TECHNICAL UNIVERSITY OF NORTH

FACULTY OF ENGINEERING IN APPLIED SCIENCE
ENGINEERING IN ELECTRICAL MAINTENANCE

GRADE WORK PRIOR TO OBTAINING THE TITLE OF ELECTRICAL MAINTENANCE ENGINEER

SCIENTIFIC ARTICLE (ENGLISH)

TOPIC:

"DESIGN AND IMPLEMENTATION OF A TRAINING MODULE FOR AUTOMATIC MONITORING AND CONTROL OF PRESSURE AND WATER TEMPERATURE."

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Ibarra – Ecuador 2016

DESIGN AND IMPLEMENTATION OF A TRAINING MODULE FOR MONITORING AND AUTOMATIC CONTROL OF WATER PRESSURE AND TEMPERATURE.

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Summary. This work on the design and implementation of a training module for automatic control and monitoring of pressure and temperature of water is intended to simulate an industrial process on a smaller scale, using sensors and actuators managed by a PLC (Programmable Logic Controller) within a process and integrate some related to instrumentation and process automation concepts; whereby it contributes to the implementation of educational material that can generate significant experiences in the academic activity of students in the career of Electrical Maintenance Engineering. The research is divided into six chapters that are described below: Chapter I, in the formulation and delimitation of problem arises, also includes the objectives or justification which were raised for research. CHAPTER II, is structured with theoretical and scientists on industrial automation, variables and instruments foundations, and other theoretical framework that formed the basis for the research and development of the proposal. Chapter III discusses the research methodology, in which the type of research, methods and applied techniques and instruments that were designed for data collection are described. CHAPTER IV presents the proposal: Design and implementation of a module for monitoring and automatic control of pressure and water temperature; in which the basic and introductory elements and module design, the main elements of the module, instrumentation, control elements are described, also it contains diagrams of the system; It is complemented by the P & ID training module; to be used in the teaching-learning process in the laboratory. CHAPTER V contains the conclusions reached in the investigation and resulted in recommendations to be considered for the implementation of the proposal. The report contains the annexes section in which the information that the statements issued in the study are complemented included; plus a list of written sources that were used in the research is presented.

Keywords
Automation, communication protocol, human machine interface

1. Introduction

Industrial automation in this global industry is very important to improve manufacturing processes and keep under control the operating parameters tool.

Humans have always sought to create tools and machines that will facilitate the realization of dangerous, heavy and repetitive tasks. In recent times, the emergence of highly sophisticated machines has led to a great development in the field of automation and control tasks, already applied in many machines that are handled daily.

All these actions are performed in the process of industrial production require a series of operations in which the presence of the human operator is constant. As is the starting and stopping of processes. Monitoring equipment product handling, alarm management and maintenance, among others. This should be done at the lowest possible cost, in the best conditions of human and environmental safety.

In this paper grade has been designed and assembled a training module to simulate a process of automatic control of pressure and water temperature by means of a PLC that controlled electric actuators.

With the implementation of this training module the student will have the ease of performing practices with automated systems and thus gain more insight into processes of the industrial environment.

2. Theoretical framework

Industrial automation is the application of different technologies to control and monitor a process, machine, apparatus or device usually performs functions or repetitive tasks, making operate automatically, minimizing human intervention.

What is sought with industrial automation is to generate as much product as soon as possible in order to reduce costs and ensure quality consistency.

Industrial automation is developed with an interdisciplinary approach, is different technologies together, such as instrumentation to measure variables of matter in its different states, gases, solids and liquids, that means we measure things like volume, weight, pressure, etc. (Campos & Velasco, 2014).

2.1**Transmitters**

Transmitters capture the process variable through the primary element and transmitted over distances as pneumatic, electronic or digital signal. The electronic signal is normalized 4 to 20 mA DC.

The digital signal is a series of pulses as bits. Each bit consists of two signs, the 0 and 1 (binary) and represents step (1) or not (0) of a signal through a conductor. If the signal is typed that manages the microprocessor of the transmitter it is 32 bits, then 32 can send binary signals (0 and 1) simultaneously (Creus, 2009).

2.1.1Level

They are landmarks that are taken to indicate the location of a quantity from the minimum or maximum point being measured.

The gauges work by measuring liquid level, either directly the height of liquid on a baseline, although the hydrostatic pressure, either the displacement produced on a float in the liquid itself in the tank of the process, but building electrical characteristics of the liquid or using other phenomena (Creus, 2009).

• Level sensor: The liquid level sensors work by measuring directly the height of liquid on a reference line, and hydrostatic pressure and the displacement produced in a float by itself liquid in the process tank, or also drawing electrical characteristics of the liquid (Creus, 2009)

2.1.2 Pressure

Pressure is defined as the amount of force exerted on a unit area of a substance that can be set with the equation:

$$P = \frac{F}{A}$$

Where:
P = Pressure, F = Force A = Area

Blaise Pascal, a scientist of the seventeenth century discovered two important principles about pressure.
• The pressure acts uniformly on all addresses in a small volume of fluid.

• In a fluid confined between solid boundaries, the pressure acts perpendicular to the border.

	Psi	*Pulgada c de agua*	*Pulgada c de Hg*	*Atmósfera*	*kg/cm²*	*cm c de a*	*mm c de Hg*	*Bar*	*Pa*
Psi	1	27,68	2,036	0,068	0,0703	70,31	51,72	0,0689	6894,76
Pulgada c de agua	0,0361	1	0,0735	0,0024	0,0025	2,54	1,868	0,0024	249
Pulgada c de Hg	0,4912	13,6	1	0,0334	0,0345	34,53	25,4	0,0338	3 386,39
Atmósfera	14,7	406,79	29,92	1	1,033	1033	760	1,0132	$1,0133 \times 10^5$
kg/cm²	14,22	393,7	28,96	0,9378	1	1000	735,6	0,98	98066
cm c de a	0,0142	0,3937	0,0289	0,00096	0,001	1	0,7355	0,0009	98,06
mm c de Hg	0,0193	0,5353	0,0393	0,0013	0,0013	1,359	1	0,00133	133,322
Bar	14,5	401	29,53	0,987	1,02	1020	750	1	10^5
Pa	0,00014	0,004	0,00029	$0,987 \times 10^{-5}$	$0,102 \times 10^{-4}$	0,01	0,0075	10^{-5}	1

• **Pressure sensor**: is a sensor that senses the pressure value or the variation thereof and accurately transforms into an electrical signal.

2.1.3Temperature

The temperature measurement is one of the most common and the most important occurring in industrial processes. Most physical phenomena are affected by it. The temperature is used frequently to infer the value of other process variables (Creus, 2009).

	Celsius	**Fahrenheit**	**Kelvin**
Celsius(1)	1	33.8	274.15
Fahrenheit(1)	-17.22	1	255.92
Kelvin(1)	-272.15	-457.87	1

• **Temperature sensor:** The temperature sensors are devices that convert temperature changes into changes in electrical signals that are processed by electrical or electronic equipment.

2.2 Final control elements

2.2.1 Solenoid

A solenoid valve is an electromechanical valve designed to control the passage of a fluid conduit or pipe. The valve is moved by a solenoid coil. Usually it has only two positions: open and closed, or everything and nothing. The valves are used in many applications to control the flow of all types of fluids.

i. **Niquelina**:

The niquelina are designed for heating in direct contact with the fluid (water) are items that are manufactured from nickel, where electrical energy is converted into heat. This amount of heat depends on the intensity of time it is connected. According to Joule's law we say that the amount of heat a resistor is directly proportional

to the square of the current and directly proportional to the resistance value and time.

$$P = V \times A$$

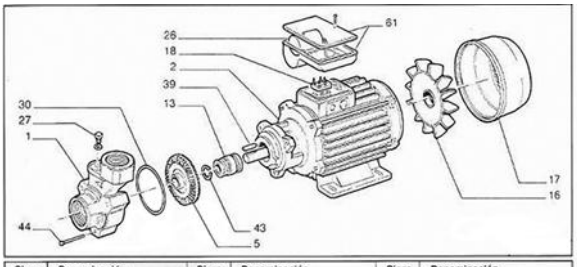
Where:

P = Power
V = Volts
A = amperes

2.2.3 Peripheral Pumps (turbine type)

peripheral pumps also called volumetric, capable of delivering high discharge pressure with low power engines. Suitable for domestic use, increased pressure from the drinking water, peripheral pumps are excellent for increasing water pressure and pumping it at high altitudes, as in the case of buildings.

Training module for a pump to increase water pressure and have low power consumption is needed and for these reasons peripheral pump type was chosen for its features.



Pieza	Denominación	Pieza	Denominación	Pieza	Denominación
1	Cuerpo de bomba	17	Tapa del ventilador del motor	39	Chaveta
2	Tapa de acople	18	Bornera de conexión	43	Aro seeger
5	Turbina de bronce	26	Capacitor	44	Tornillo sujeción del cuerpo
13	Sello mecánico	27	Tapón de cebado	61	Caja de conexión monofásica
16	Ventilador del motor	30	O´ring del cuerpo		

2.2.4 Inverter

The electronic speed by frequency variation is a team of power electronics, which operates a squirrel cage motor and performs its start and stop smoothly. Additionally, it varies in a controlled manner maintaining the engine speed constant torque to rated speed (WEG, 2015).

By varying the frequency applied to the motor engine speed based on the following relationship it is varied:

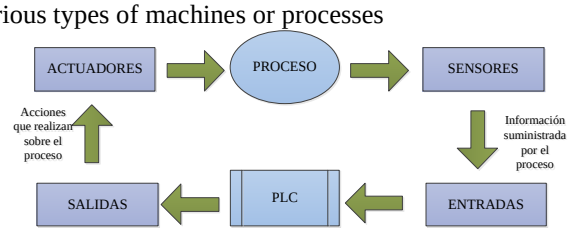
$$ns = 120 * \frac{f}{p}$$

Where:

ns = synchronous speed is
f = is the applied frequency
p = number of poles

2.2.5 Programmable Logic Controller

A programmable logic controller is an electronic machine that handles a programmable memory for internal storage of instructions for controlling a process to establish specific solutions such as logic, sequencing, timing, counting and arithmetic functions, in order to intervene through inputs and outputs, digital and analog various types of machines or processes



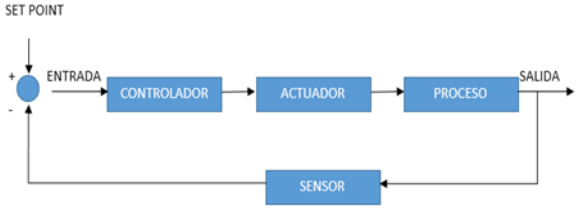
2.3 Control Systems

2.3.1 System Control loop open

Those in which the output variable (controlled variable) has no effect on the control action (control variable), is the system output to the desired value of the system output (Academy, 2015) does not compare.

2.3.2 System of closed control loop

System closed-loop control those in which the output signal of the system (controlled variable) has direct effect on the control action (control variable (Academy, 2015).



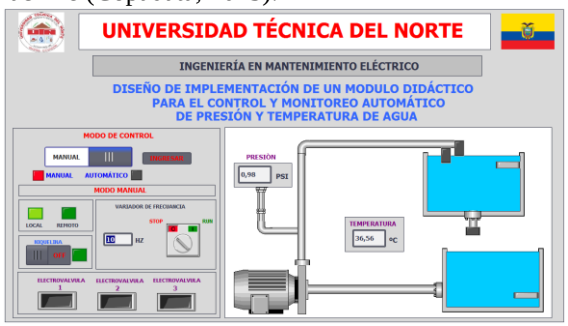
2.3.3 Control system implemented in the module

The control system implemented in the training module is closed laso because you have instrumentation to provide feedback to the controller, according to system variables to control the type of controller is determined closed for temperature and pressure both laso.

2.4 Man-machine interface HMI

A man-machine interface (HMI), is part of the software that communicates with the user, the term user interface is defined as "all parts of an interactive system (software or hardware) that provide information and control needed for the user to perform a task interactively. the user interface / human-machine interface (HMI) is the

point of action when a man comes into contact with a machine (Copadata, 2015).



2.5 Industrial Networking

Industrial networks are primarily intended to convey information either from the field level, level control or supervision, industrial networks are managed under different types of communication protocols.

2.5.1 Ethernet

It is standard networks, has physical level characteristics regarding wiring and signaling data link level in terms of formats of data frames on the basis of the OSI model.
The international standard IEEE 802.3 defines the characteristics of Ethernet-based networks, the most important specifications of this protocol is the multiple access system with carrier sense and collision detection.

2.5.2 RS-485 Modbus

It is a standard protocol, widely used in the industry that has more available for connecting industrial devices.

Among the devices that we use include:

- Programmable logic controllers PLC
- Human Machine Interfaces
- Drivers
- remote sensors and actuators

2.6 Programming Platform

2.6.1 Tia Portal

TIA Portal is an innovative software for all automation tasks in his capacity Tia portal not only allows the programming of the controller, but also the system configuration and parameterization of drives internal communications program.
In Tia Portal system you can perform simulations of project applications from the PC without placing an online PLC (SIEMENS, 2014).

2.6.2 Step 7

STEP 7 Professional is a modern engineering tool for configuration and parameterization of all SIMATIC controllers:

STEP 7 allows:
- Perform graphical configuration
- programming errors through integrated system diagnostics, increased real-time tracking and online features.
- Set the siemens systems through bookstores and communication compatibility

STEP 7 help us solve engineering tasks intuitively and efficiently. Options such as drag and drop, copy and paste, faster and easier work decisively. (SIEMENS, 2014).

2.6.3 WinCC

With WinCC you can visualize process management, manufacturing lines, machines and facilities. With the high functionality of this modern system include ease of event messages in a form suitable for industrial application, the file of measurement values, recipes and a list of them.

With its powerful process coupling, especially with SIMATIC, and secure archive data, WinCC makes possible a high-level solutions for driving technique process. (SIEMENS, 2014)

3.Results

The construction of this training module is aimed at strengthening the expertise in industrial automation and instrumentation students of Engineering in Electrical Maintenance, providing a tool where they have the ability to manipulate a simulation of an industrial process
The module has a PLC for the acquisition, monitoring and control of system parameters just as you would in an industrial process, allowing the student to put into practice the knowledge acquired in the field of instrumentation.

3.1 Design of the training module

The equipment is designed to use modern technology to ensure the protection of people and equipment related to acquaint students with methods of control and industrial automation.

3.2 Electrical architecture module

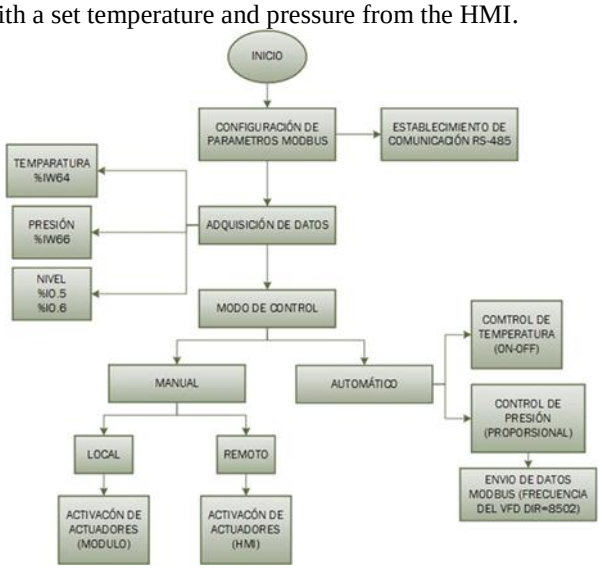
The electrical system architecture is composed of several subsystems shown below:
- Control Subsystem: it is mainly composed of the programmable logic controller which acquires the information from the sensors and performs the control system in the control subsystem it is also made up of the inverter.
- Subsystem instrumentation: performs measurements of pressure, temperature which deliver analog signals to the PLC 0-10, mediation of tank levels that deliver digital signals to the PLC is also performed.
- monitoring subsystem: the system is monitored by a Human Machine Interface.

3.3 Flowcharts

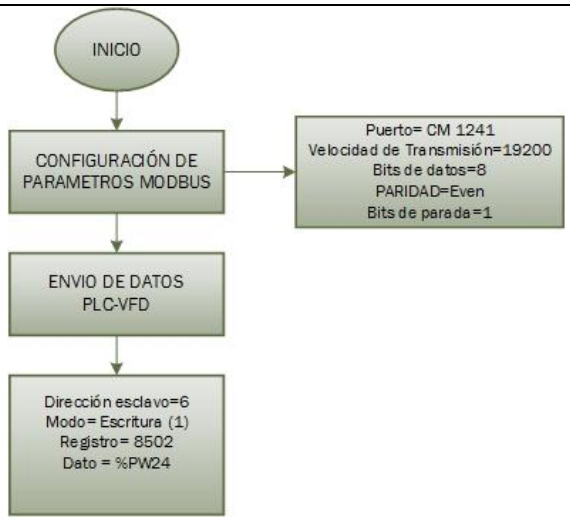
The programming logic begins by setting the parameters of the Modbus communication, which allows you to write the frequency from the HMI to the inverter, then the status of the inputs connected to both digital PLC, such as analog is acquired; the level of the main tank, storage tank level, the value of the temperature sensor, the value of the pressure sensor.

The control mode can be manual where activation of the actuators is selected in local mode through didactic or remote module through the HMI interface.

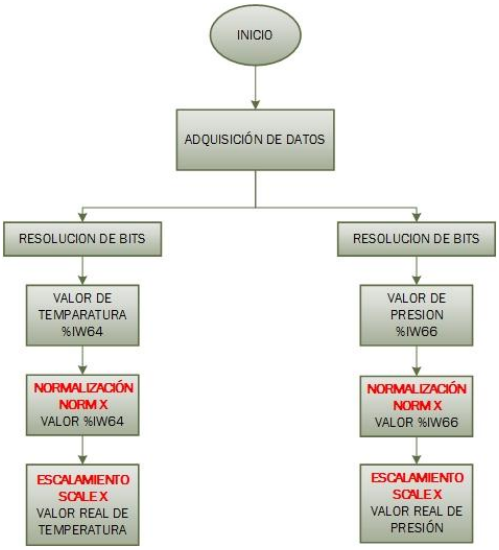
The process will start automatically, the user sets a set point temperature where the module after that set point is reached can be set for the module starts circulating water storage tank to the main tank a set point pressure with a set temperature and pressure from the HMI.



The following figure shows the flowchart of Modbus parameter settings where the transmission rate, data bits, parity and stop bits set.

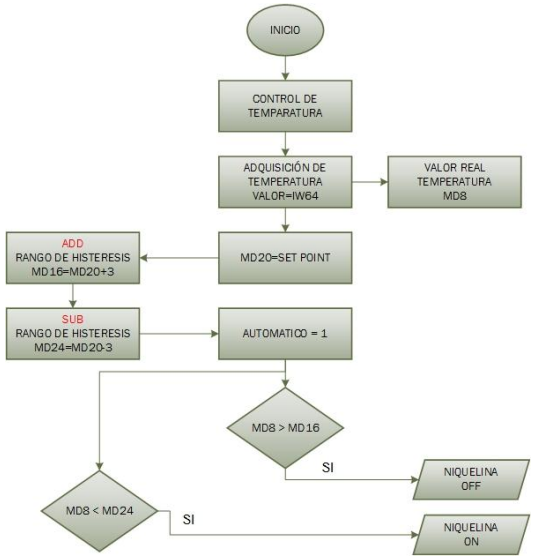


Data acquisition is done through two channels, channel 0 the temperature sensor is connected and the voltage signal 0-10V is acquired through IW64 direction, the pressure sensor is connected to channel 1 and the voltage signal of 0-10V is acquired through IW66 direction once the bit value is acquired and normalized scale data to have an actual sensor reading.

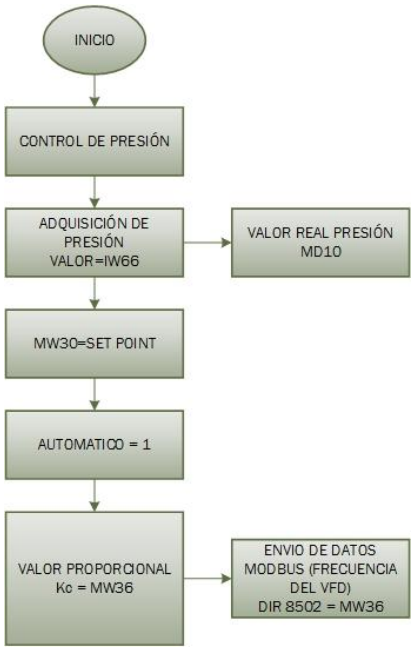


In automatic mode the temperature and pressure control is performed, where the temperature for an ON-OFF control with hysteresis is performed.

The real value of the sensor in degrees Celsius is acquired, then the value of the Set Point adds and subtracts a hysteresis range of 3 to perform the comparison of the two values and to develop control logic as shown in Figure



In Figure 33 the flow diagram of the automatic pressure control is performed by means of a proportional control, depending on the set point value and the value of the pressure sensor Kc value is proportional to the value set shown the often written in the Modbus address of the inverter.



4. CONCLUSIONS

• It is important to the development of a training module with real equipment used in the industrial field that allows students to consolidate the knowledge acquired in the different subjects and be able to manipulate them without any problem.

• For better accuracy of the sensors is necessary to use current signals, but for the training module is sufficient to use voltage signals because the distance is not great between the PLC and sensors, so there are no falls voltage and signal interference.

• For communication between the inverter and the PLC communication module CM-1241, which has communication protocol Modbus RTU via RS-485 was chosen because with this kind of communication there is no problems with noise and generated electrical disturbances when operating the module.

• The training module has an automatic pressure and temperature control, and additionally during the tests the need to add a manual control was determined to check the operation of each device and be able to detect any abnormalities that may occur in the process.

• The TIA Portal is a software program developed by Siemens for programming the S7-1200 PLC and through this training module will help students understand the language that is programmed into it.

• It was decided in a peripheral pump for pressure process module as the technical feature is coupled to the control devices, plus the pump has good performance when working with high pressures and its price is inexpensive yet It has a low power consumption.

5. Acknowledgement

Our special thanks to the Technical University of the North, to fulfill its educational mission senior professionals.

At the Faculty of Engineering of Applied Sciences UTN, for opening their doors to their classrooms we will share experiences excellent intellectual growth and formation in our career.

Our undying gratitude to Ing. Pablo Danilo Mendez, for your friendship, wise teachings and right direction in this paper grade, thanks to his contribution, we completed successfully in this new goal.

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y
Darwin Geovanny

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