Automation of Agricultural Product Watering at Futuka Farm in Lubumbashi: A Comprehensive Study

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Abstract: ***This study focuses on automating the watering system for agricultural products at Futuka Farm in Lubumbashi. The aim is to improve productivity and reduce manual labor by replacing the current manual watering method. The study considers theoretical aspects of automated production systems, utilizing a sprinkler system for uniform irrigation. Data collection involves documentary research and interviews with farm agents. The proposed automated system will feature a sprinkler trolley controlled by a motor, speed variator, and an S7 - 300 PLC for control, along with sensors to collect process information. The study seeks to enhance productivity and competitiveness by optimizing water usage and minimizing labor efforts.***

Keywords: Automation, Watering system, Agricultural products, Productivity, Sprinkler irrigation

1. Introduction and Research Object

The human being by his nature has always sought the means to economize his efforts. He has never ceased to put his intelligence and his imagination at the service of this goal in order to create a partner who will do the work for him. Thus automated systems make it possible to eliminate a good number of tedious work and to carry out repetitive and tedious tasks, carried out by humans.

We should also point out that in the face of the economic challenge with which global industry has been confronted in recent times, the transformation of the productive system is proving necessary: automation, for example, is becoming essential to obtain better competitiveness for manufactured products and ensure optimal performance.

More and more agricultural products are of great necessity in a developing country for better growth the latter need water supply. Therefore watering is very necessary to allow a better harvest.

The cost of production is a major factor for competitiveness. It must be optimized and controlled. Automated processes reduce downtime and avoid bottlenecks.

Irrigation is the process of bringing water to cultivated plants to increase production and allow their natural growth. This method is essential in the agricultural sector for a gain in productivity. Generally, we talk about irrigation for small areas (garden, vegetable patch) and irrigation for large areas (agricultural fields) but there are no standards in this area.

The watering method consists of transporting water from the source of supply such as a well, a river with a bucket or a watering can. We will then speak of manual watering which is very simple and inexpensive (in material level) since all that is needed is a garden hose or a watering can (C. BROUWER, 1990, p5).

However, this method has drawbacks, in particular: a large workforce, great physical effort, loss of time, thus making the watering work tedious. In addition to this there is no watering if the staff is not available yet agricultural products require frequent watering. Which is a problem.

The plants are ruined and their growth is reduced due to insufficient or excessive watering.

We found that the Futuka Farm operates the manual watering system for its agricultural products. This system has many drawbacks as we have pointed out in the preceding paragraphs. This is how we proposed to carry out a study on "the automation of the watering of agricultural products from the Futuka farm in the city of Lubumbashi". To do this, we will set up a command and control system which will take care of the control and command of various field equipment ensuring the watering of the products.

The objective pursued in this work is to improve the watering of agricultural products within the Futuka farm. The interest of this study lies in the fact that it will replace manual watering tasks performed by staff with an automated watering system, thus saving time and improving production.

2. Theoretical Considerations of Automated Production Systems (SAP)

2.1 Definition of an automated production system

An automated system is a system that performs operations and for which humans only intervene in the programming of the system and in its adjustment. Today, it would be difficult to design a production system without using the various technologies and components that make up automated production systems (A. Lyes, 2011, p21).

2.2 Structure of an automated production system

An automated system is composed of a control part and an operative part to operate this system, the operator (person who will operate the system) will give instructions to the control part.

This will translate these instructions into orders that will be executed by the operational part. Once the orders have been completed, the operative part will report it to the control part (it makes a report) which will in turn report it to the operator. The latter will therefore be able to say that the work has been carried out.

Also called the power part, it is the visible part of the system that allows the incoming work material to be transformed. It is made up of mechanical elements of actuators (cylinders, motors), pre - actuators (distributors and contactors) and detection elements (sensors, detectors).

The Pre - actuator are directly dependent on the actuators and are necessary for its operation, which allows the passage of energy from the external environment to the actuator. (A. Lyes, 2011, p9). The pre - actuator distributes the energy required by the actuator according to the orders received from the control part. The pre - actuator can be: Is an element of the operational part whose role is to execute orders. They transform pneumatic (compressed air), hydraulic (pressurized oil) energy into usable energy in another form (electrical or mechanical). These actuators belong to three categories: (A. Lyes, 2011, p16). The sensors inform the control part of the execution of the work. For example, we will find mechanical, pneumatic, electrical or magnetic sensors. The role of the sensors (or detectors) is therefore to control, measure, monitor and inform the P. C on the evolution of the system.

The sensor is an electronic element which transforms the state of a physical quantity into an electrical quantity, it detects (with or without contact) a physical phenomenon (presence or movement of an object, heat, light) and sends it to the control part (A. Lyes, 2011, p16).

3. Methodological devices for collecting data

To succeed in gathering the data necessary for the development of this work, we made use of the documentary technique as well as interviews and interviews. The documentary technique allowed us to consult the various works and texts related to the object under study. The interview allowed us to collect necessary information related to the Futuka farm. We conducted interviews with the agents of the Futuka farm and other actors likely to provide us with information related to our research.

4. Presentation of research site "the FUTUKA farm"

4.1 History and geographical location

Historically, the FUTUKA farm existed even before the independence of our country. It had as initiator Mr. DURTU, who had in turn entrusted it to Mr. BOSTON its area during all this time was only a dozen hectares.

After the independence of the Democratic Republic of Congo, the management of the farm was transferred into the hands of Mr. ARONSON. With the Zairianization policy of November 1973, the management of the said farm passed from whites to blacks and the first black who had ensured its management was Mr. AHUKE, then Mr. MUERE who in turn gave the baton of command to Mr. MAGOMA in his time commander of the gendarmerie, Mr. KATEBE KATOTO.

A few years later, Mr. MOISE KATUMBI will come to take over this property to develop it, it is he who has increased the area by paying other of his neighbors the farm has 5400 hectares to date.

From where we can quote that he is also the owner of multiple flour mills of which MASHAMBA is also a part. The FUKUTA farm is located 30 km from the city of Lubumbashi, on the road

KASENGA in the territory of KIPUSHI its neighbors are 41 villages, the villages BULAYA, KYALUBAMBA, MUSOSWA, PETRO, KASOMBO, KATUBA and FUTUKA.

4.2. Current status of the Futuka farm

Irrigation system Futuka Farm uses three common techniques for watering these products used are: gravity or surface irrigation, drip irrigation and sprinkler irrigation.

a) Gravity or surface irrigation
Surface irrigation consists of bringing water to the highest point of the land and letting it flow by gravity. The water is then distributed to the fields either by submersion. This was the only possible method until the middle of the 20th century in the vast majority of cases, the transport of water is done by channels operating on the free surface. It is therefore a technique which continues to be very widespread, particularly in developing countries (C. BROUWER, 1990, p22).

b) Drip irrigation
Drip irrigation consists of bringing water under pressure through a system of pipes, usually made of PVC; this water is then distributed in drops to the field by a large number of drippers distributed all along the rows of plantations.

c) Sprinkler irrigation
Sprinkler irrigation is designed on the model of natural rain: water is pushed back under pressure into a network of pipes, then it is diffused by rotating sprinklers in the form of artificial rain. The water comes out in the form of a jet and is distributed in water droplets which fall on the ground A pressurized irrigation installation (C. BROUWER, 1990, p24).

4.3. Disadvantages of Futuka Farm Sprinkler System

Futuka Farm's current watering system is purely manual. Watering is done by operators (farm staff). However, this manual system makes the watering of the products tedious insofar as the work is slowed down by the failure of the human workforce. Hence the importance of automating the system.

5. Futuka Farm Irrigation System Automation

We opted for a sprinkler system. This is the sprinkler irrigation system that allows uniform irrigation, and is particularly appreciated. It will essentially include a:

- A sprinkler trolley that will move thanks to a motor;
- A speed variator which will control and ensure the desired movement, by the sprinkler carriage, taking into account the speed carried out by the translation guidance.
- For the control we will use an S7 - 300 PLC.
- Sensors will be used to collect process information; The sprinkler system includes in its mechanical part a sliding link, a translation guide of a sprinkler carriage and thus of a mister.

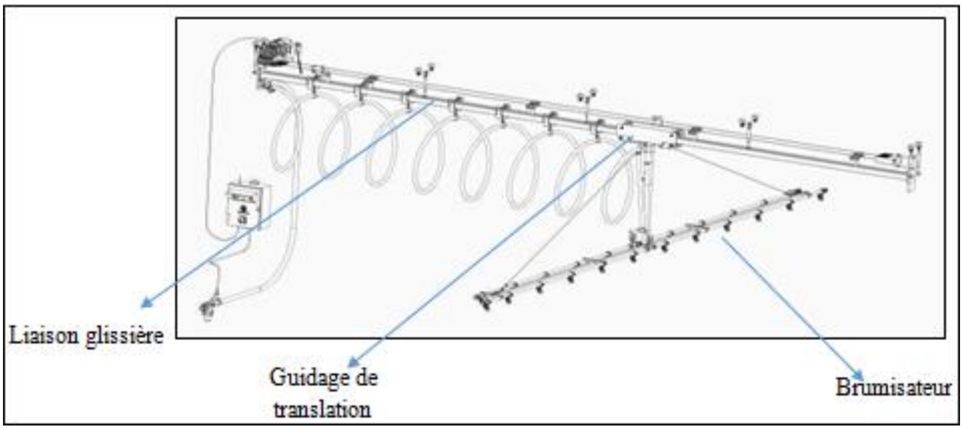

Figure 1: Système arroseur partie mécanique

5.1. Sprinkler system composer for Futuka Farm irrigation automation

The sprinkler system will include:

a) Slide connection
The sliding link is a mobile (fixed) part considered as a path, a path, a passage allowing the circulation of the translation guide to perform movements.

b) Translation guidance
The translation guidance is a mechanical part allowing the movement of the parts in a straight line of our sprinkler system.

Figure 2: The transmission pulley

c) The fogger
It is a device for projecting water in very fine water droplets it is connected to a garden hose, the water is then pressurized and projected into the air. The mist allows the plants not to have too much water by moistening the soil and the plant, so during the hot weather and the plants are protected from drought. On the other hand a sprinkler trolley, a motor for moving the sprinkler trolley and a variable speed drive.

d) The sprinkler cart
We considered setting up a metal structure providing support for a single - rail watering trolley.

Figure 3: Sprinkler cart

e) The electric motor
An electric motor it transforms the electrical energy received into mechanical energy. This from a battery or other power source. The motors are powered by either direct current (DC) or alternating current (AC). Since we are going to use this type of motor in our automated sprinkler system to ensure the movement of the sprinkler cart. We opted for that of the asynchronous motor because of its robustness, the simplicity of its structure, its weight and its size, the asynchronous machine offers new technological perspectives in many industrial fields, where we mainly appreciate its low maintenance and its low cost (M. MOUHAMED ELHADI, 2016/2017, p31).

Figure 4: Engine

f) The variable speed drive
A variable speed drive, often called a "frequency converter", is an electronic device intended to control the speed of an electric motor and they are widely used in industrial automation.

We considered implementing a variable speed drive from Schneider Electric as a solution, which offers its Altivar range, which makes it possible to control three - phase or single - phase motors.

Figure 5: Altivar variable speed drive from scheider

5.2 Choice of sprinkler system field instruments

The sensor is the essential element for measuring these physical quantities. We are going to list the sensors used to control our irrigation system.

a) The humidity sensor
The soil moisture sensor measures the water content in the soil. The sensor is equipped with two analog and digital outputs. In practice, when we talk about humidity measurement, we are referring to the humidity level expressed in % in this project the humidity sensor used to manage watering with precision so as not to cause a lack or too much water in the soil.

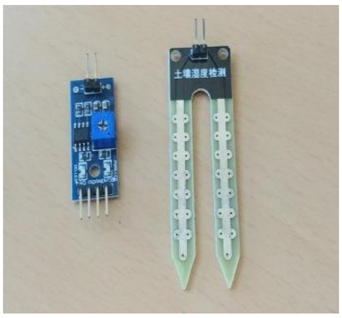

Figure 6: Soil moisture sensor

b) The level sensor
Level sensors are used to measure the level in a tank or in a reservoir. In this project the level sensor is used to measure the level of water in the tank to fill it when it starts to empty.

Figure 7: water level sensor

c) The proximity sensor
The All or Nothing (TOR) proximity sensor delivers binary information to the control part: the information adopts state 0 or state 1. An inductive type proximity sensor which has a long detection range, an assembly easy, robust and has a good value for money. The sensor delivers electrical signals corresponding to a threshold (level, position). Intended to transform a measurable physical quantity (pressure, temperature) into an electrical signal of an analog or digital nature (M. MOUHAMED, 2017, p40) For this we distinguish between different types of position sensor, namely:

Figure 8: proximity sensor

d) The S7 - 300 programmable logic controller
The PLC used in our project belongs to the SIMATIC S7 range from SIEMENS; The S7 - 300 is a modular mini - controller for entry - level and mid - range applications, with the possibility of expansion up to 32 modules.

Figure 9: Siemens PLC S7 - 300

5.3 Grafcet of the automated watering system of the Futuka farm

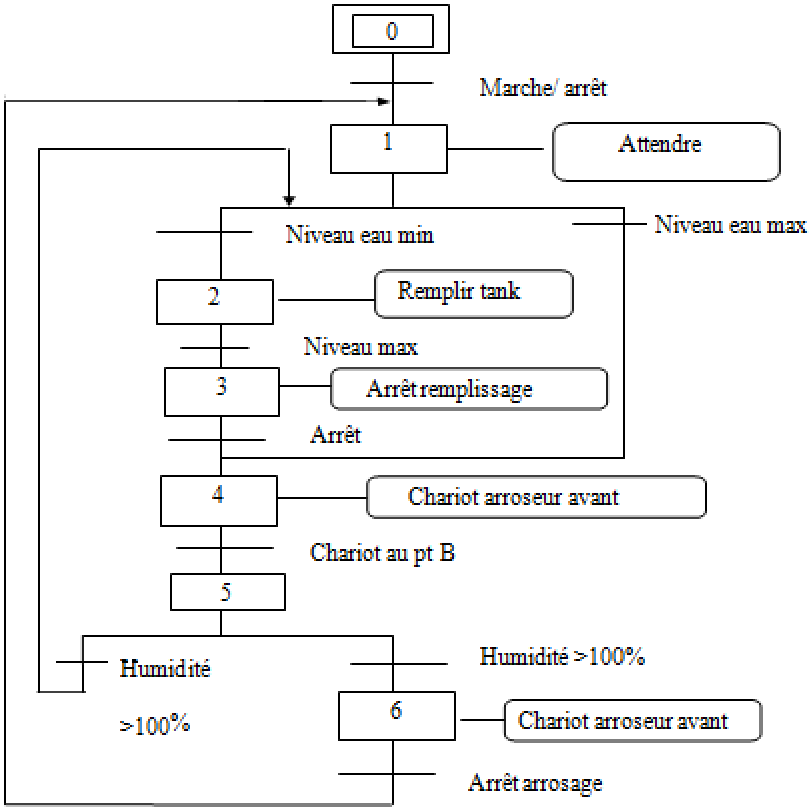

Figure 10: Grafcet of the automated watering system

5.4 Configuration of the irrigation system API in TIA PORTAL

The S7 - 300 PLC will be programmed using a PC with STEP 7 software (or using the Siemens TIA Portal (Totally Integrated Automation) platform under Windows which offers the following functions (EL HAMMOUMI, 2010, p4).

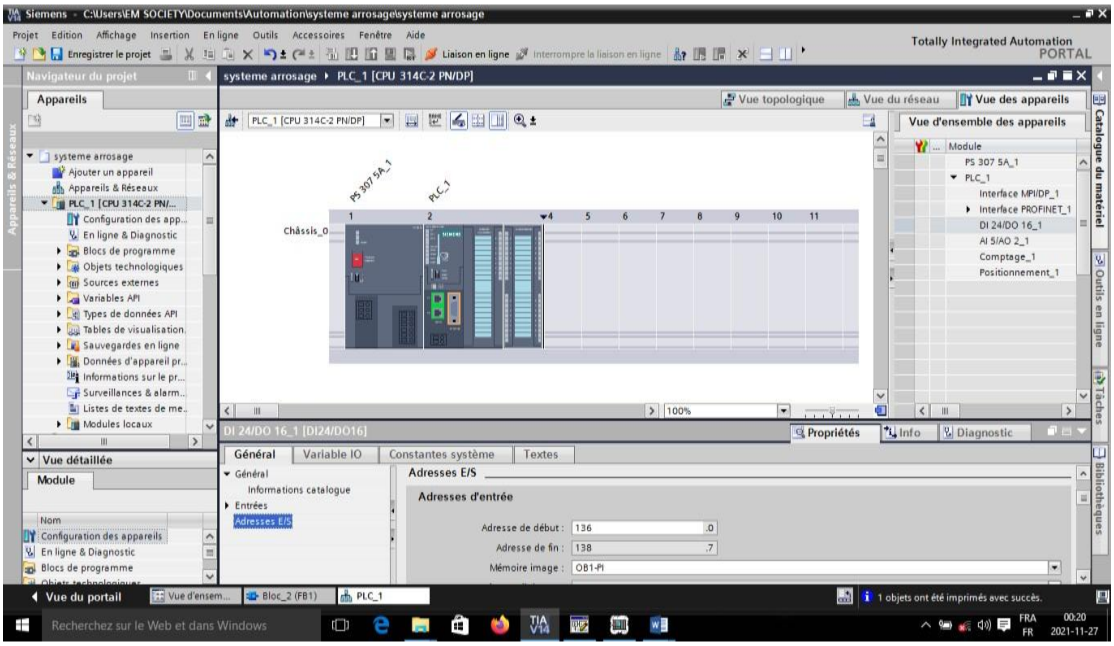

Figure 11: TIA programming interface

5.5 Addressing field instruments

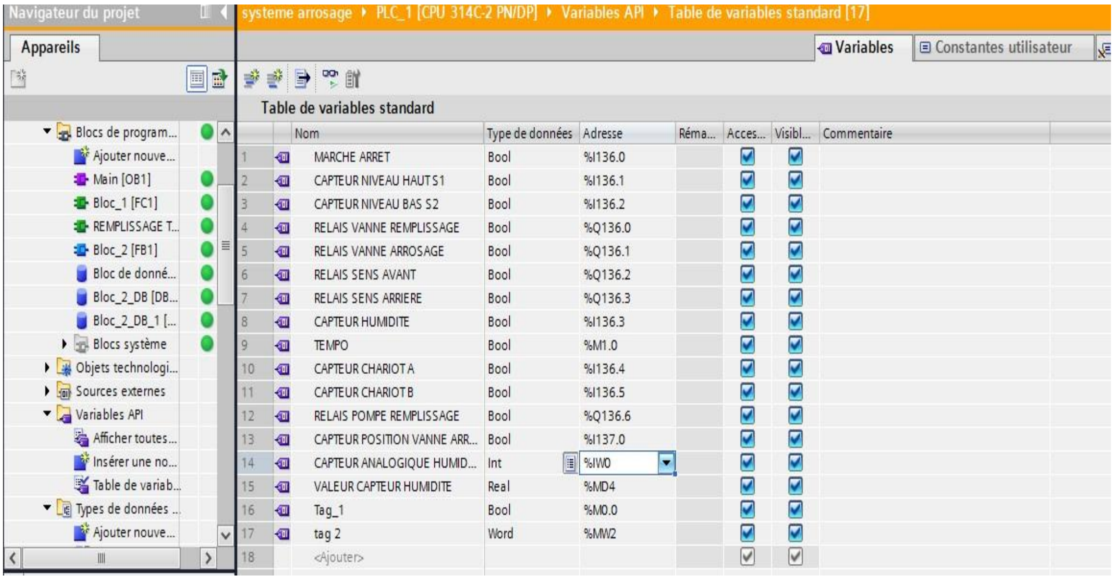

Figure 12: Configuration of the API under TIA

5.6 Programming in TIA Portal

Programming under the Siemens TIA portal uses the step7 programming tool for PLC programming and for the automation system, allowing significant time savings to be made during the development of systems and for human - machine interfaces. The S7 - graph is a graphical programming tool for sequential processing on SIMATIC S7 PLCs in accordance with the standard SFC language (Sequential Function chart) defined in standard IEC 61131 - 3; the S7 - GRAPH software is an integral part of the software workshop STEP 7 Professional.1

5.7 Creation of functional blocks

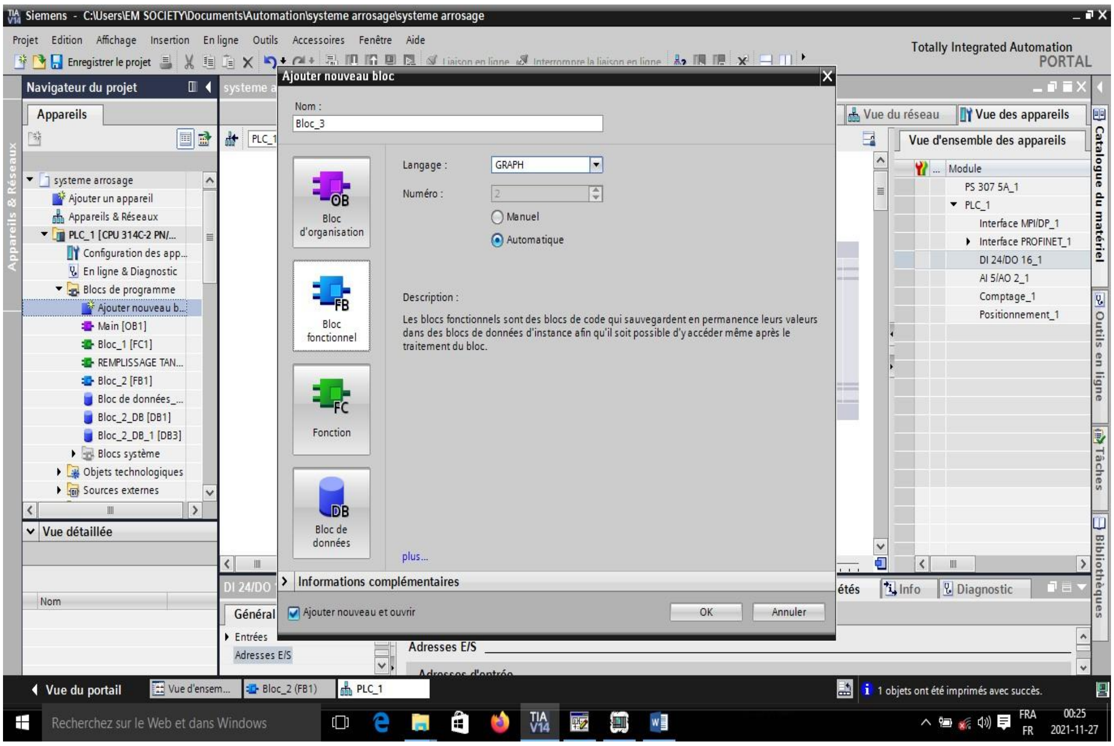

Figure 13: Creation of functional blocks

5.8 Grafcet of the watering system under TIA portal

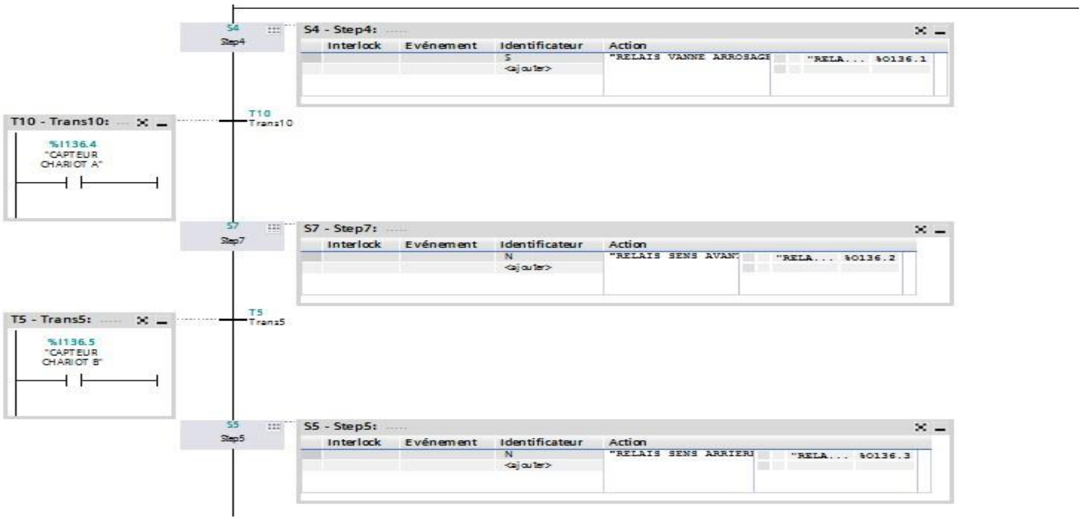

Figure 14: Programming in graph language

5.9 Loading the function block into the organization block OB and scaling the analog humidity sensor.

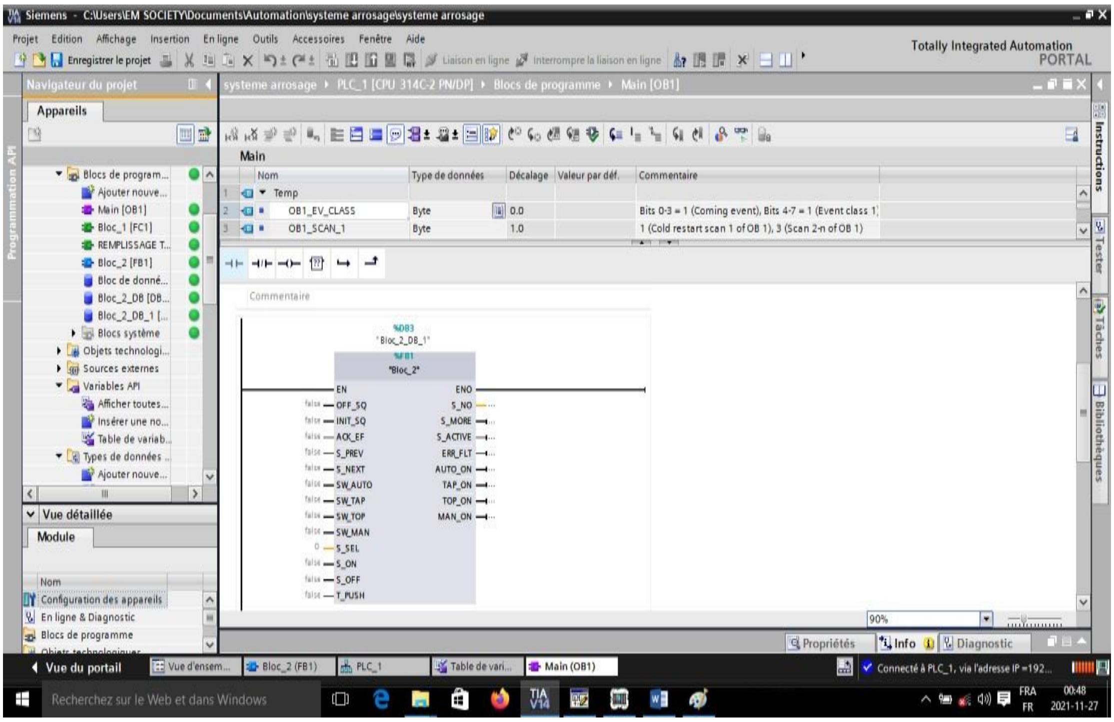

Figure 15: function block and OB block

5.10 Loading the program into the PLCSLIM

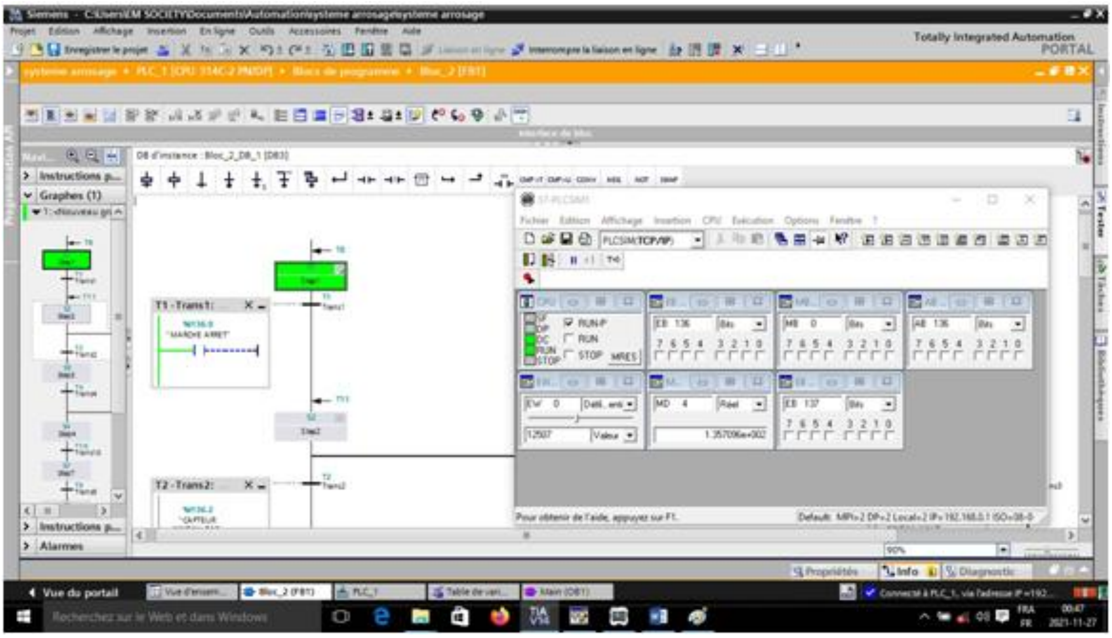

Figure 16: loading the program into the PLC

6. Conclusion

Our study focused on the automation of the watering of agricultural products" from the Futuka farm. This study aimed to improve the watering of agricultural products of the Futuka farm. To do this, we first studied the functioning of the irrigation system of the futuka farm in order to immerse ourselves in the different irrigation methods it has in order to highlight the disadvantages. The new system will include an industrial programmable logic controller programmed under TIA PORTAL through the development of a grafcet.

References

Works

[1] IEC 1131 - 3 standard. » Programmable automata - Part 3: Programming languages. International Electrotechnical Commission", 1993.

[2] G. BBOUJAT, J. P. PESTY "automated systems, graphic tools, specifications, pneumatic control logic, electrical and electronic control logic, programmable control logic", 1998

[3] PHILLIPE RAYMOND "industrial programmable logic controllers (API) ", 2005

[4] ANDJOUH LYES "Automation and supervision of the lifting pit of the oil refinery at the cevitalagri - food complex" year 2013

[5] LAIDI ABEDALLAH, OUANOUCHE OURIDA, TALEM Hand "The adaptation of an S7 - 300 programmable logic controller to a welding machine", automation department, 2008/2009.

[6] KESSI SAMIA, BENAKEZOUH YAMINA "Study of the automation of a machine to fill stator notches", automatic department, 2003/2004.

[7] A. LYES AND BELFAKED HASSINA. "Automatic production system and adaptation of an automaton to an electro - industrial machine" automatic department 2011

[8] BOUKHECHEM ISMAIL "Study and realization of an automated didactic system implementation of the Siemens S300 automaton" electrotechnical department, 2013/2014

[9] MARTANI MOUHAMED ELHADI "automation and contribution to the improvement of an irrigation system" department of mechanical engineering, 2017/2018

[10] LEMDANI RAFIK, MR. MALOUADJMI NABIL: "Study, design and production of a platform for the automation and remote control of agricultural greenhouses. " Option: Automatic, 2013/2014

[11] BACI WASSIME "Automatic management of agricultural greenhouses on a farm" IT department, 2015/2016

[12] BEN KHALFALLAH ROUMAISA "automation of an irrigation system" electrical engineering department, 2019/2020

[13] LAHLOUH MOHAMED RIDHA AND AZIZOU Abderrahmane "Study and realization of an automatic irrigation system" Department of Science and Technology 2016/2017

[14] Ms. EL HAMMOMI, "course on industrial logic and (API) automation"

[15] ALAIN GONZAGA, "industrial programmable logic controllers"

[16] M. TAHIRI, ENIM Rabat (Morocco) 2015 "automatism and industrial automation",

[17] C. BROUWER (1990) "Irrigation method"

[18] J - M BLEUX, J - L FANCHON, 1998 "Industrial Automation".

[19] RENE DAVID. HASSANE ALIA 1993. "From grafcet in automation".

Websites

[20] http: //www.siemens. com

[21] http: //www.automation - sense. com