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Remote control of PLC regulation system by IoT device design

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***Abstract* — The aim of this paper is to describe PLC Regulation system and possibilities of his remote monitoring and control. This proposal is based on an increasingly prevalent concept of IoT (Internet of Things) devices. IoT is no longer used in domestic automation, which is known well from the smart buildings, but more and more applications we can find in thesedays in industry as well. The application of the IoT concept in industry is known as IIoT (Industry Internet of Things). This implementation and constantly advancing technological development, creates space for new, accessible and efficient ways of regulate industrial processes.**

Keywords* — *automatization, industry, IoT, PLC

I. Introduction

Currently, we standing at the threshold of the Fourth Industrial Revolution called Industry 4.0.This revolution will completely change the current industry and calculates that industrial companies will soon cease to exist in the form we know them today [1]. Basic component of Industry 4.0 is IoT. The application of the IoT concept in industry is referred as Industry Internet of Things (IIoT). IIoT will allow get large amounts of data from industrial processes. These data will be obtained from the sensors and then shared with other control devices and computers. Analysis of the data obtained will enable industrial enterprises to optimize and make more efficient production [2]. IIoT will transform industrial enterprise into the big network, where all of his components will be connected to internet and will communicate with each other.

II. PLC REGULATION SYSTEM

At present, the regulation of industrial processes is largely based on its element –PLC. The PLC can be defined as a numerically controlled electronic system designed for industry and automation. The basic principle of PLC operation is as follows: The PLC receives data from his sensors and then according program stored inside him switch outputs. Inputs are usually sensors and outputs are most often different types of actuators. An important feature of PLC is the fact, that they perform program cyclically. This is a feature that distinguishes them from classical computers. The big advantage of the PLC is the principle of how it works. This system prevents malfunctions and also prevents the not defined states. In PLC controlled systems, the source of the problem is also quickly determined, which makes the repair possible faster [4].

A. PLC Regulation system

Department of Theoretical and Industrial Electrical Engineering own a control system controlled by the PLC. However, the system is a model that can also be applied in industry. This system consists of the Simatic S7 300 station, the four Sinamics S110 frequency inverters and two pairs of asynchronous and synchronous motors.

Simatic S7 300 – One of the most used stations in industry. The main role of station in the described system is to ensure the regulation of the whole system. The station is connected to the frequency inverters via the PROFIBUS bus. Communication processor CP 324–5 takes care of communication via this bus. In case of using Ethernet, the CP 343–1 Lean provides communication. Simatic S7 300 can be powered in two ways. The first method is with an alternating voltage of 120/230 V and the second one with a DC voltage of 24V [5]. The program can be uploaded into the S7–300 station via a computer with Simatic Manager software. This computer is usually referred to as PG (Programming Device). Protocols MPI or TCP/IP are usually used for the mutual communication between PG and PLC.

Sinamics S110 – These frequency inverters are just like the S7–300 from Siemens, which guarantees high compatibility. The main task of these inverters is the efficient and safe regulation of the motors. The regulation is performed according of the instruction received from station S7–300. The inverters monitor speed, motor temperature, torque or absolute current. AS interface provides communication between inverters and motors. The inverters can be powered with alternating voltage, either single phase or three phase. For single phase power supply the power range is 120 to 750W [6].

Motors – Motors are generally used to convert energy – electric to mechanical. There are two pairs of motors in the described system. One pair of motors are asynchronous motors and another pair are synchronous. Because of simple operation asynchronous motors are mainly used in industry. Synchronous motors are specific in that they work without the slip and therefore they find usage in application where are increased demands for precision or constant speed. The whole described system illustrates **Chyba! Nenašiel sa žiaden zdroj odkazov.**.

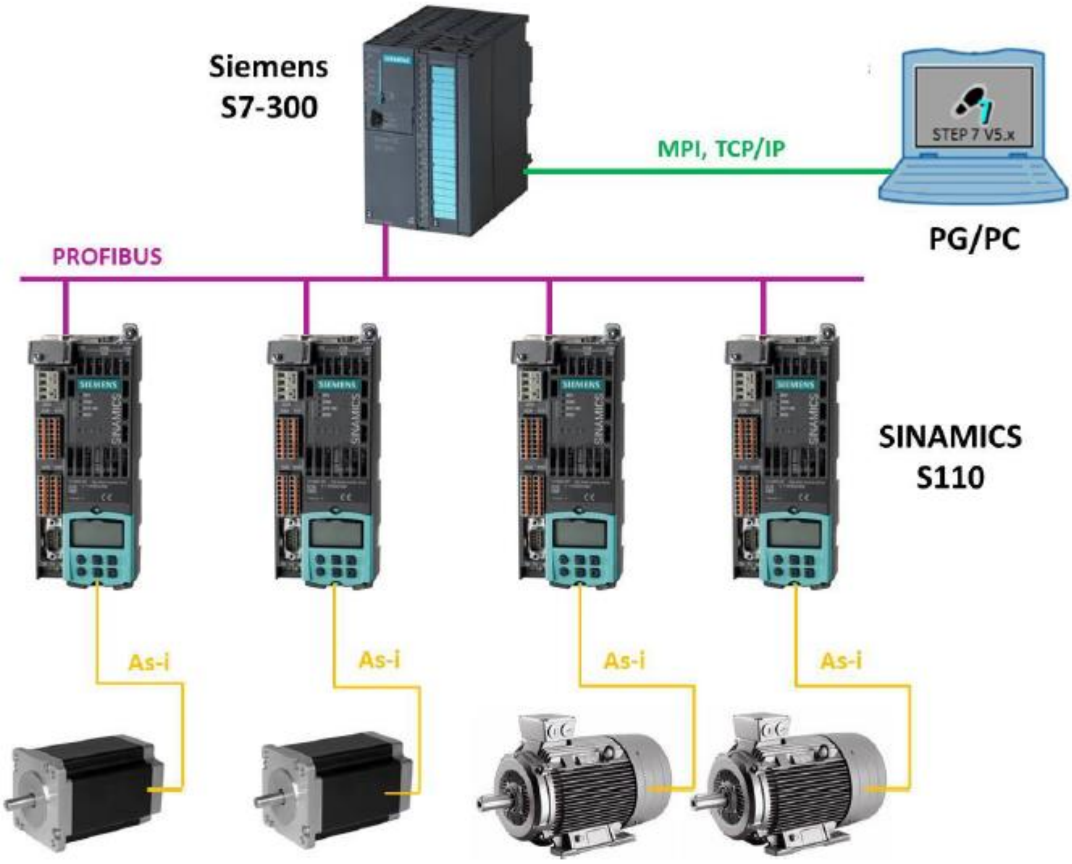

Fig. 1 PLC Regulation system

B. *The principle of system control*

As mentioned, the whole system controls the S7–300 station. Inside station is a program to control the entire system. This program generally contains different blocks. Blocks that care for regulation are called organizational blocks (OB). Separately functional parts of the organizational blocks create various functions (FC) and functional blocks (FB). Some blocks serve for storing data. Such blocks are called data blocks (DB). In the described system, in these blocks are stored data from individual motors at their own addresses. Totally, the program contains two DB marked as DB1 and DB2. The most important monitored data from motors and their addresses are tabulated in Table 1.

Tab. I Monitored addresses

	Asynchronous		Synchronous	
Monitored data	**Address Motor 1**	**Address Motor 2**	**Address Motor 3**	**Address Motor 4**
Actual speed	DB1.DBW 2	DB1.DBW 14	DB1.DBW 26	DB1.DBW 38
Motor temperature	DB1.DBW 4	DB1.DBW 16	DB1.DBW 28	DB1.DBW 40
Absolute current	DB1.DBW 6	DB1.DBW 18	DB1.DBW 30	DB1.DBW 42
Torque	DB1.DBW 8	DB1.DBW 20	DB1.DBW 32	DB1.DBW 44
State	DB2.DBX 1.0	DB2.DBX 5.0	DB2.DBX 9.0	DB2.DBX 13.0
Set speed	DB2.DBW 2	DB2.DBW 6	DB2.DBW 10	DB2.DBW 14

III. ANALYSIS OF USER REQUIREMENTS

This part of the work is aimed to determining user requirements for the regulatory system. The proposed system should be suitable for industrial application.

Control options – It is appropriate for the proposed system to be controllable not only one way. For instance, locally (via buttons and display) or remotely (using another device). It would be also desirable for the proposed system, have ability to regulate all four motors that the system contains.

Compact – It is good to ensure that the whole system will have a suitable shape. The hardware part of the system should not occupy so much space and should be suitable for industrial applications.

Compatibility – All components of the proposed system must be compatible to ensure trouble–free communication. These components should support the same communication protocols.

Simplicity and clarity – Processed and monitored data should be displayed appropriately. Therefore screen should have a suitable concept with data appropriately sorted into groups, for instance by motor number. On most important information (speed, torque, temperature and current) should be given the greatest emphasis.

Robustness of the system – The main program should be suitably adjusted to avoid frequent failures or other not defined conditions.

Security – It would be appropriate to prevent access to unauthorized users. Moreover, proposed system should have feature to turn off the entire system at any time, for instance in case of very high values some of the monitored quantities.

IV. SYSTEM PROPOSAL

Once the system requirements have been collected, it's possible start with system proposal. System proposal calculates that the whole system will be controlled in two ways. First way of controlling is via webserver, so it means remote control. Second way of controlling is local. Like form of interface was chosen touch display. This display will be directly connected to microcontroller. This part of the system control will be one piece, made on circuit board. The proposed system can be divided into hardware and software part.

A. Hardware part

Microcontroller – The most important HW part is of course a microcontroller. The big advantage of ESP microcontrollers is their "all in one" feature – they combine microcontroller functions with integrated Wi–Fi communication interface. Thanks to this feature, two development boards based on ESP8266 or the new ESP–32 were considered. Despite the many similarities with the ESP8266 chip, a more powerful development platform based on ESP–32 does not support a number of external libraries usable to make easier easy mutual communication between the devices. Thanks to this fact and advantages described above, the NODEMCU v1.0 development board was chosen as the microcontroller. A detailed description of the development board deals with [7].

Touch display –Local way of controlling should have appropriate HMI. The choice fell on Nextion touch displays. The advantages of these displays are their favorable price and benefits of its own integrated microcontroller. This microcontroller will take care about load associated with the graphical interface.

Additionally, it is possible to communicate with the display thanks to the built–in UART interface. Another advantage of these displays is the graphical way of their programming. The graphics editor includes a built–in simulator and his own debugger. This is why these displays save a lot of time during developing the graphical part of the interface. Specifically, the model NX4832K035 was selected. A detailed description of the model can be found on the manufacturer's website [8].

B. Software part

Development environments – Development environments generally serve to create a program in a particular language. Totally, three development environments were used.. A well–known Arduino IDE was selected to create main control program. The second used development environment is the Nextion Editor. In this graphics editor Nextion touch displays can be programmed. The editor is freely available on the manufacturer's site [9]. The third development environment that has been used is Simatic Manager. With the integrated tools of this environment, it is possible to program Siemens PLC. In this case it is primarily about making data from PLC data blocks available. These data blocks contain addresses on which data like motor speed, absolute current or motor temperature are stored.

External libraries – Communication between some parts of the system can sometimes be quite complicated. However, some libraries have been created for programmers to making this communication easier. Arduino IDE already contains many of these libraries. All the other necessary libraries must be uploaded into this environment. For the proposed system are especially important mainly libraries Settimino.h and Nextion.h. The purpose of Settimino.h library is make communication between ESP and PLC easier. This library is freely available on the manufacturer's site [10]. The Nextion.h library has a similar meaning as Settimino.h and serves to make communication between Nextion touch displays and microcontrollers easier. The library is also freely available on the manufacturer's website [9].

The complete proposal of the system with the described elements is illustrated in Fig. 2

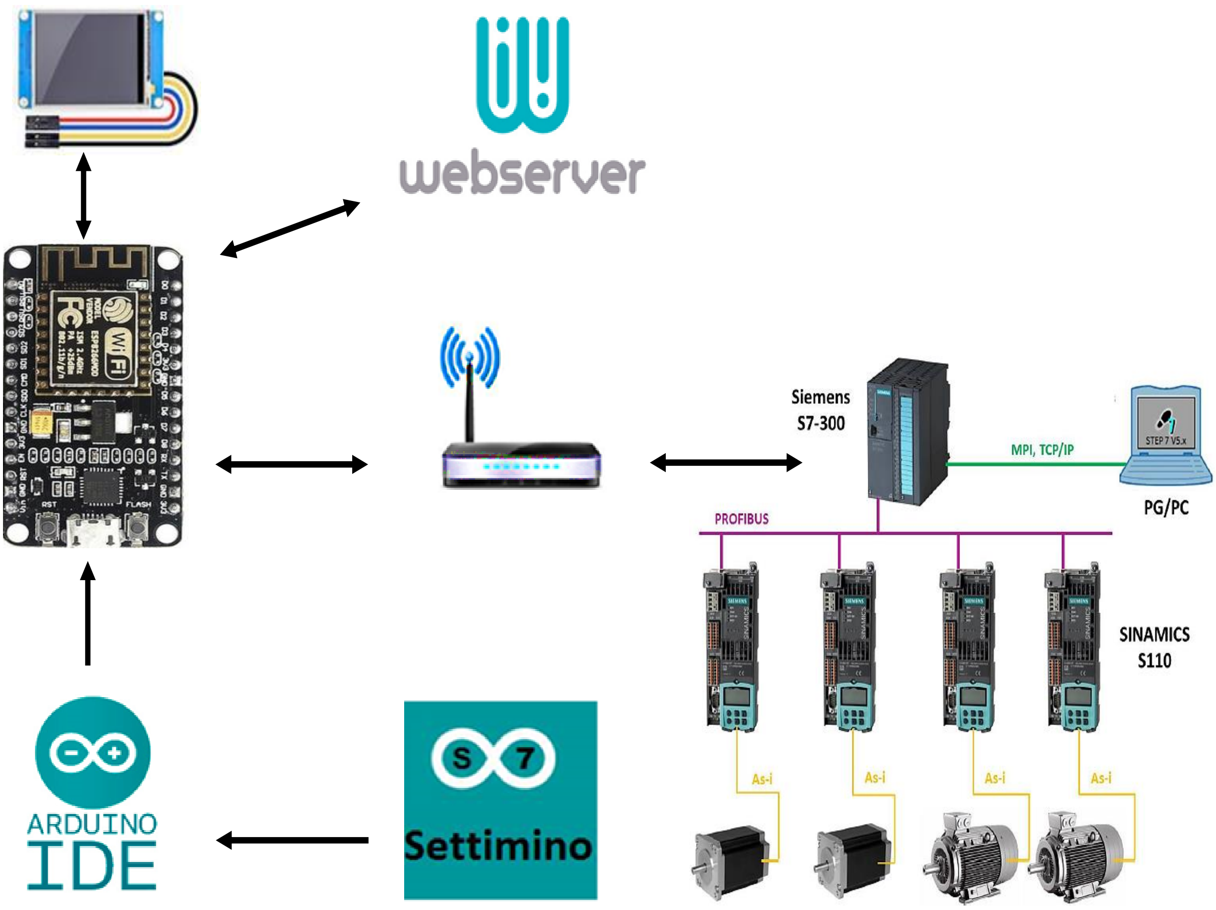

Fig. 2 System proposal

V. Conclusion

Technologies used in industrial automation are continually improving. That is why we cannot say exactly how enterprises of future will look like. However, we know that Industry 4.0 is about to create decentralized enterprises that will make decision and control whole enterprise. The basic element that enables these activities is IoT and its implantation into the industry called IIoT. It opens up space for completely new forms of monitoring and control of production processes.

In the work was presented a proposal of IoT device usable for remote control of PLC regulation system. The proposal represents an alternative to traditional PLC control using computers and operator panels.

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