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# Siemens Profinet IO System for Academic Purposes

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***Abstract*— Profinet is the communication standard for automation .It was developed by Siemens to cover all the limitation of Profibus especially when it comes to speed and precision required by motion control applications. In fact, profinet is seen as an extra development of Profibus. Nowadays, Profinet is becoming the leading networking solution that offers high speed data transmission and easy connection with various plant devices.**

**This paper aims to provide a brief study on profinet IO system as the study is to be undertaken for the first time for engineering students at Murdoch University. The paper summaries the works that were completed as part of the aim to design and implement a fully operational profinet IO system for teaching purposes. The results of this study then will be the basic for future students to develop more complex networks in the Industrial Computer Systems Engineering Facility.**

***Index Terms*— Siemens Profinet, Profinet IO, Programmer logic controller (PLC), TCP/IP Protocol, Totally Integrated Automation (TIA) portal , PID controller, TIA portal** .

## I. INTRODUCTION

In 1980, the American organization IEEE (Institute of Electrical and Electronics Engineers) designed the first standard for the LAN (Local Area Network) communication, which is known as Ethernet. At that time, the speed of transmission rate was set down at 10 Mbps Megabit per second[1]. Nowadays, Ethernet has become very popular due to its simple structure and implementation. In fact, Most of the Internet communications relies on the Ethernet standard that was introduced by IEEE 802.3. Typically, Ethernet connects PCs together with printers and servers of the local network to the Internet [2] .

Engineers wondered if they can transfer the technology used in the office Ethernet to the plant side. However, Ethernet had some limitation when it comes to the industrial automation. Until recently, Ethernet switches and routers were not sophisticated enough to sustain the rough environment in plants. These limitations prevented the wide acceptance of Ethernet on the factory floor. Now Ethernet has been developed to be much stronger and faster so it can be used in industrial applications[2] .

PI (PROFIBUS & PROFINET International) was the first organization who developed the first industrial Ethernet and its application for distributed automation. Profinet or the industrial Ethernet uses standards Ethernet hardware and software to build a network that structures the task of configuring, accessing and controlling industrial automation devices[2] .

Like Ethernet, Profinet uses a series of communication protocols such as IP (Internet Protocol); TCP, (Transport Control Protocol); and many other protocols for exchanging data[3]. However, Instead of accessing files and printers using rational Ethernet, Profinet provides an easy way for controllers to access data embedded in drive systems, I/O devices and operator workstations[2] .

Since Profinet system is still a new package at Murdoch University and there is no enough information conducted ,the major aim of this study is to have a fully operational Profinet IO network. Particularly, this study focuses on the Profinet network implementation, testing and software design. To achieve this aim ,a small profinet network will be designed. From this design, the capabilities of the system will be then tested on a testing panel. Upon completion this testing; a number of manuals will be created in order to provide an easy description of Profinet for future students.

In Section II, a design of profinet IO network is given . In Section III, several testing examples are presented. Finally, the conclusion is in section IV.

## II. PROFINET IO NETWORK DESIGN

The main object of this section is to build a small profinet IO network which can be the basics for students to create bigger networks in the future [4]. To do so, it was decided that the first step is to establish a simple profinet communications between Computer and PLC. Then extend this network and add HMI. The last step was to create a star topology consists of PLC,HMI and remote IO and connect them into one network.

### *A. Project Requirements*

This section describes the various hardware and software requirements required to design a star topology.

- IO Controller( S7-1200)
- ET 200s distributed IO Device,
- Compact switch,

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- Intel(r) pro/1000 GT desktop adapte
- SIM 1274 Input Simulator
- Profinet cable
- Power supply(24 VDC)
- Human Machine Interface (HMI).
- Programming device with TIA portal v11

### *B. TIA portal overview*

Totally Integrated Automation (TIA) is the software part of this research .It is a programming tool that allows operators to program the S7-1200, HMI and other devices in order to develop, edit, and monitor the logic required to control a process applications .Various SIMATIC products are integrated in the Totally Integrated Automation Portal (TIA portal) in order to produce one comprehensive framework where productivity and efficiency are increased [5]. These software products include STEP 7 professional, WinCC Basic, and WinCC Advanced which can be operated together within the TIA portal and support all application required for automation solution. The following figure illustrates a typical automation solution which includes the TIA portal, PLC, and IO devices.

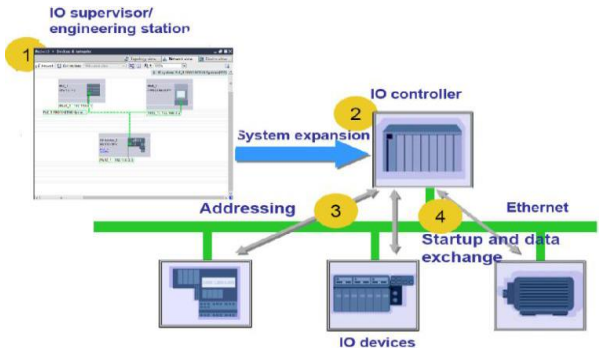


Figure. 1 Automation solution using TIA portal[5].

As illustrated in figure.1, the code and configuration are created using TIA portal then transported through a profinet wire to the IO comptroller where the program is being executed .Based on the required task the controller can then communicate with the I/O Devices.

### *C. Building Small profinet network*

This small network is considered to be a star network which includes of all profinet equipment which has been purchased by the university except Scalance X208. Figure.2 Shows the block diagram of a small profinet network which comprises of a computer with interface profinet card ,PLC,ET200S (remote I/O) ,HMI, and a compact switch connecting together through profinet cable[4] .

For this network, four profinet cables are utilized to connect all components together through theCSM-1277 profinet switch. This switch has four profinet ports. One port is already utilized by the computer. The second port is used to connect the S7-1200 to the computer so it can communicate to the computer .The third and fourth ports are connected to the HMI device and the distributed I/O respectively.

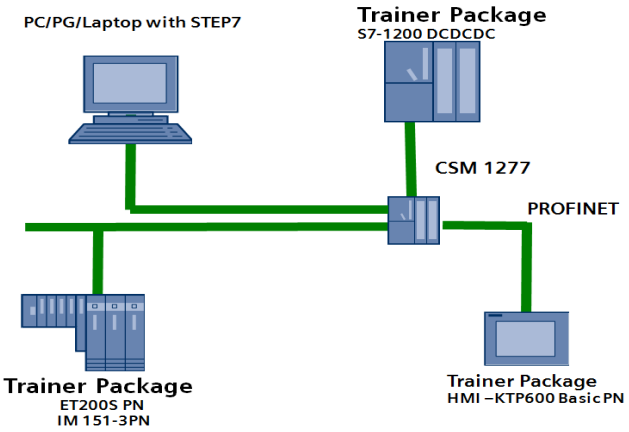


Figure 2:Block diagram of a star profinet network[5].

### *D. Hardware configuration*

To be able to run the above network, several hardware configurations had to be done using TIA portal . Once the proper PLC was selected from the hardware catalog which in this case would be the S7-1200C DCDCDC, a project was created within TIA portal. It was decided that to keep the IP address and the subset Mask for the S7-1200 as default: 192.168.0.1, 255:255:255:0 respectively. This was done in the hardware configuration window inside TIA portal .

The IP address of interface cared was set up to 192.168.0.255.Therefor, in the future; all the profinet devices that need to be connected in the same network must be less than 255.

The number of network devices that can be connected to an IP address represented by the subnet mask.
In the same project which was created earlier for the PLC connection, HMI and ET 200S were added and connected to the existing network as depicted in figure.3. For the Profinet network, the IPaddresses of each device were assigned according to their default addresses. Student may change the IP addresses and set up new ones. The device types and IP addresses have been numbered as per Table 1 below.

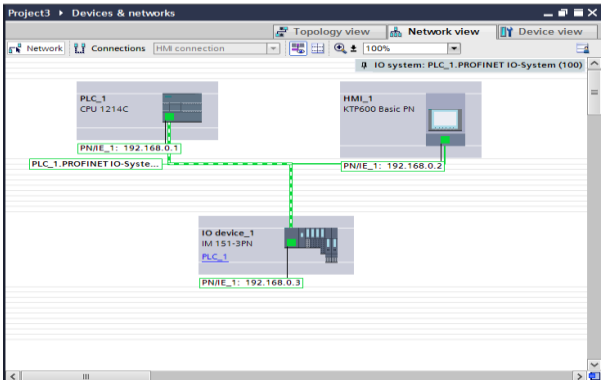


Figure. 3 Network view of the small network

Table 1: Profinet network addressing

| Device Name | IP address |
|---|---|
| **Personal Computer (PC)** | 192.168.0.255 |
| **Programmable Logic Controller (PLC)** | 192.168.0.1 |
| **Human Machine Interface (HMI)** | 192.168.0.2 |
| **ET200S** | 192.168.0.3 |

After the devices were configured, the system would displayed each IP address and device name of each device as they previously assigned .This can be seen in Figure 3.The S7-1200 was then coded in order to read and write to/from the ETS200s information such as, On/Off commands and the LEDS status.

## III. PROJECT TESTING

Through TIA portal, several testing examples were conducted in order to operate the profinet package by developing a programming code in ladder diagram. The code aims to run the S7-1200 PLC,HMI,and ET200s individually and as a network. Based on the network designed earlier, profinet data Exchange Examples were implemented on a testing platform.

### *A. Testing panel*

In this study, a testing panel as indicated in Figure. 4 was designed for education purposes. This testing panel not only developed for profinet data exchange examples but it also provided a functional station where new devices could be tested on it. The panel contains an S7-1200 controller with simulator switches attached to a DIN rail .At the same rail on the left, there is a profinet compact switch(CSM1277) used as connection point .Both are powered with 24 D DC power supply as shown in figure. 4. On the left, a HMI device was installed using 4screws at the back of the panel. The distributed system appears on the right top of the panel where several digital inputs outputs could be attached to it. The Scalance was installed on the top of panel but not used so far[4].

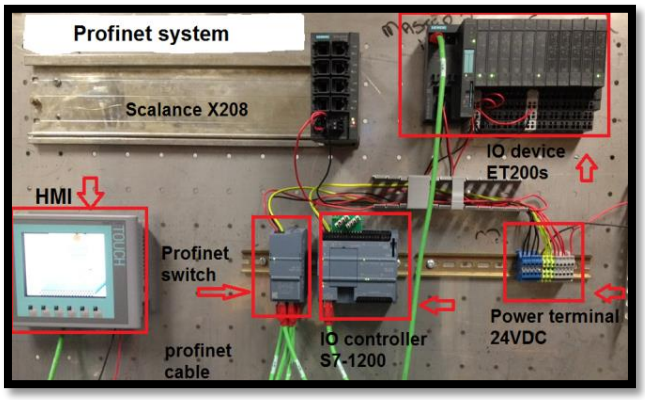


Figure. 4 Testing platform

AS illustrated in the figure, the CSM 1277switch works as collection point between the computer and the other profinet devices. This switch operates as a distribution device .It receives the signal from the programming device and distributes it based on the IP address of each signal.
To run the package, several programs in ladder diagram were developed with TIA portal .Based on these programs, the S7controller changed the output based upon the states of the inputs. The HMI operated as a secondary controller where it can perform some basic control function such as switching alight.

### *B. Profinet Data Exchange Example 1*

The first experiment conducted was to test the performance of the S7-1200 by developing a simple code in ladder diagram such as switching a light or flashing sequence. As shown in figure.5 , 8 switches connected on the top of the S7 controller used as digital inputs to change the state of outputs which are the LEDs according to the exited program. In this experiment, the first switch was linked to the first digital input contact I0.0 while the LED connected to output Q0.8.

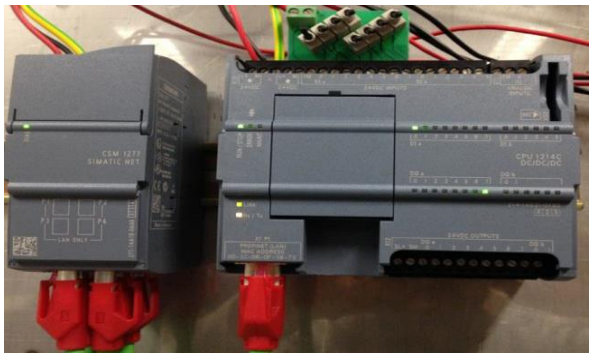

Figure. 5 Testing example for the S7-1200

Upon completion of this example, students will be able to create more complex tasks using the S7-1200 controller such as using timers, counters, Interrupters and so on.

### *C. Profinet Data Exchange Example2*

This example tends to explore the HMI device capabilities as one component of the profinet IO system. To verify the operational of the HMI device as per the design, it was decided to simulate a process so students can investigate how the HMI would operate. Students can use WinCC Basic in the TIA portal to create screens for operating and monitoring machines and Plants. The WinCC Basic within the TIA portal provides several predefined objects to help students create their screens such as simulating a machine, displaying processes and defining process values.
In this example, It was decided to simulate a pasteurization process in which a bottle of milk heated by heating chamber and moves from left to right across the conveyor. This movement based on the state of a switch which connected to internal HMI tags to animate the objects. The process is simulated as shown in Figure. 5.

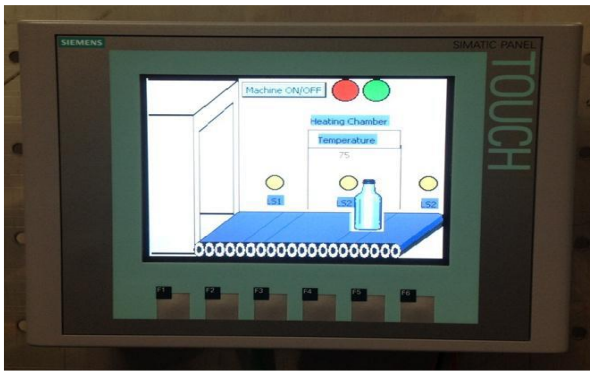

Figure. 5 HMI testing example

*D. Profinet Example3 "PID controller"*

The use of PID controller is very significant especially when it comes to industrial automation .This example provides an overview of the operational of PID controller within the TIA portal. The TIA portal contains a PID block which is the image of the real PID controller in the software where it can be programmed and configured inside a cyclicinterrupt OB35. The PID controller is used to reach desire physical values such as temperature, pressure or speed as fast as possible to keep a set point at certain value.

In this example, a temperature controller was designed in order to control a heating chamber used to heat the bottle of milk which was explained in the previous example. To simulate this process, a process simulation blocks "PROC_C" was uploaded to the TIA portal library so it can be used as a real time simulation without the need to of additional hardware. See fig. 6.The output of process block, which is the actual temperature of the heating charmer, is used as input of the PID block and the output of the PID is linked to the process block as an input. The desire temperature was determined as 75°C and the PID controller was required to maintain this value.

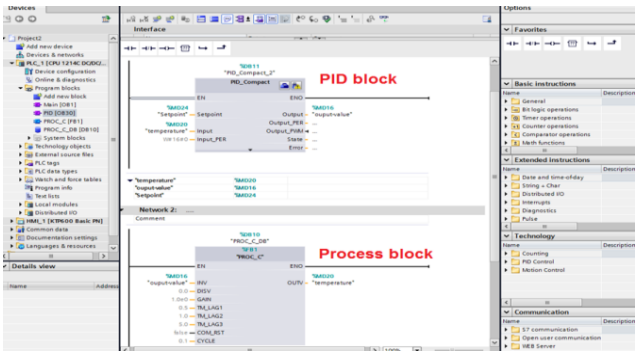

Figure 6: PID controller and simulating process blocks in TIA portal

In addition to the process simulation capabilities, The TIA portal is supported with a real time trending where all controller parameters can be displayed on it. This can be done by activating the PID controller in online mode. Figure.7 shows the control results of a PID controller which was designed to maintain the temperature at75°C in the trend window after tuning.

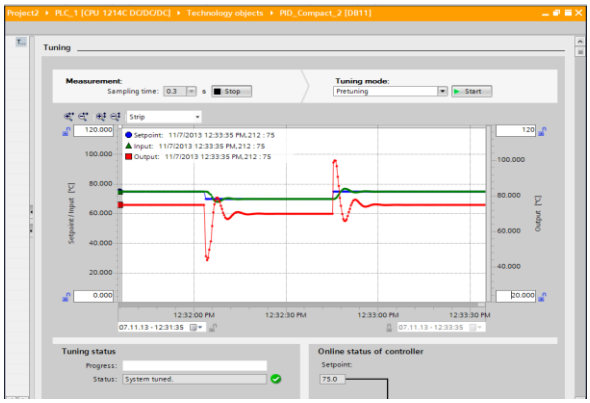

Figure. 7 Real time trending window

Upon completion of this example students will be able to create more complex HMI examples using TIA portal.

## IV. CONCLUSION

Profinet is defined as an industrial Ethernet standard for automation .It differentiates from Profibus by the high speed data transmission ,which can reach up to 100Mbps.

Furthermore, Profinet offer a big advantage for engineers in which profinet have a continuous communication system from the office side to automation side .In contract with Ethernet, Profinet devices are designed to be adopted in the automation area where the environment conditions for the devices are extreme dust, temperature, etc.

This paper has only reviewed the important aspects of Profinet and its implementation and application .A profinet IO network was built , implemented and tested on a testing panel. This panel was designed for education purposes to provide an easy understating on the operation of each profinet device. Various types of data exchange examples are created based on the designed networks to demonstrate the capabilities of Profinet system.

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