# CONTROL AND SUPERVISION OF A SIMULATED INDUSTRIAL PROCESS USING SCADA SYSTEMS, PLC S7-1500 AND SIEMENS VARIABLE SPEED DRIVES

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**Abstract**: This document is carried out the result of the implementation of a SCADA system for the control and supervision of a process that must perform position and speed profiles in a servomotor and in a three-phase motor using a connection of 6 S7-1500 PLC controllers. In the industry, SCADA systems are of vital importance since they allow remote visualization and control of one or several processes, since in some cases the plants are at considerable distances and for this specific case they are carried out from PC stations and HMI screens through of two communication protocols (main and secondary) which allows the connection between the PLCs and that when one connection falls the other (PROFIBUS) supports it, in addition to configuring the driver of the servomotor and the frequency inverter so that the profiles are made correctly, and finally a main network of 6 PLCs is obtained in a ring connection through PROFINET where they all communicate with each other, and send and receive data that is used to activate the sequential processes programmed for the profiles in the motors of any station. job.

**Abstract**: This document shows the result of the implementation of SCADA system to control and to supervise the process following position and speed profiles of both servo motor and a three phase motor using connection of 6 PLC S7-1500. In the industry the SCADA systems are very important because it shows and control one or more remote processes, sometimes the work stations are in considerable lengths and for this specific case it is made for PC Stations and HMI Screens through two communication protocols (main and secondary ) that makes the connection of PLC and when one communication fails the other takes its place and keep communicating, adding the configuration of parameters for driver for the servo motor and the variable frequency drive to make the profiles correctly. Finally it is obtained a main network of 6 PLC by PROFINET ring connection where the controllers communicate one each other sending and receiving data use to make the sequential process programmed for profiles in any work station in the lab.

## INTRODUCTION

SCADA systems provide supervision and control software through multiple programmable logic controllers. These systems are designed to be used over long distances such as water or extensive electrical networks. Due to the long distances, these systems allow a process to be visualized and controlled in real time by means of a monitoring station.[1]

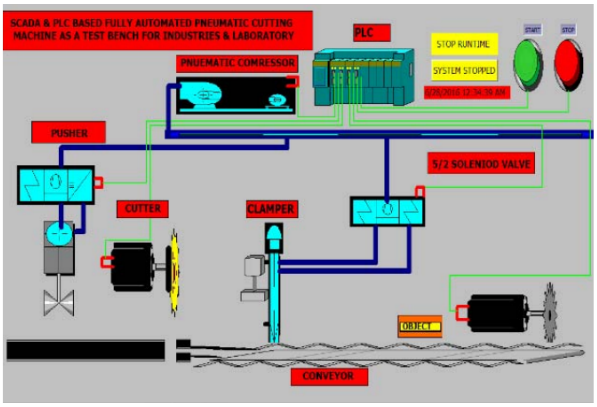



*Figure 1: Example of a SCADA system.[2]*

The PROFIBUS protocol is a communication standard for field buses. It derives from the words **PRO**cess **FI**eld **BUS**, the most used version is PROFIBUS DP. Specially designed for communication between automation control systems and distributed inputs/outputs. A typical system consists of: A PLC or PC as the control system (master) and several I/O devices configured as slaves, such as digital or analog I/O, AC or DC drives, and magnetic or pneumatic valves.[3 ]

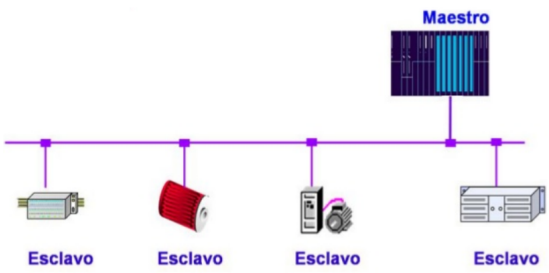



*Figure 2: Typical PROFIBUS DP connection*

The frequency inverter regulates the speed of electric motors so that the electricity from the motor is adjusted to the real demand of the application. An inverter is an industrial controller that sits between the power supply and the motor. Mains power passes through the drive and regulates the power before it reaches the motor, then adjusts the frequency and voltage based on procedure requirements.[4]

*Figure 3: Micromaster SIEMENS drives[5]*

Servomotors with their corresponding driver are drive devices for precision control of speed, torque and position. These replace pneumatic and hydraulic drives (except in high-torque applications) and are the best performing alternative to drives via frequency converters, since they do not provide position control and are ineffective at low speeds.[6] ]

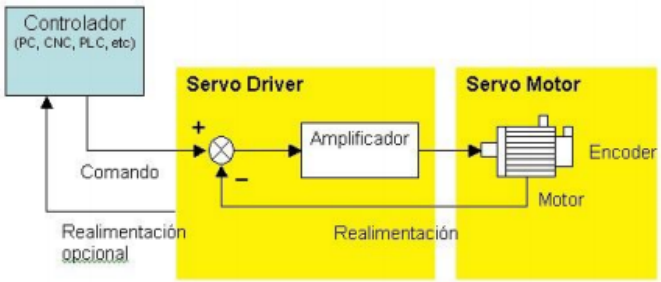



*Figure 4: Servomotor with driver[6]*

Objectives:

- General

Design and implement different workstations where each one is in a different subnet where there are speed variators, servo systems and PLCs; These plants must communicate through a SCADA system through WinCC and the HMI.

- Specific

Design and implement SCADA system to supervise different plants that are in different subnets

. Implement predefined profiles in the servomotor through the Driver and in the motor through the micromaster speed variator.

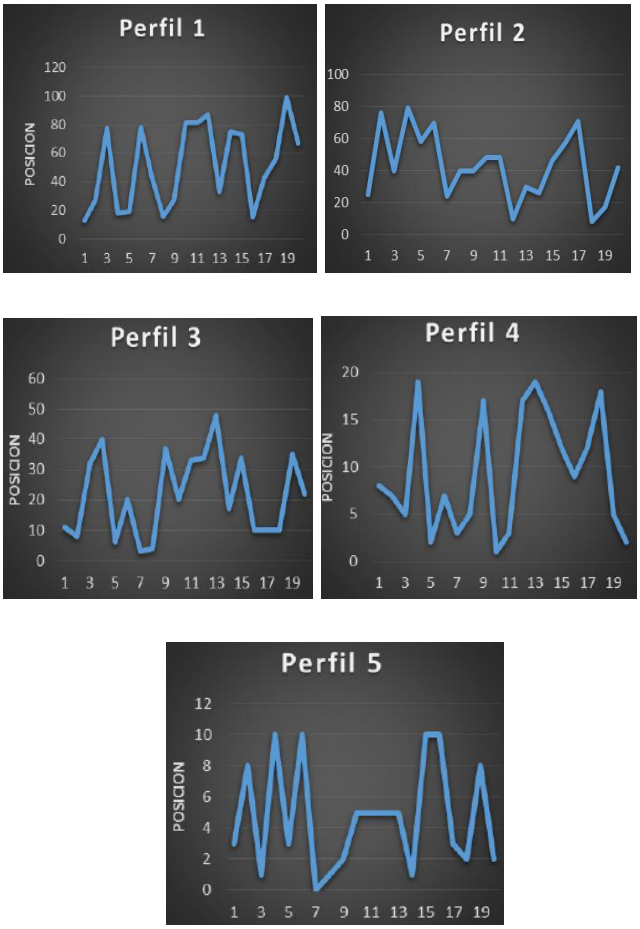
## DEVELOPMENT

For the development, position and speed profiles must be made in the servomotor and in the motor through the frequency variator, respectively. These are displayed and controlled on the PC stations and on the HMIs that are in a joint network of the 6 PLCs available in the laboratory.

Materials:

- PLC Siemens S7-1500
- Realtek RTL8188EU Wireless LAN 802.11n USB 2.0 Network Adapter.
- TIA Portal V13
- ETHERNET cables
- RS485 cable PROFIBUS
- Servomotor YASKAWA Sigma - II
- Micromaster 440 Siemens
- Siemens Motor 1LA7 070 2YA60
- HMI KTP600 Basic Siemens

## PROCEDURE




**Frequency inverter**: The frequency inverter, as mentioned above, controls the percentage of the phase coming from the electrical network that enters the motor, in this way it becomes a controller for the motor, it communicates through PROFIBUS to the PLC and thus be able to control the three-phase motor.


*Figure 5: Micromaster 440 SIEMENS Inverter*

All the parameters that are characteristics of the motor, communication and electrical are entered here. These parameters and their respective function are found in table 1:

| Parameter | Value | Description |
|---|---|---|
| P10 | 30 | Factory |
| setting P970 | 1 | Reset values |
| P3 | 3 | Expert user |
| P4 | 0 | All parameters |
| P918 | # = 55 | Card address |
| P10 | 1 | Start-up |
| P100 | 1 | American system 60Hz |
| P304 | 220 | Motor voltage [V] |
| P305 | 1.9 | Motor current [A] |
| P307 | 0.5 | Motor power [HP ] |
| P310 | 60 | Motor frequency [Hz] |
| P311 | 1590 | Rated speed [RPM] |
| P700 | 6 | PROFIBUS connection |
| P1000 | 6 | PROFIBUS connection |
| P1080 | 0 | Minimum frequency [Hz] |
| P1082 | 60 | Maximum frequency [Hz] |
| P1120 | 5 | Time at max speed [sec] |
| P1121 | 2 | Time deceleration [sec] |
| P2040 | # | Monitoring time |
| P3900 | x | Load configuration |

*Table 1: Micromaster 440 drive*

Parameters (words) are sent to the drive from the TIA Portal so that it changes the percentage of the phase frequency e that reaches the motor, which is directly proportional to the speed exerted by it.

**Servomotor**: For the servomotor, a position control is performed by sending values every 2 seconds, these values correspond to voltages configured in the TIA Portal and the PLC through the analog outputs. First, it consists of converting speed values necessary for the servo to reach an angular position (radians) for a certain time, which in this case is 2 seconds. After having this, we proceed to review the manual of the analog output module when the minimum and maximum voltage that the PLC can send is +10V and -10V, which are equivalent to an internal number that the PLC handles, which is 27648. Knowing this, parameter Pn300 of the servo driver is set to 800, which is equivalent to 8V reference and that at 8 volts the motor will rotate at nominal speed, which is 3000 rpm. These values are sent according to the servo fulfilling certain positions in radians.

*Figure 6: YASKAWA Sigma II servomotor*

**PC Station - Win CC**: The PC station is responsible for supervising and controlling the process through the computer, this is linked to a PLC through a subnet, which must be the same, in order to be able to control the from a remote site. For the PC station, an interface is programmed where buttons and coordinate axes are located, in the axis of the interface the profiles are graphed in real time with the motor.

Figure 7 shows the main image of the PC station through WinCC, in it there are 6 buttons for each of the PLCs and an emergency STOP button.


*Figure 7: WinCC main image*

And when any of the PLCs are activated, you proceed to see the image shown in figure 8, which has 5 buttons that allow you to perform any of the profiles, "play" and "stop" buttons to start and stop the profile at any time, in addition to having an axis in which the profile made by the motors is graphed in real time.


*Figure 8: Image when accessing a PLC, WinCC*

**HMI**: The human-machine interface is configured in the same way as with the PC station, images are created which are shown to the user when he accesses it, in which he interacts with programmed buttons with different events that allow to control the entire SCADA system.


*Figure 9: KTP600 Basic HMI*

The main image for each HMI is found in figure 8, in which 6 buttons are shown to select in which of the 6 PLC workstations the profiles are going to be carried out and also the emergency stop button , which consists of stopping all the CPUs that are connected.


*Figure 10: HMI KTP600 Basic*

**PROFIBUS**: For the connection through this protocol, an RS485 cable is used using the PROFIBUS DP (Decentralized Peripherals) profile that allows fast and cyclical data exchange. One of the characteristics of this method is its efficiency and profitability. To carry out this communication, it was necessary to connect the 6 PLCs available in the laboratory and define a single master PLC, for

this the switch is activated ON in the terminal of the cable connected to the controller that is defined as master, and in the rest the switch must be in OFF meaning that they will be the slaves of the process.

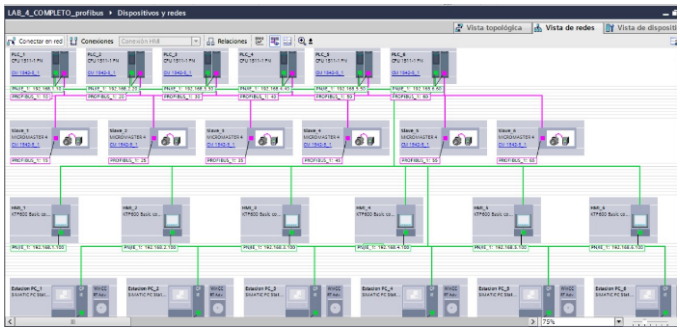


*Figure 11: Devices and networks*

When making this configuration, two buffers are created that allow the communication of variables between master and slave, making it possible for PLCs to communicate through inputs and outputs, which are memory marks.

**PROFINET**:

It is an industrial ethernet standard with characteristics similar to profibus and one of the most used in the industrial world of automation due to its speed and data transmission security. according to IEC 61784-2 [7]

More specifically can be applied to discrete and process applications, motion control, P2P vertical integration, has more security, energy management and many more features that make it one of the leaders in the market for being in addition to everything open.

The difference between profinet and standard ethernet load capacity and immunity in different components can be used in the lower part of the automation pyramid up to the process management part.[8]

It is a standard used by the simatic family that can be incorporated with components such as HMIs, other PLC's and other field devices.



Tabla 2- 3 Especificación técnica de la interfaz PROFINET

| Propiedad física | Técnica de conexión | Tipo de cable / medio de transmisión<br>Estándar | Velocidad de transferencia / Servicio | Long. máx. segmento | Ventajas |
|---|---|---|---|---|---|
| **Eléctrica** | Conector RJ 45<br>ISO 60603-7 | 100Base-TX<br>Cable de cobre de par trenzado 2x2, simétrico y apantallado, exigencia de transmisión según CAT 5<br>IEEE 802.3 | 100 Mbits/s / dúplex | 100 m | Conexión de cable simple y económica |
| **Óptica** | SCRJ 45<br>ISO/IEC 61754-24 | 100Base-FX<br>Cable de fibra óptica POF (Polymer Optical Fiber)<br>980/1000 µm (sección del núcleo/sección externa)<br>ISO/IEC 60793-2 | 100 Mbits/s / dúplex | 50 m | Uso con grandes diferencias de potencial<br>Insensible a la radiación electromagnética<br>Baja atenuación del cable<br>Posibilidad de segmentos considerablemente más largos |
| | | Fibra óptica recubierta de plástico (Polymer Cladded Fiber, PCF)<br>200/230 µm (sección del núcleo/sección externa)<br>ISO/IEC 60793-2 | 100 Mbits/s / dúplex | 100 m | |
| | BFOC (Bayonet Fiber Optic Connector) y SC (Subscriber Connector)<br>ISO/IEC 60874 | Cable de fibra óptica – fibra monomodal<br>10/125 µm (sección del núcleo/sección externa)<br>ISO/IEC 60793-2 | 100 Mbits/s / dúplex | 26 km | |
| | | Cable de fibra óptica – fibra multimodal<br>50/125 µm y 62,5/125 µm (diámetro de núcleo/diámetro exterior)<br>ISO/IEC 9314-4 | 100 Mbits/s / dúplex | 3000 m | |
| **Ondas de radio** | - | IEEE 802.11 x | Dependiendo de la ampliación utilizada (a / g / h / etc.) | 100 m | Mayor movilidad<br>Interconexión económica con estaciones lejanas y difícilmente accesibles |

*Figure 12: PROFINET characteristics simatic user manual "profinet overview"*

The main PROFINET connection is made through an Ethernet cable between the 6 PLCs

## CONCLUSIONS

* The SCADA system allows supervision of several processes but in some cases this supervision is limited, this is evidenced in the HMI as it only allows monitoring and acquiring data from 4 devices at a time.

* For position control, a speed was applied for a certain time to reach the desired position in the desired time, this is done in this way because it is more complex for the program to calculate the angular distance and it is more expensive for companies buy position sensors, and with a perfect characterization the speed control works properly.

References

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