipc/industrial-pc/cp22xxen.pdf

Step Motor documentation:
https://download.beel7031ckhoff.com/download/document/motion/as1000_ba_en.pdf

Step Motor terminal EL7031 documentation:
https://download.beckhoff.com/download/document/io/ethercat-terminals/el70x1en.pdf

Colour sensor:
https://files.pepperl-fuchs.com/webcat/navi/productInfo/edb/132618_eng.pdf?v=20180423144517

Distance Sensor:
https://files.pepperl-fuchs.com/webcat/navi/productInfo/edb/232763_eng.pdf?v=20180511000116

Magnetic Sensor:
https://files.pepperl-fuchs.com/webcat/navi/productInfo/edb/278605_eng.pdf?v=20180525095525

Inductive Sensor:
https://files.pepperl-fuchs.com/webcat/navi/productInfo/edb/085499_eng.pdf?v=20180503000059

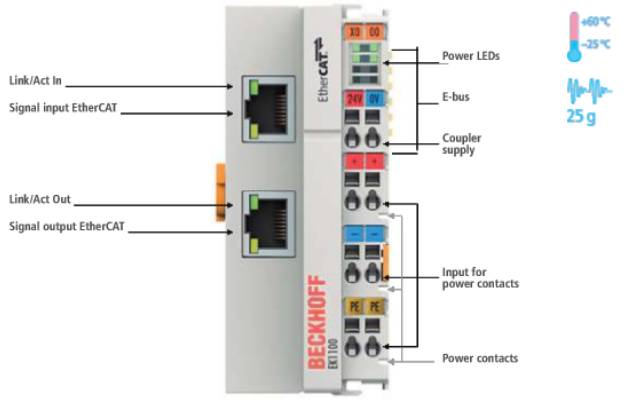
Photoelectric sensor:
https://files.pepperl-fuchs.com/webcat/navi/productInfo/edb/267075-100002_eng.pdf?v=20180427000146

Cable DOL-1205-G02M:
https://sick-virginia.data.continum.net/media/pdf/7/57/057/dataSheet_DOL-1205-G02M_6008899_en.pdf

Cable V19-G-BK5M-PUR-U:
https://files.pepperl-fuchs.com/webcat/navi/productInfo/edb/456504_eng.pdf?v=20180525015332

Cable V1-G-5M-PUR-ABG-V1-G:
https://files.pepperl-fuchs.com/webcat/navi/productInfo/edb/203934_eng.pdf?v=20180423144527

EtherCAT | **EK1100**



EK1100 | EtherCAT Coupler

The EK1100 coupler connects EtherCAT with the EtherCAT Terminals (ELxxxx). One station consists of an EK1100 coupler, any number of EtherCAT Terminals and a bus end terminal. The coupler converts the passing telegrams from Ethernet 100BASE-TX to E-bus signal representation.

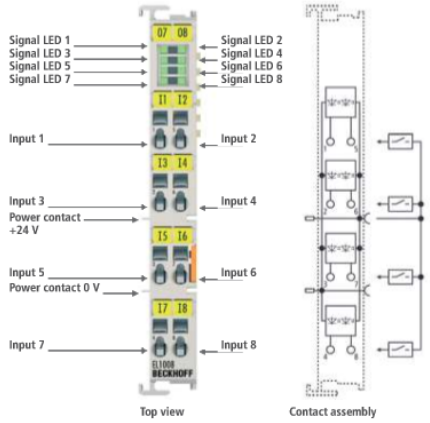
The coupler is connected to the network via the upper Ethernet interface. The lower RJ45 socket may be used to connect further EtherCAT devices in the same strand. In the EtherCAT network, the EK1100 coupler can be installed anywhere in the Ethernet signal transfer section (100BASE-TX) – except directly at the switch. The coupler BK9000 (for K-bus components) is suitable for installation at the switch.

Technical data	EK1100
Task within EtherCAT system	coupling of EtherCAT Terminals (ELxxxx) to 100BASE-TX EtherCAT networks
Data transfer medium	Ethernet/EtherCAT cable (min. CAT 5), shielded
Distance between stations	max. 100 m (100BASE-TX)
Number of EtherCAT Terminals	up to 65,534
Protocol	EtherCAT
Delay	approx. 1 µs
Data transfer rates	100 Mbaud
Configuration	not required
Bus interface	2 x RJ45
Power supply	24 V DC (-15 %/+20 %)
Current consumption from U_S	70 mA + (Σ E-bus current/4)
Current consumption from U_P	load
Current supply E-bus	2000 mA
Power contacts	24 V DC max./10 A max.
Electrical isolation	500 V (power contact/supply voltage/Ethernet)
Operating/storage temperature	-25…+60 °C/-40…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/variable
Approvals	CE, UL, Ex

Accessories	
Cordsets	cordsets and connectors

System	
EtherCAT	For further EtherCAT products please see the system overview

Digital input | **EL1008**

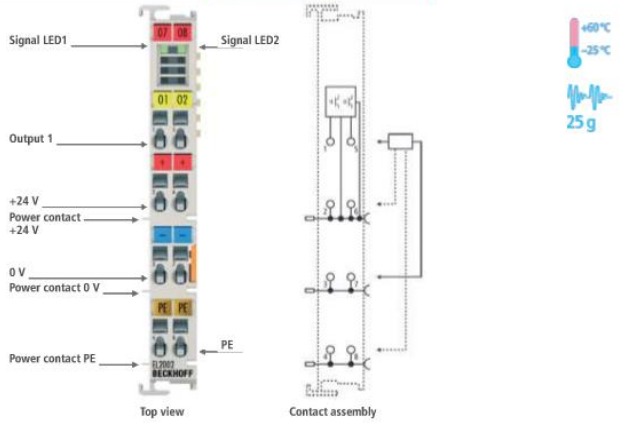


EL1008 | 8-channel digital input terminal 24 V DC, 3 ms

The EL1008 digital input terminal acquires the binary control signals from the process level and transmits them, in an electrically isolated form, to the higher-level automation unit. Digital input terminals from the EL100x series have a 3 ms input filter. The EtherCAT Terminals indicate their state via an LED.

Technical data	EL1008 | ES1008
Connection technology	1-wire
Specification	EN 61131-2, type 1/3
Number of inputs	8
Nominal voltage	24 V DC (-15 %/+20 %)
"0" signal voltage	-3…+5 V (EN 61131-2, type 3)
"1" signal voltage	11…30 V (EN 61131-2, type 3)
Input current	typ. 3 mA (EN 61131-2, type 3)
Input filter	typ. 3.0 ms
Distributed clocks	–
Current consumption power contacts	typ. 2 mA + load
Current consumption E-bus	typ. 90 mA
Electrical isolation	500 V (E-bus/field potential)
Bit width in the process image	8 inputs
Configuration	no address or configuration setting
Special features	standard input terminal for bouncing signals (filter 3 ms)
Weight	approx. 55 g
Operating/storage temperature	-25…+60 °C/-40…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/see documentation
Pluggable wiring	for all ESxxxx terminals
Approvals	CE, UL, Ex, IECEx

Digital output EL2002

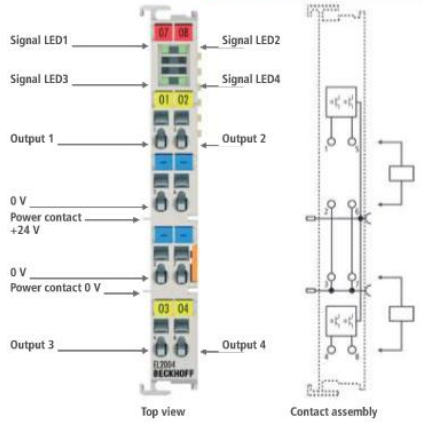


EL2002 | 2-channel digital output terminal 24 V DC, 0.5 A

The EL2002 digital output terminal connects the binary control signals from the automation unit on to the actuators at the process level with electrical isolation. The EtherCAT Terminal indicates its signal state via an LED.

Technical data	EL2002 | ES2002
Connection technology	4-wire
Number of outputs	2
Rated load voltage	24 V DC (-15 %/+20 %)
Load type	ohmic, inductive, lamp load
Distributed clocks	–
Max. output current	0.5 A (short-circuit-proof) per channel
Reverse voltage protection	yes
Breaking energy	< 150 mJ/channel
Switching times	typ. T_{ON}: 60 µs, typ. T_{OFF}: 300 µs
Current consumption E-bus	typ. 100 mA
Electrical isolation	500 V (E-bus/field potential)
Current consumption power contacts	typ. 15 mA + load
Bit width in the process image	2 outputs
Configuration	no address or configuration setting
Weight	approx. 55 g
Operating/storage temperature	-25…+60 °C/-40…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/variable
Pluggable wiring	for all ESxxxx terminals
Approvals	CE, UL, Ex

Digital output EL2004

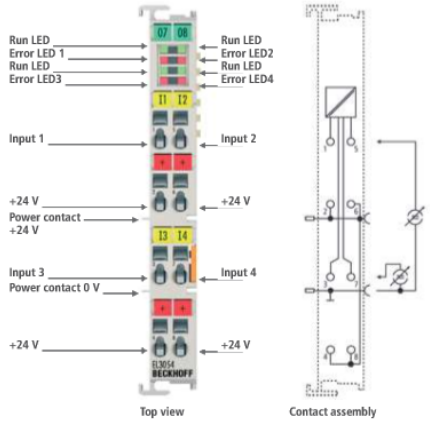


EL2004 | 4-channel digital output terminal 24 V DC, 0.5 A

The EL2004 digital output terminal connects the binary control signals from the automation unit on to the actuators at the process level with electrical isolation. The EtherCAT Terminal indicates its signal state via an LED.

Technical data	EL2004 | ES2004
Connection technology	2-wire
Number of outputs	4
Rated load voltage	24 V DC (-15 %/+20 %)
Load type	ohmic, inductive, lamp load
Distributed clocks	–
Max. output current	0.5 A (short-circuit-proof) per channel
Short circuit current	typ. < 2 A
Reverse voltage protection	yes
Breaking energy	< 150 mJ/channel
Switching times	typ. T_{ON}: 60 µs, typ. T_{OFF}: 300 µs
Current consumption E-bus	typ. 100 mA
Electrical isolation	500 V (E-bus/field potential)
Current consumption power contacts	typ. 15 mA + load
Bit width in the process image	4 outputs
Configuration	no address or configuration setting
Weight	approx. 55 g
Operating/storage temperature	-25…+60 °C/-40…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/variable
Pluggable wiring	for all ESxxxx terminals
Approvals	CE, UL, Ex

Analog input | **EL3054**

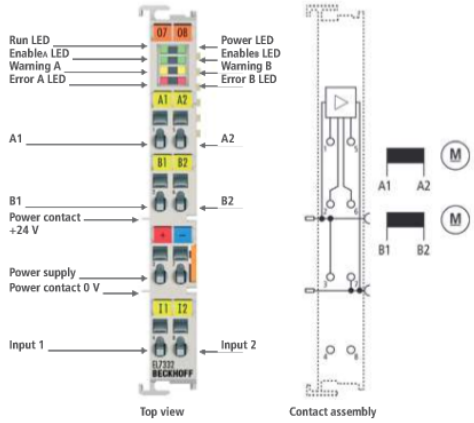


EL3054 | 4-channel analog input terminal 4…20 mA, single-ended, 12 bit

The EL3054 analog input terminal processes signals in the range between 4 and 20 mA. The current is digitised to a resolution of 12 bits and is transmitted (electrically isolated) to the higher-level automation device. The input electronics are independent of the supply voltage of the power contacts. In the EL3054 with four inputs, the 24 V power contact is connected to the terminal in order to enable connection of 2-wire sensors without external supply. The power contacts are connected through. The signal state of the EtherCAT Terminal is indicated by light emitting diodes. The error LEDs indicate an overload condition and a broken wire.

Technical data	EL3054 | ES3054
Number of inputs	4 (single-ended)
Technology	single-ended
Signal current	4…20 mA
Distributed clocks	–
Internal resistance	85 Ω typ.
Input filter limit frequency	1 kHz
Dielectric strength	max. 30 V
Conversion time	0.625 ms default setting, configurable
Resolution	12 bit (16 bit presentation, incl. sign)
Measuring error	< ±0.3 % (relative to full scale value)
Electrical isolation	500 V (E-bus/signal voltage)
Current consumption power contacts	–
Current consumption E-bus	typ. 130 mA
Bit width in the process image	inputs: 16 byte
Configuration	no address or configuration setting required
Special features	standard and compact process image, activatable FIR/IIR filters, limit value monitoring
Weight	approx. 60 g
Operating/storage temperature	-25…+60 °C/-40…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/variable
Pluggable wiring	for all ESxxxx terminals
Approvals	CE, UL, Ex

Motion | **EL7332**



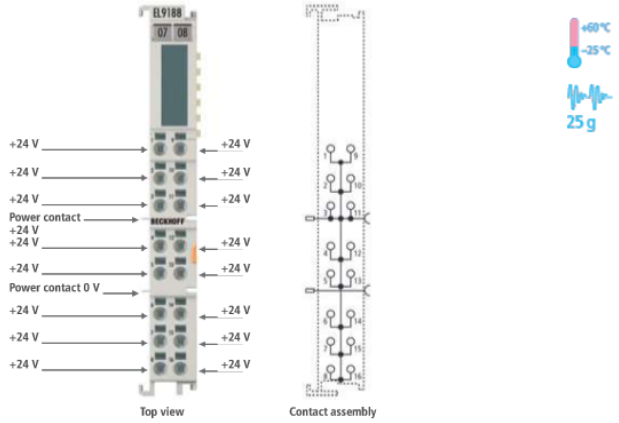
25 g

EL7332 | 2-channel DC motor output stage 24 V DC, 1 A

The EL7332 EtherCAT Terminal enables direct operation of two DC motors. It is galvanically isolated from the E-bus. The speed is preset by a 16 bit value from the automation unit. The output stage is protected against overload and short-circuit. The EtherCAT Terminal has two channels that indicate their signal state via light emitting diodes. The LEDs enable quick local diagnosis.

Technical data	EL7332 | ES7332
Technology	direct motor connection
Number of outputs	2
Number of channels	2 DC motors, 2 digital inputs
Rated load voltage	24 V DC (-15 %/+20 %)
Load type	DC brush motors, inductive
Nominal voltage	24 V DC (-15 %/+20 %)
Max. output current	2 x 1 A
Performance increase	Yes, through ZB8610 fan cartridge
output current with ZB8610	max. 3.0 A (overload- and short-circuit-proof)
PWM clock frequency	32 kHz with 180° phase shift each
Duty factor	0…100 % (voltage-controlled)
Electrical isolation	500 V (E-bus/field potential)
Current consumption power contacts	typ. 40 mA + motor current
Bit width in the process image	2 x 16 bit status, 2 x 16 bit control, 2 x 16 bit output
Current consumption E-bus	typ. 140 mA
Distributed clocks	yes
Control resolution	max. 10 bits current, 16 bits speed
Special features	travel distance control
Weight	approx. 50 g
Operating/storage temperature	0…+55 °C/-25…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/see documentation
Pluggable wiring	for all ESxxxx terminals
Approvals	CE, UL

Accessories	
EL9576	brake chopper terminal, 72 V, 155 µF
ZB8610	fan cartridge for EtherCAT and Bus Terminals



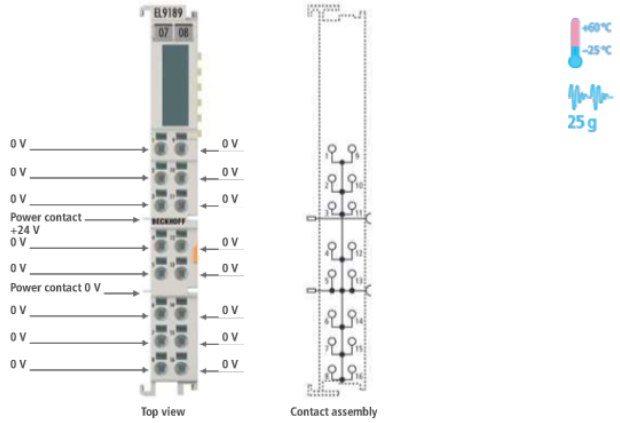
EL9188 | HD EtherCAT Terminal, 16-channel potential distribution

The EL9188 potential distribution terminal provides 16 terminal points with a potential and enables the voltage to be picked up without further bus terminal blocks or wiring.

The conductors can be connected without tools in the case of solid wires using a direct plug-in technique.

The HD EtherCAT Terminals (High Density) with increased packing density feature 16 connection points in the housing of a 12 mm terminal block.

Technical data	EL9188
Technology	potential distribution terminal
Number of outputs	e.g.: 16 x 24 V contact
Current load	≤ 10 A
Power LED	–
Defect LED	–
Renewed infeed	yes
Current consumption E-bus	–
Nominal voltage	≤ 60 V
Integrated fine-wire fuse	–
Electrical isolation	500 V (E-bus/field potential)
Diagnostics in the process image	–
Reported to E-bus	–
PE contact	–
Shield connection	–
Bit width in the process image	0
Electrical connection to DIN rail	–
Housing width in mm	12
Side by side mounting on EtherCAT Terminals with power contact	yes, left without PE
Side by side mounting on EtherCAT Terminals without power contact	yes
Special features	direct plug-in technique
Conductor types	solid wire, stranded wire and ferrule
Conductor connection	solid wire conductors: direct plug-in technique; stranded wire conductors and ferrules: spring actuation by screwdriver
Rated cross-section	solid wire: 0.08…1.5 mm²; stranded wire: 0.25…1.5 mm²; ferrule: 0.14…0.75 mm²
Weight	approx. 60 g
Operating/storage temperature	-25…+60 °C/-40…+85 °C
Approvals	CE, UL, Ex



EL9189 | HD EtherCAT Terminal, 16-channel potential distribution

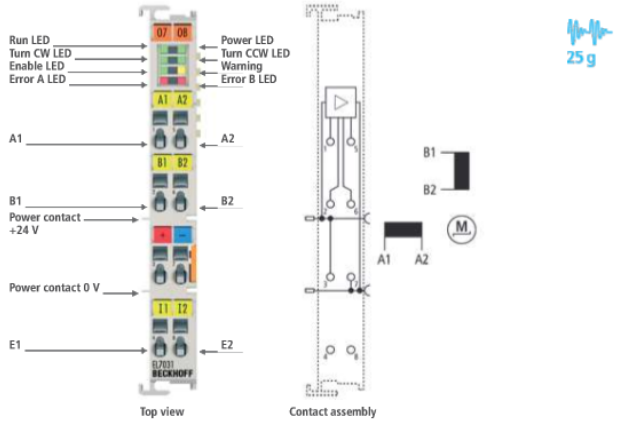
The EL9189 potential distribution terminal provides 16 terminal points with a potential and enables the voltage to be picked up without further bus terminal blocks or wiring.

The conductors can be connected without tools in the case of solid wires using a direct plug-in technique.

The HD EtherCAT Terminals (High Density) with increased packing density feature 16 connection points in the housing of a 12 mm terminal block.

Technical data	EL9189
Technology	potential distribution terminal
Number of outputs	e.g.: 16 x 0 V contact
Current load	≤ 10 A
Power LED	–
Defect LED	–
Renewed infeed	yes
Current consumption E-bus	–
Nominal voltage	≤ 60 V
Integrated fine-wire fuse	–
Electrical isolation	500 V (E-bus/field potential)
Diagnostics in the process image	–
Reported to E-bus	–
PE contact	–
Shield connection	–
Bit width in the process image	0
Electrical connection to DIN rail	–
Housing width in mm	12
Side by side mounting on EtherCAT Terminals with power contact	yes, left without PE
Side by side mounting on EtherCAT Terminals without power contact	yes
Special features	direct plug-in technique
Conductor types	solid wire, stranded wire and ferrule
Conductor connection	solid wire conductors: direct plug-in technique; stranded wire conductors and ferrules: spring actuation by screwdriver
Rated cross-section	solid wire: 0.08…1.5 mm²; stranded wire: 0.25…1.5 mm²; ferrule: 0.14…0.75 mm²
Weight	approx. 60 g
Operating/storage temperature	-25…+60 °C/-40…+85 °C
Approvals	CE, UL, Ex

Motion | **EL7031**



EL7031 | Stepper motor terminal 24 V DC, 1.5 A

The EL7031 EtherCAT Terminal is intended for the direct connection of different small Stepper Motors. The slimline PWM output stages for two motor coils are located in the EtherCAT Terminal together with two inputs for limit switches. The EL7031 can be adjusted to the motor and the application by changing just a few parameters. 64-fold micro-stepping ensures particularly quiet and precise motor operation.

Technical data	EL7031 | ES7031
Technology	direct motor connection
Number of outputs	1 stepper motor, 2 phases
Number of inputs	2
Number of channels	1 stepper motor, 2 digital inputs
Load type	uni- or bipolar stepper motors
Nominal voltage	24 V DC (-15 %/+20 %)
Power supply	24 V DC via the power contacts, via the E-bus
Max. output current	1.5 A (overload- and short-circuit-proof)
Max. step frequency	1000, 2000, 4000 or 8000 full steps/s (configurable)
Step pattern	64-fold micro stepping
Current controller frequency	approx. 25 kHz
Diagnostics LED	error phase A and B, loss of step/stagnation, power, enable
Resolution	approx. 5000 positions in typ. applications (per revolution)
Electrical isolation	500 V (E-bus/signal voltage)
Current consumption power contacts	typ. 30 mA + motor current
Current consumption E-bus	typ. 120 mA
Distributed clocks	yes
Control resolution	approx. 5000 positions in typ. applications (per revolution)
Special features	travel distance control
Weight	approx. 50 g
Operating/storage temperature	0…+55 °C/-25…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/see documentation
Pluggable wiring	for all ESxxxx terminals
Approvals	CE, UL

Accessories	
EL9576	brake chopper terminal, 72 V, 155 µF
AS20xx | AS10xx	Product overview stepper motors
Leitungen und Getriebe	Prefabricated connecting cables in IP 20 and IP 67 protection for AS10xx stepper motors

DATI TECNICI
TECHNICAL DATA

serie
series

RH158

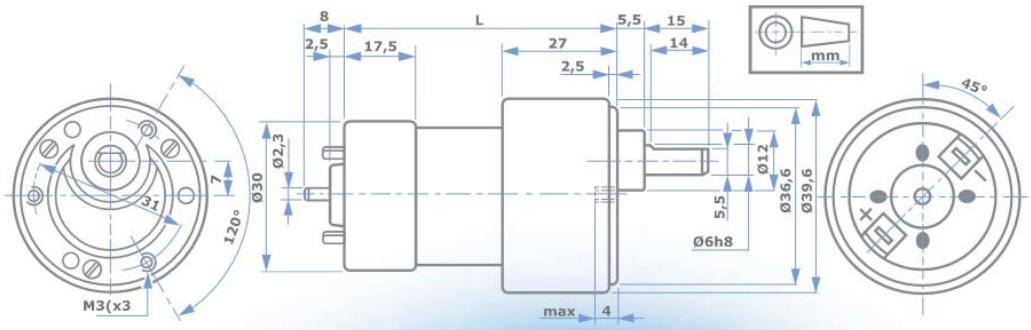
Soppressione disturbi con VDR sul collettore
Direzione di rotazione secondo polarità
Può essere montato in ogni posizione
Massimo carico radiale: 50N
Massimo carico assiale: 10N
Temperatura di esercizio: -20°C/60°C
Peso approssimativo: 190g

VDR interference suppression on the collector
Direction of rotation depending on polarity
Can be mounted in any position
Maximum radial shaft load: 50N
Maximum axial shaft load: 10N
Temperature range: -20°C/60°C
Approx weight: 190g

Valori tipici a temperatura ambiente +20° Tolleranza +/- 10%
Typical values at ambient temperature +20° Tolerance +/- 10%

TIPO TYPE	TENSIONE NOMINALE NOMINAL VOLTAGE	L	RAPPORTO :1 RATIO TO:1	COPPIA NOMINALE NOMINAL TORQUE	VELOCITÁ SPEED		CURRENT CORRENTE	
					SENZA CARICO NO LOAD	CON COPPIA NOMINALE AT NOMINAL TORQUE	SENZA CARICO NO LOAD	CON COPPIA NOMINALE AT NOMINAL TORQUE
	v	mm		Ncm	rpm		mA	
RH158·12/24·15	12/24	64	14,14	10	440	300	<140/<70	660/330
RH158·12/24·30	12/24	64	29,75	20	210	140	<140/<70	660/330
RH158·12/24·75	12/24	66,5	76,84	50	81	55	<140/<70	680/340
RH158·12/24·100	12/24	66,5	94,37	60	66	45	<140/<70	680/340
RH158·12/24·200	12/24	69	198,5	100	33	23	<140/<70	580/290
RH158·12/24·250	12/24	69	243,8	100	26	21	<140/<70	500/250
RH158·12/24·510	12/24	72	512,85	100	12	10,5	<140/<70	300/150
RH158·12/24·630	12/24	72	629,82	100	10	9	<140/<70	270/135

RH158



RH158

micro motors s.r.l.
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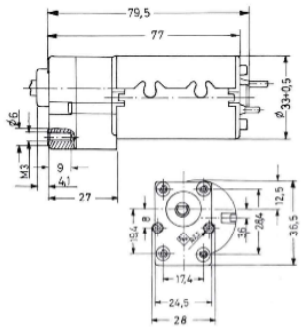
A Nidec Group Company
Nidec Motors & Actuators –All for dreams

Series GMAG
Motor type 402 781

Design Data	
Commutation	Brushed
Direction of rotation	Bi-directional
Bearing type	



Performance data		
Rated voltage [V]	U_N	24
Nominal torque [Nm]	M_N	0.50
No-load speed [min^{-1}]	n_0	55.0
Nominal power [W]	P_N	2.56
Nominal current [A]	I_N	0.5
Nominal force [kN]	F_N	0.00
Duty cycle		s3

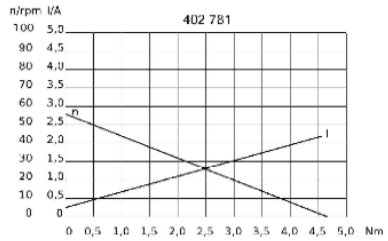
Sensor data	
Pulses	0
Output channels	0

Other data	
Gear ratio	109/1
Gear wheel material	
Suppression components	
Enclosure class	IP40
Weight [kg]	0.180

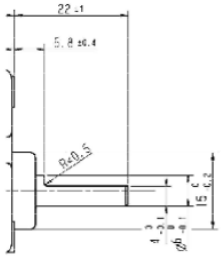
Remarks:

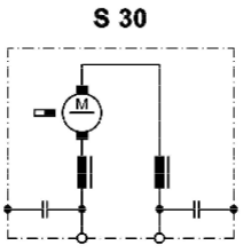
Motor picture

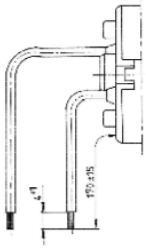
Characteristic curves



Output shaft drawing (W), Wiring diagrams (S) and Connector layout (K)







11.4 AS1030-0000

Technical data	Symbol [Unit]	AS1030
Rated supply voltage	V_{DC}	24 – 50
Rated current	A	1,5
Rated power	W	19,5
Standstill torque	M_o [Nm]	0,6
Winding resistance Ph-Ph	R_{20} [Ω]	0,80
Winding inductance Ph-Ph	L [mH]	3,80
Rotor moment of inertia	J [kg cm²]	0,21
Resolution	[steps]	1.8° / 200 full steps
Weight	[kg]	0,68
Cogging torque	M_r [Nm]	0.029 ~ 0.032

Mechanical data	Symbol [Unit]	AS1030
Axial load	[N]	15
Radial load 0 mm from the shaft end	[N]	52
Radial load 5 mm from the shaft end	[N]	65
Radial load 10 mm from the shaft end	[N]	85
Radial load 15 mm from the shaft end	[N]	123
Backlash at standstill	[°]	± 0,054
Axial backlash max.[1)]	[mm]	0,075
Radial backlash max.[2)]	[mm]	0,025
Bearing life	[h]	30.000

1) measured at a load of 9 N

2) measured at a load of 4.4 N

Product data sheet
Characteristics

XB6ECF3B2P
square green illuminated pushbutton Ø16-flush push to release 24 VDCpolarised2CO

Product availability : Stock - Normally stocked in distribution facility

Price* : 18.00 USD

Main

Range of product	Harmony XB6E
Product or component type	Illuminated monolithic push-button
Device short name	XB6E
Bezel material	Plastic
Mounting diameter	0.63 in (16 mm)
Sale per indivisible quantity	5
Shape of signaling unit head	Square
Type of operator	Latching
Operator profile	Green flush
Contacts type and composition	2 C/O
Contact operation	Snap action
Connections - terminals	Faston connectors: 2.8 x 0.5 mm Soldered connectors
Contacts material	Gold-flashed silver
Light source	Integral LED
[Us] rated supply voltage	24 V DC polarised

Complementary

Height	0.71 in (18 mm)
Width	0.71 in (18 mm)
Depth	1.57 in (40 mm)
Terminals description ISO n°1	(13-14-11-12)OF (23-24-21-22)OF
Product weight	0.01 lb(US) (0.006 kg)
Overvoltage category	II conforming to IEC 60536
Operating position	Any position
Marking	CE
Operating force	1.3 N (C/O changing electrical state)
Mechanical durability	250000 cycles
Short-circuit protection	3 A by gG cartridge fuse

[Ith] conventional free air thermal current	3 A
[Ui] rated insulation voltage	250 V (degree of pollution: 2) conforming to IEC 60947-1
[Uimp] rated impulse withstand voltage	2.5 kV conforming to IEC 60947-1
Electrical durability	50000 cycles DC-12, 1 A - 30 V conforming to IEC 60947-5-1 appendix C 50000 cycles AC-12, 0.5 A - 125 V conforming to IEC 60947-5-1 appendix C 50000 cycles AC-12, 0.5 A - 250 V conforming to IEC 60947-5-1 appendix C
Electrical reliability	Λ = 10exp(-8) at 5 V and 1 mA with confidence level of 90 % conforming to IEC 60947-5-4
Signalling type	Steady
Current consumption	10 mA
Service life	50000 h
Compatibility code	XB6

Environment

Ambient air temperature for storage	-40...158 °F (-40...70 °C)
Ambient air temperature for operation	14...131 °F (-10...55 °C)
IP degree of protection	IP65 conforming to IEC 60529
Standards	IEC 60947-1 UL 508 JIS C 4520 CSA C22.2 No 14 IEC 60947-5-1 JIS C 852
Product certifications	CURus CCC
Vibration resistance	1 mm (5...55 Hz) conforming to IEC 60068-2-6 9 gn (5...55 Hz) conforming to IEC 60068-2-6
Shock resistance	20 gn (duration = 11 ms) half sine wave acceleration conforming to IEC 60068-2-27
Electromagnetic compatibility	Electrostatic discharge immunity test 8 kV - test level conforming to IEC 61000-4-2

Ordering and shipping details

Category	22459 - PUSHBUTTONS, 16MM
Discount Schedule	CS2
GTIN	00785901178613
Nbr. of units in pkg.	5
Package weight(Lbs)	2.9999999999999999E-2
Returnability	N
Country of origin	CN

Contractual warranty

Warranty period	18 months

Product data sheet
Characteristics

XB6ECF4B2P
square red illuminated pushbutton Ø16 flush push to release-24 VDCpolarised-2CO

Product availability : Stock - Normally stocked in distribution facility

Price* : 18.00 USD

Main

Range of product	Harmony XB6E
Product or component type	Illuminated monolithic push-button
Device short name	XB6E
Bezel material	Plastic
Mounting diameter	0.63 in (16 mm)
Sale per indivisible quantity	5
Shape of signaling unit head	Square
Type of operator	Latching
Operator profile	Red flush
Contacts type and composition	2 C/O
Contact operation	Snap action
Connections - terminals	Faston connectors: 2.8 x 0.5 mm Soldered connectors
Contacts material	Gold-flashed silver
Light source	Integral LED
[Us] rated supply voltage	24 V DC polarised

Complementary

Height	0.71 in (18 mm)
Width	0.71 in (18 mm)
Depth	1.57 in (40 mm)
Terminals description ISO n°1	(23-24-21-22)OF (13-14-11-12)OF
Product weight	0.01 lb(US) (0.006 kg)
Overvoltage category	II conforming to IEC 60536
Operating position	Any position
Marking	CE
Operating force	1.3 N (C/O changing electrical state)
Mechanical durability	250000 cycles
Short-circuit protection	3 A by gG cartridge fuse

[Ith] conventional free air thermal current	3 A
[Ui] rated insulation voltage	250 V (degree of pollution: 2) conforming to IEC 60947-1
[Uimp] rated impulse withstand voltage	2.5 kV conforming to IEC 60947-1
Electrical durability	50000 cycles DC-12, 1 A - 30 V conforming to IEC 60947-5-1 appendix C 50000 cycles AC-12, 0.5 A - 125 V conforming to IEC 60947-5-1 appendix C 50000 cycles AC-12, 0.5 A - 250 V conforming to IEC 60947-5-1 appendix C
Electrical reliability	Λ = 10exp(-8) at 5 V and 1 mA with confidence level of 90 % conforming to IEC 60947-5-4
Signalling type	Steady
Current consumption	10 mA
Service life	50000 h
Compatibility code	XB6

Environment

Ambient air temperature for storage	-40...158 °F (-40...70 °C)
Ambient air temperature for operation	14...131 °F (-10...55 °C)
IP degree of protection	IP65 conforming to IEC 60529
Standards	IEC 60947-1 JIS C 852 CSA C22.2 No 14 IEC 60947-5-1 UL 508 JIS C 4520
Product certifications	CCC cURus
Vibration resistance	1 mm (5...55 Hz) conforming to IEC 60068-2-6 9 gn (5...55 Hz) conforming to IEC 60068-2-6
Shock resistance	20 gn (duration = 11 ms) half sine wave acceleration conforming to IEC 60068-2-27
Electromagnetic compatibility	Electrostatic discharge immunity test 8 kV - test level conforming to IEC 61000-4-2

Ordering and shipping details

Category	22459 - PUSHBUTTONS, 16MM
Discount Schedule	CS2
GTIN	00785901176619
Nbr. of units in pkg.	5
Package weight(Lbs)	2.9999999999999999E-2
Returnability	Y
Country of origin	CN

Contractual warranty

Warranty period	18 months

Product data sheet
Characteristics

XB6EDW5B2P
rectangle yellow illuminated pushbutton Ø16-flush springreturn24 VDCpolarised2CO

Product availability : Non-Stock - Not normally stocked in distribution facility

Price* : 17.70 USD

Main

Range of product	Harmony XB6E
Product or component type	Illuminated monolithic push-button
Device short name	XB6E
Bezel material	Plastic
Mounting diameter	0.63 in (16 mm)
Sale per indivisible quantity	5
Shape of signaling unit head	Rectangular
Type of operator	Spring return
Operator profile	Yellow flush
Contacts type and composition	2 C/O
Contact operation	Snap action
Connections - terminals	Fast connector socket Solder terminal, clamping connection <= 0.75 mm² / AWG 19 min Insulated faston: 2.8 x 0.5 mm
Contacts material	Gold-flashed silver
Light source	Integral LED
[Us] rated supply voltage	24 V DC polarised

Complementary

Product weight	0.01 lb(US) (0.006 kg)
Overvoltage category	II conforming to IEC 60536
Operating position	Any position
Marking	CE
Mechanical durability	1000000 cycles
Contact resistance	< 50 mOhm for 1/6 V
Short-circuit protection	2 A by gG cartridge fuse
[Ith] conventional free air thermal current	3 A with fast connector socket 5 A
[Ie] rated operational current	1.5 A at 120 V, AC-12 conforming to EN/IEC 60947-5-1 1 A at 240 V, AC-12 conforming to EN/IEC 60947-5-1 1 A at 24 V, DC-12 conforming to EN/IEC 60947-5-1 0.7 A at 24 V, DC-13 conforming to EN/IEC 60947-5-1

	0.2 A at 125 V, DC-12 conforming to EN/IEC 60947-5-1 0.15 A at 125 V, DC-13 conforming to EN/IEC 60947-5-1
Electrical durability	100000 cycles AC, 0.7 A - 220 V conforming to EN/IEC 60947-5-1 appendix C
Signalling type	Steady
Current consumption	10 mA
Service life	30000 h
Compatibility code	XB6

Environment

Ambient air temperature for storage	-40...158 °F (-40...70 °C)
Ambient air temperature for operation	14...131 °F (-10...55 °C)
IP degree of protection	IP65 conforming to IEC 60529
Standards	UL 508 IEC 60947-5-1 CSA C22.2 No 14 JIS C 852 JIS C 4520 IEC 60947-1
Product certifications	CCC cURus
Vibration resistance	1 mm (10...55 Hz) conforming to IEC 60068-2-6
Shock resistance	10 gn (duration = 11 ms) half sine wave acceleration conforming to IEC 60068-2-27

Ordering and shipping details

Category	22459 - PUSHBUTTONS, 16MM
Discount Schedule	CS2
Nbr. of units in pkg.	5
Package weight(Lbs)	0.12
Returnability	N
Country of origin	CN

Contractual warranty

Warranty period	18 months

Product data sheet
Characteristics

XB7NS8445
Emergency stop Ø 22 - red - mushroom head Ø 40mm - turn to release - 1 NO + 1 NC

Main

Range of product	Harmony XB7
Product or component type	Emergency stop push-button
Device short name	XB7
Mounting diameter	22 mm
Sale per indivisible quantity	10
Shape of signaling unit head	Round
Type of operator	Mechanical latching
Reset	Turn to release
Operator profile	Red mushroom Ø 40 mm unmarked
Contacts type and composition	1 NO + 1 NC
Connections - terminals	Screw clamp terminals : <= 2 x 1.5 mm² with cable end conforming to EN/IEC 60947-1 Screw clamp terminals : 1 x 0.34...2 x 2.5 mm² without cable end conforming to EN/IEC 60947-1
Device presentation	Monolithic product

Complementary

CAD overall width	40 mm
CAD overall height	40 mm
CAD overall depth	72 mm
Terminals description ISO n°1	(13-14)NO (21-22)NC
Product weight	0.035 kg
Device mounting	Fixing hole: Ø 22.5 mm (22.3 +0.4/0) conforming to EN/IEC 60947-1
Fixing center	>= 30 x 40 mm on support panel, metal, thickness: 1...6 mm >= 30 x 40 mm on support panel, plastic, thickness: 2...6 mm
Fixing mode	Fixing nut beneath head recommended torque: 2...2.4 N.m
Contact operation	Snap action
Contacts usage	Standard
Positive opening	With positive opening conforming to EN/IEC 60947-5-1 appendix K
Mechanical durability	100000 cycles
Tightening torque	0.8...1.2 N.m conforming to EN 60947-1
Shape of screw head	Cross head compatible with JIS No 1 screwdriver Cross head compatible with Philips no 1 screwdriver Cross head compatible with pozidriv No 1 screwdriver

	Slotted head compatible with flat Ø 4 mm screwdriver Slotted head compatible with flat Ø 5.5 mm screwdriver
Short-circuit protection	4 A cartridge fuse type gG conforming to EN/IEC 60947-5-1
[Ui] rated insulation voltage	250 V (degree of pollution: 3) conforming to EN/IEC 60947-1
[Uimp] rated impulse withstand voltage	4 kV conforming to EN/IEC 60947-1
[Ie] rated operational current	0.75 A at 240 V, AC-15, C300 conforming to EN/IEC 60947-5-1 1.5 A at 120 V, AC-15, C300 conforming to EN/IEC 60947-5-1 0.1 A at 250 V, DC-13, R300 conforming to EN/IEC 60947-5-1 0.22 A at 125 V, DC-13, R300 conforming to EN/IEC 60947-5-1
Electrical durability	1000000 cycles, DC-13, 0.3 A at 24 V, operating rate: 216000 cyc/mn, load factor: 0.5 conforming to EN/IEC 60947-5-1 appendix C 1000000 cycles, AC-15, 0.03 A at 230 V, operating rate: 216000 cyc/mn, load factor: 0.5 conforming to EN/IEC 60947-5-1 appendix C 1000000 cycles, AC-15, 0.09 A at 240 V, operating rate: 108000 cyc/mn, load factor: 0.5 conforming to EN/IEC 60947-5-1 appendix C
Electrical reliability	Λ < 5 x 10exp(-7) at 17 V, 5 mA conforming to IEC 60947-5-4
Compatibility code	XB7

Environment

Protective treatment	TH
Ambient air temperature for storage	-40...70 °C
Ambient air temperature for operation	-25...70 °C
Electrical shock protection class	Class II conforming to IEC 60536
IP degree of protection	IP20 (rear face) conforming to IEC 60529 IP65 (front face) conforming to IEC 60529
NEMA degree of protection	NEMA 12 conforming to UL 50 NEMA 3 conforming to UL 50
Standards	EN/IEC 60204-1 EN/IEC 60947-1 EN/IEC 60947-5-1 EN/IEC 60947-5-5 EN/ISO 13850 IEC 60364-5-53 UL 508 CSA C22.2 No 14
Product certifications	CCC GOST
Vibration resistance	5 gn (f = 2...500 Hz) conforming to IEC 60068-2-6
Shock resistance	15 gn (duration = 11 ms) for half sine wave acceleration conforming to IEC 60068-2-27

Offer Sustainability

RoHS (date code: YYWW)	Compliant - since 1145 - Schneider Electric declaration of conformity Schneider Electric declaration of conformity
REACh	Reference not containing SVHC above the threshold Reference not containing SVHC above the threshold

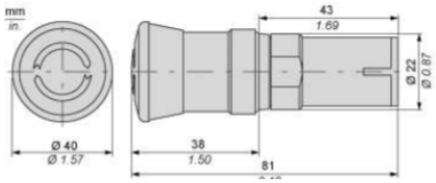
Contractual warranty

Warranty period	18 months

Product data sheet
Dimensions Drawings

XB7NS8445

Non-illuminated Pushbutton



1) Connect the machine to the power supply, switch on the PLC, the machine and the air supply. Open the visualization on the PLC screen. Be sure that the Ethernet cable is connected to the PLC on the second connector.

   In case that the visualization doesn't open correctly download the program from a computer into the PLC using another Ethernet cable connected to the first connector.

2) On the touch screen you will be able to log in by entering your username and password.

3) We open the configuration screen where we must select which types of piece we are going to classify in each zone. Validate each of the settings using the buttons to the right. We select the type of work, whether it is with a robot or not and whether it is manual or automatic. We introduce the dimensions of the pieces we are going to classify. We adjust the motor speeds if necessary always taking into account the minimum and maximum values (it is recommended to leave the default values).

4) We open the control screen and we will see that the stop sign is on, and if we have validated the settings correctly, they will appear in the central part of the display, and the blue configuration sign will also be on. We check that the sensors are in their idle state and that there are no obstacles in the circuit. The machine will be ready to start.

5) We start the machine by pressing the green start button from the touch screen or from the physical control panel and wait until the display indicates that the machine is ready to receive a piece.

6) The piece is placed at the beginning of the machine. If we do it manually we will have to place it in the sensor S1 cut-off point. If the piece is placed by the robot, the machine itself will manage the communication with it through signals. The cycle will begin. During the machine cycle, we should not perform any complementary actions.

7) When the piece has been classified or eliminated we will repeat actions from the 5th step.

There are several ways to stop the machine if necessary:

– Through an emergency mushroom located on the physical panel of the machine. If we use this stop, we won´t be able to restart the

engines again until a reset is carried out. Recommended for use in emergencies.

- One stop button on the physical panel and one on the touch screen. With this type of stop, you can resume the cycle from the point where it left off.

If the machine stops or fails at any part of the process for any unknown reason, it is recommended to reset it completely and perform all the machine start up steps again. We can also reset it if we want to change the entered configuration.

In case the screen is locked, turn off the whole system and restart it.