Sensor Monitoring in an Industrial Network
Experimental Tests for Computer Supported Education

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Abstract: The integration of field level and higher communication is expanding and ensuring ideal conditions for open networks in process automation at industry. For a better knowledge on the referred networks, some experiments were developed to ensure a better comprehension on how they work and application possibilities. The experimental tests with industrial network using a PLC (Programmable Logic Controller) based computer education, allows the electrical engineering students perform experiments on-line by a remote laboratory for the study of industrial automation process.

1 INTRODUCTION

Nowadays with the development of information technology, communication between devices and the use of standardized mechanisms, open and transparent have become key concepts in automation technology, especially in today's industrial environment. The integration of field level and higher communication is expanding and ensuring ideal conditions for open networks in process automation at industry, as it happens with the combination of AS-Interface and PROFIBUS (PROFIBUS Association, 2006).

For a better knowledge on the referred networks, some experiments were developed to ensure a better comprehension on how they work and application possibilities. For the experiments, were analyzed the behavior of sensor networks with AS-I, the devices were linked by the PROFIBUS network and controlled by the PLC S7-300 from Siemens. The whole system was configured by the STEP7 software from Siemens as well. A teaching supervisory platform was implemented in the software LabVIEW, and it provided students an online system monitoring.

2 INDUSTRIAL NETWORKS

In Figure 1 is presented the system in study, illustrating the devices and networks linking them. For a better comprehension of the networks, their operation is explained in this section.

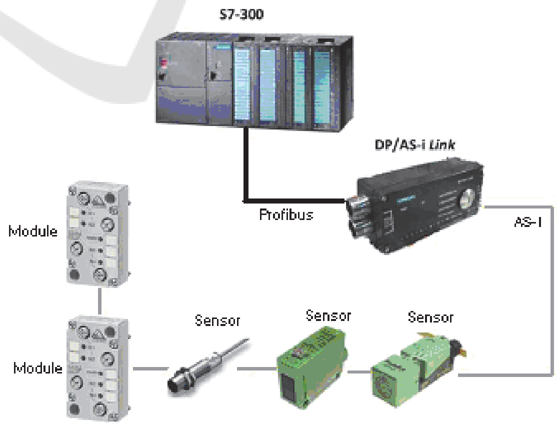

Figure 1: Simple diagram scheme of the system in study.

2.1 Profibus

PROFIBUS, an acronym for Process Field Bus, is an open industrial communication network, used mainly to make the connection of digital controllers with sensors/actuators (the field level to cell level) for both high-speed data transmission and special communication services. By being an open pattern, its independence of the manufacturer and of specification is guaranteed by norms EN50170 and EN50254. Therefore, devices from different manufacturers can communicate without any adjustment in their respective interfaces. Figure 2

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presents a diagram with the PROFIBUS application areas, emphasizing the communication profile, the application used and the standard cycle time for each level.

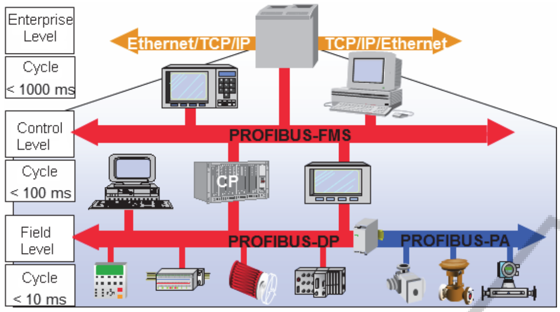

Figure 2: Diagram showing application areas of PROFIBUS.

The PROFIBUS-DP (Decentralized Periphery) is an optimized variation with high-speed connection and low cost. Suitable for the factory floor, where there is a large volume of information and the necessity of high speed communication to events is quickly treated (PROFIBUS Association, 2006). It uses a transmission technology RS-485 or optic fiber, making transmissions at rates from 9.6 kbit/s to 12 Mbit/s.

2.2 AS-I

AS-I, an acronym for Actuator Sensor Interface, is a standardized network system (EN 50295) for industrial communication and open to the lowest level of automation and came to meet certain requirements defined from the experience of members founders and to supply the market which hierarchical level is the bit-oriented (Siemens, 2010). The AS-I was designed to complement the others systems and make it easier and faster connections between sensors and actuators with their respective controllers (Siemens, 2008).

The AS-I is a master-slave type network with cyclic data capture. It has a master device, capable of controlling the entire network, reading by cycle all other integrated devices to it, called slaves. The AS-I master performs various tasks such as network boot, identification and diagnosis of the slaves and transferred data analysis (Lian, 2003). Also, usually communicates with a controller (PLC or PC) to receive control configuration of AS-I, report errors, to address new slaves, among other tasks (Becker, 2002).

Slaves are passive devices, so they may have access to the network when the master makes a request and data transfer from slave to slave is only possible through the master. Slaves can be connected to four sensors or actuators, which have their values read/written cyclically by the master. There are intelligent sensors that have an AS-I chip integrated, allowing direct coupling to the cable. There are also slaves who work with analog values, but these need four cycles of the network so that a read/write is complete (Siemens, 2008).

For proper exchange of information between the master and slave, the slaves receive a unique address that will identify them (Lian, 2003).

2.3 DP/AS-I Link

The DP/AS-I Link creates an interface between AS-I and PROFIBUS-DP networks. It operates as a common DP slave and as the master of AS-I network. Like others DP slaves, requires a DP master. It has its principle of operation similar to any other gateway device, where the protocols of the systems in question are converted (Siemens, 2000). The DP/AS-I Link is used to perform the exchange of the sensors and actuators of AS-I network to the PROFIBUS-DP network (Siemens, 1995). At the system analyzed on the experiment, it is used the DP/AS-I Link from Siemens and its image is visualized in Figure 3.

Figure 3: Image of the DP/AS-I Link from Siemens.

3 EXPERIMENTAL PLATAFORM

The devices connected by the system networks are presented in this section. Their data acquisition procedure is explained as well as their functionality in the experimental platform.

3.1 PLC S7-300

The Programmable Logic Controller (PLC) S7-300 is a modular system used in centralized or distributed applications. Its modular nature allows a quick and easy expansion, with the possibility of adding 32 modules of various types, divided into I/O modules, communication modules and function modules.

A control system based on a S7-300 is basically composed by the expansion modules, power supply and CPU. The CPU is accessed by a Multi Point Interface (MPI) port, which does the whole setup and configuration. In addition, some CPUs have a second communication interface, as PROFIBUS-DP or serial point-to-point (Siemens, 1998).

3.2 Sensors and Modules

The sensors that were used in the experiment were inductive and photoelectric.

The photoelectric sensor has a transmitter circuit responsible for the emission of a light beam and an infrared receiver circuit responsible for receiving the beam. Light can be reflected or interrupted by an object, detecting it and triggering the sensor.

At the system analyzed, it is used one of VF AS-I OS1K-VF-AS-I series, from Sense, that can be seen in Figure 4.

Figure 4: Image of the photoelectric sensor VF AS-I from Sense.

The inductive proximity sensor is an electronic device that detects the approach of metal parts. The electromagnetic field generated by a high-frequency resonant coil installed on the sensing face, suffers interference when a metal part approaches, and the signal variation is compared to a standard signal, enabling the output stage.

Two inductive sensors were used, a Pentakon PS15 + UI + AS-I series from Sense, illustrated in Figure 5, and a Bero 3RG4613-3WS00 series from Siemens illustrated in Figure 6.

Two modules make part of the system, an AS-I connector module with four outputs, identified by M12 4AR 3RG9001-0AB00, and an AS-I connector module with two inputs and two outputs, identified by M12 2E/2AR 3RG9001-0AC00.

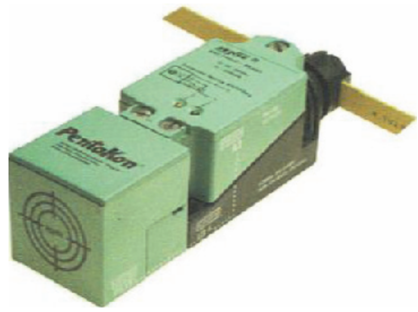

Figure 5: Image of the inductive sensor Pentakon PS15 + UI + AS-I VF AS-I from Sense.

Figure 6: Image of the inductive sensor Bero 3RG4613-3WS00 series from Siemens.

4 EXPERIMENTAL RESULTS

By the use of the growing and useful computational tools to increase the method of learning, students are experiencing a better integration with the real platforms. In the developed experiment, some procedures had been done to reach the desired results for analysis and a successful comprehension. The steps taken and the results are presented in this section.

4.1 Experiments

For a better comprehension of the devices and networks presented, experiments were made with some theory explanation and a step guide in order to monitor the sensors attached to the network and to analyze the Ladder language program configured in the PLC by the STEP 7 software, which is developed by Siemens.

Using the resources of STEP 7 software, it was possible to see how the network was configured as well as the devices, sensors and modules were configured and addressed on the network.

A network scheme with the addressed elements linked to MPI and PROFIBUS, could be seen on the NetPro as it appears in the Figure 7.

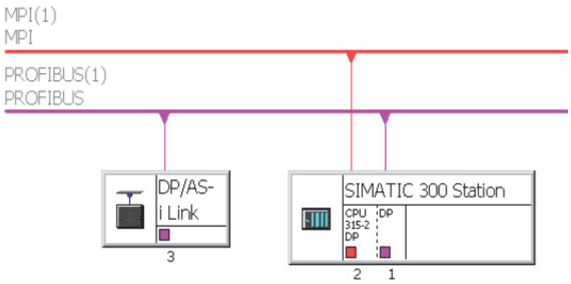

Figure 7: Representation of connections on NetPro.

On HW Config, a list of the hardware components could be seen with their configuration at the station and the respective input (I) and output (Q) address. The image of the hardware address organization can be seen in Figure 8.

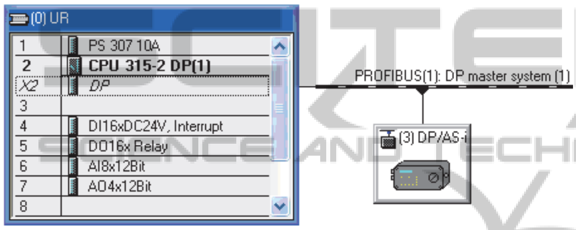

Figure 8: Representation of hardware list on HW Config.

The monitoring is used to identify the condition of the variables when the device changes of state, and these states help to understand the logic of control elaborated in the Ladder code. The configured code in the PLC is seen in LAD/STL/FBD Program blocks, where the online monitoring is also possible, and allows the user to know which inputs and outputs are activated when the sensors and modules work, as well as the blocks data.

The Ladder is a simple programming language based on blocks. The inputs and outputs of the sensors are referenced as they are configured. The code is divided in networks to simplify the understanding. This implementation eliminates the necessity of adding new electronic devices to the hardware.

After the configuration of the system in the STEP 7, a human/machine interface was implemented by the software of National Instruments: LabVIEW, so that it simulates an industrial environment via the sensors connected to a hybrid industrial network, originated from the ASI and PROFIBUS-DP's networks and using the PLC, with STEP 7 software.

OPC (OLE for process control) is a standard interface between numerous data sources and sensors on a factory floor to HMI/SCADA applications, application tools, and databases. The OPC Foundation defines the standards that allow any client to access any OPC-compatible device. The OPC Specification was based on the OLE, COM, and DCOM technologies developed by Microsoft for the Microsoft Windows operating system family. The specification defined a standard set of objects, interfaces and methods for use in process control and manufacturing automation applications to facilitate interoperability (Halvorsen, 2012).

In virtue of a network using the OPC server, the LabVIEW communicates with the PLC. In order to connect the LabVIEW with the OPC tags, it's created an I/O Server, which automatically updates the LabVIEW with the tag's values in a specific rate. It's required to create shared variables that are similar to OPC tags and obtain native access in the LabVIEW to PLC data.

LabVIEW is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". The execution is determined by the structure of a graphical block diagram on which the programmer connects different function-nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector panel (Halvorsen, 2012).

LabVIEW Remote Panels turns the application into a remote laboratory, where the created HMI with the purpose of manage and evaluate the industrial plant is fully accessible by the remote user. The interface designed with LabVIEW and used in a web browser is presented in Figure 9.

4.1.1 Pentakon Inductive Sensor Monitoring

To check the variable values in Pentakon inductive sensor, a piece of metal was passed in front of it and the LED associated with this sensor is activate and metal parts counter is incremented in the interface implemented in LabVIEW. The code in language G can be seen in Figure 10.

4.1.2 Photoelectric Sensor Monitoring

With the photoelectric sensor, any object could be used to test its operation, passing it front and ensuring no interference from others. On the HMI built in LabVIEW, the LED associated with this sensor is activated and total parts counter is incre-

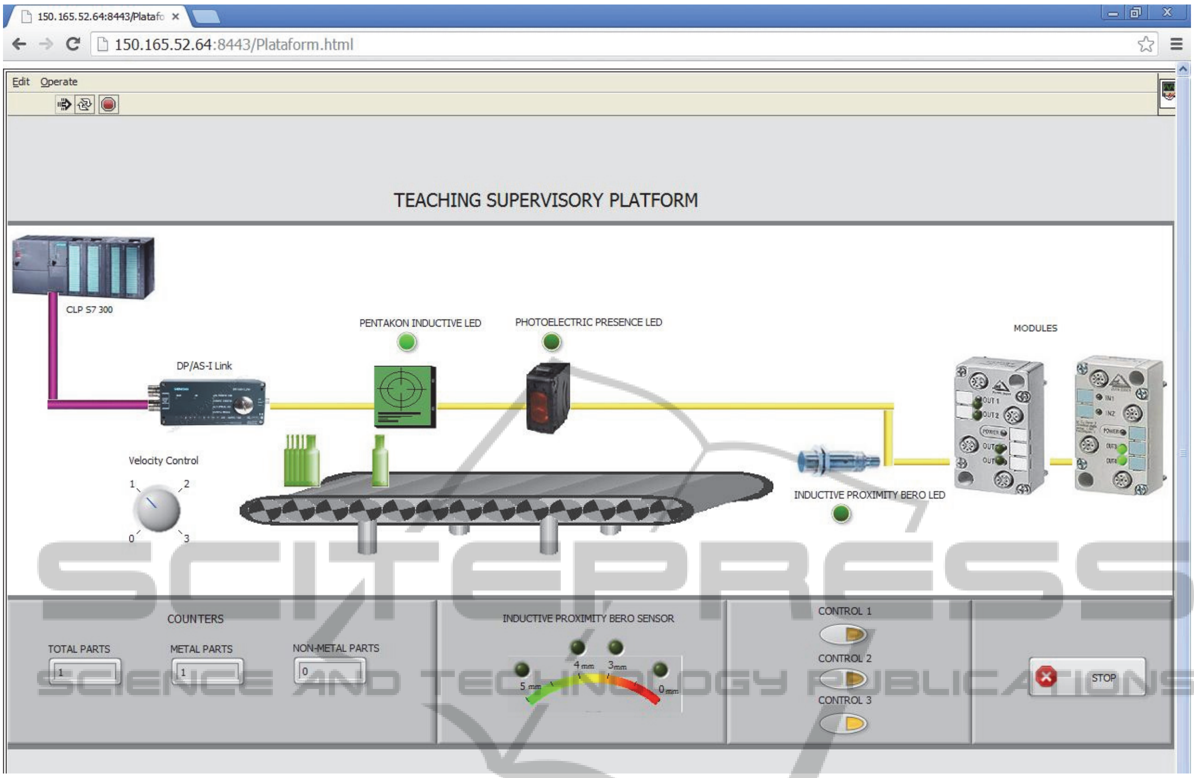

Figure 9: Online monitoring interface.

mented. Figure 11 illustrates it as implemented in the program.

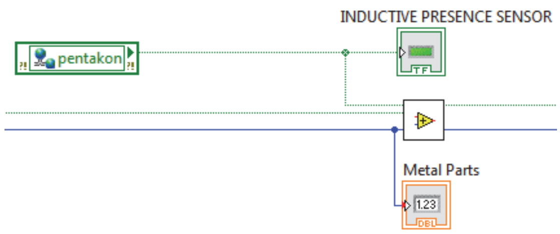

Figure 10: Code of the increment of metal parts counter.

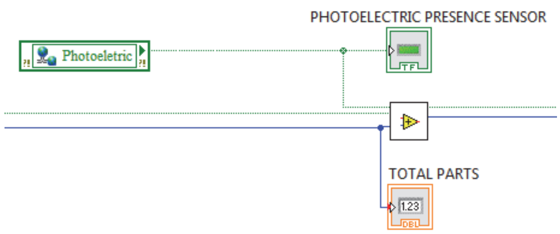

Figure 11: Code used for the increment of the total parts counter.

4.1.3 Bero Inductive Sensor Monitoring

The operation of the inductive Bero sensor could be seen approaching a metal part gradually. According to the proximity of which a metal object is the sensor will generate combinations of bits "1" and "0" which will enable different outputs of the PLC according to the object proximity.

The inductive Bero sensor is the end of the conveyor belt and is monitored by the LED panel located at the bottom center of the VI, indicating the proximity of a metallic object of this sensor, progressively completing the lights of LEDs as the object approaches going Green (5mm) through to yellow (4mm) and orange (3mm), to red when the contact part with the sensor occurs.

4.1.4 Remote Laboratory

A remote laboratory is defined as a computer-controlled laboratory that can be accessed and controlled externally over some communication medium (National, 2006). In this paper, a remote laboratory is an experiment, demonstration, or process running locally on a LabVIEW platform but with the ability to be monitored and controlled over the Internet from within a Web browser using the interface in Figure 9.

The acquisition is still occurring on the host computer however the remote user has the total control. Other users can report their Web browser to the same URL to monitor the application in progress but only one client can control the application at a time. At any time during this process, the operator of the host machine can assume control of the application back from the client currently in control functionality.

5 CONCLUSIONS

In this paper are presented the advisability of using technology tools for auxiliary the process of distance learning, for example, a hypertext which simulates (emulates) a virtual laboratory for realization of on-line experiments.

The discussed experiments attempted to report to the students the concepts involved in this paper using the computer as a main tool for performing and analyzing experiments.

The innovative use of technology applied to education, and more specifically, the distance education, must be supported by a philosophy of learning which provides the students the opportunity to interact, to develop joint projects, to recognize and respect different cultures and to build knowledge.

By the use of the LabVIEW software, students could follow the progress of sensor's activity as well as the network communication process. The code used the processed data to build control logic to perform varied tasks and analysis. This showed how suitable is the system with different applications and approached the student to the real industrial automation process.

Also, the flexibility of iteration between students and teacher provided by technology tools establishes a new dynamic of teaching. The students can better organize your questions and subjects under study and they have the initiative to find their answers.

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REFERENCES

Becker, R.; Müller, B.; Schiff, A.; Schinke, T.; and Walker, H., 2002. *AS-Interface - The Automation Solution*. AS-International Association, Germany.

Halvorsen, P. H. 2012. *OPC and Real-Time Systems in LabVIEW.*

Lian, S.C.P. 2003. *AS-i Master Bus Controller*. Thesis submitted to the School of Information Technology and Electrical Engineering, The University of Queensland, June.

National Instruments, 2006. "Distance-Learning Remote Laboratories using LabVIEW"; available from < http://www.ni.com/white-paper/3301/en/> accessed December, 2013.

PROFIBUS Association, 2006. *Profibus – Technical Desciption.*

Siemens, 1995. *Distributed I/O System DP/AS-I Link*. Manual. 3rd edition.

Siemens, 1998. Manual. *S7-300 Programmable Controller Hardware and Installation*. 2nd edition.

Siemens, 2000. Manual. *SIMATIC NET PROFIBUS Networks*.

Siemens, 2008. System Manual. *AS-Interface/AS-Isafe*.

Siemens, 2010. Reference Manual. *AS-Interface - IO Link - Profibus*. Industrial Controls.