JIEE Časopis priemyselnej elektrotechniky
Journal of Industrial Electrical Engineering
ISSN 2454-0900
www.jiee.eu

IoT device for PLC regulation system

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***Abstract* — The goal of this paper is to describe design and implementation of a device usable for remote monitoring and control of PLC Control system. This proposal is based on an increasingly prevalent concept of IoT (Internet of Things). Specifically, it is about the control of a pair of asynchronous motors, while the main control element being a microcontroller with an integrated Wi-Fi chip labeled like ESP8266. Thesis also deals with the application of the IoT concept in industry, which is labeled as the IIoT (Industry Internet of Things). It also deals with the collection and analysis of requirements for IoT devices. The last chapter describes the result of the work - IoT device usable for monitoring and controlling of PLC regulation system.**

Keywords — automation, IoT, industry, PLC

I. Introduction

We are currently standing on the threshold of the fourth industrial revolution, labeled as Industry 4.0 [1] The basic unit of Industry 4.0 is IoT (Internet of Things). The usage of IoT in industry is labeled as IIoT (Industrial Internet of Things). The IIoT will make it possible to extract large amounts of data from industrial processes. These data are labeled as *Big Data* [2]. Analysis of acquired data will enable industrial enterprises to optimize and streamline production. These changes are an answer to an increasingly unstable market where the product lifecycle is becoming increasingly short. It can be said that the IIoT opens the door for completely new ways of monitoring and controlling production processes [3].

Since the IoT connects individual parts of industry into the large network, one of its possible uses is its connection with the basic unit in automation at present – a programmable logic controller (PLC). Department of Theoretical and Industrial Electrical Engineering owns a PLC regulation system. However, this system is a model that can also be applied in industry. The whole system can be regulated by visualization. The compact IoT model can therefore be an innovative alternative to this type of control.

However, the communication between the PLC and the IoT can be quite complicated. One of the reasons why this is so is the fact that the IoT sector is starting to develop more strongly only now.

There is a plenty of manufacturers of IoT devices, and so far there is no unification in the used communication protocols. Functioning and trouble – free communication between the PLC and the IoT device therefore appears to be essential and key.

II. ANALYSIS OF USER REQUIREMENTS

The following part of the paper is focused on determination of user requirements for PLC regulation system by IoT device.

Control options – It is appropriate that the proposed system could be controlled by several ways. One method should be directly using the designed control device. Such a method can be called local. The control device should have a suitable form of HMI. The control device should have a suitable form of HMI. The secondary way of controlling should provide an alternative to the first described method..

Compactness – It is good to secure suitable form of IoT device. The hardware part of the IoT device should not occupy much space and its design 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 –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.

III. SYSTEM PROPOSAL

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 [4]. Thanks to this fact and advantages described above, the NODEMCU v1.0 V2 development board was chosen as the microcontroller. A detailed description of the development board NodeMCU is in [5].

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. Specifically, model NX4832K035 was selected. A detailed description of the model is provided on the manufacturer's website [6].

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 [7]. Third used development environment 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 were 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 is especially important library called Settimino. The purpose of Settimino library is make communication between ESP and PLC easier. Library Settimino is freely available on the manufacturer's website [8]. The complete proposal of the system with the described elements is illustrated on Fig. 1.

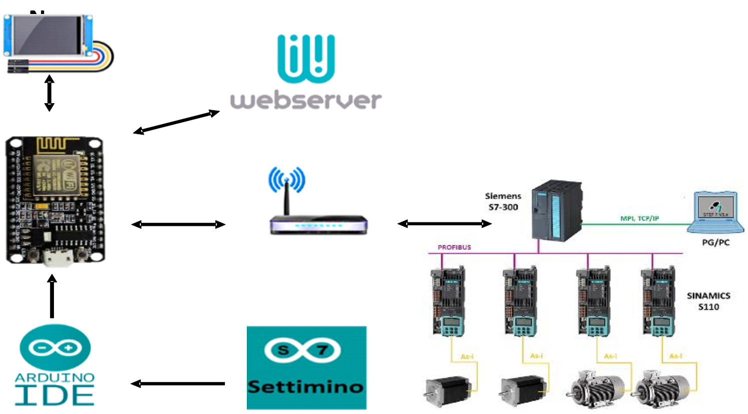

Fig. 1 System proposal

IV. REALIZATION OF IoT DEVICE

The result of the project is a relatively small device with dimensions 13.2x9.8x3 cm – Fig. 4. Behind the display, on the side of the device there is a button to restart the IoT device. In front there is a Micro USB port used to communicate with the control MCU and also to power the IoT device with a voltage of 5V. The main components of the IoT device are: NodeMCU development board, Nextion touch screen and Micro USB module. Inside of the IoT device is control circuit. The scheme of control circuit of the IoT device is shown on figure Fig. 2.

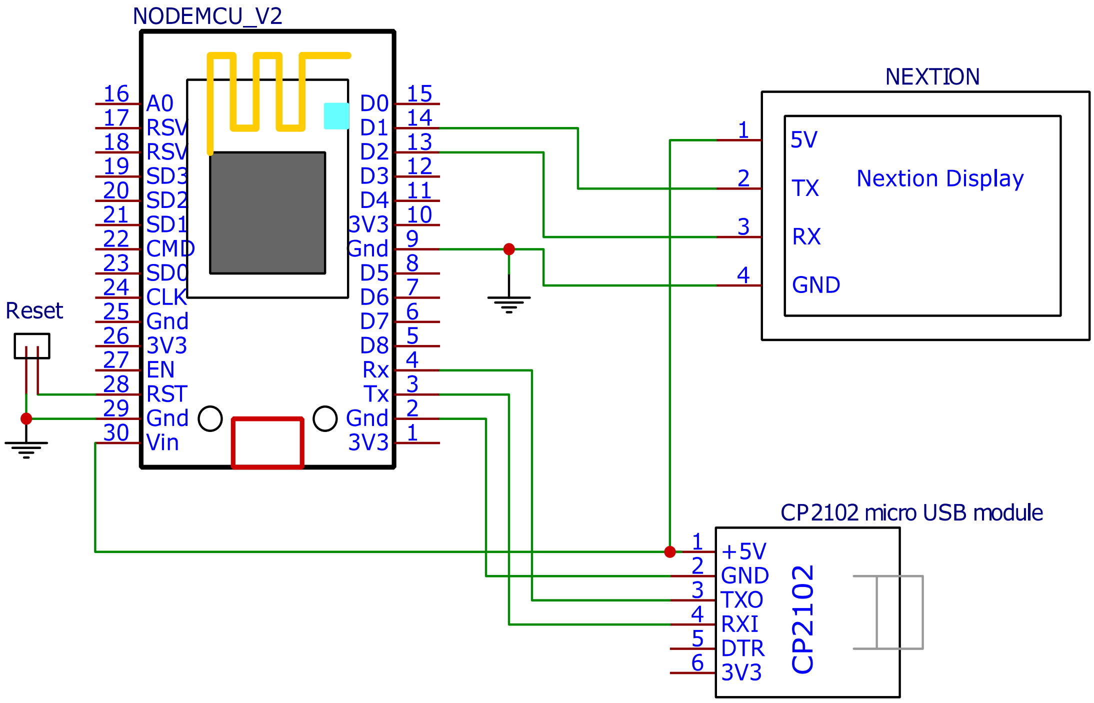

Fig. 2 Scheme of IoT device control circuit

The individual components of the IoT device are connected by a printed circuit board (PCB). The location of the individual elements on the printed circuit board is shown on Fig. 3.

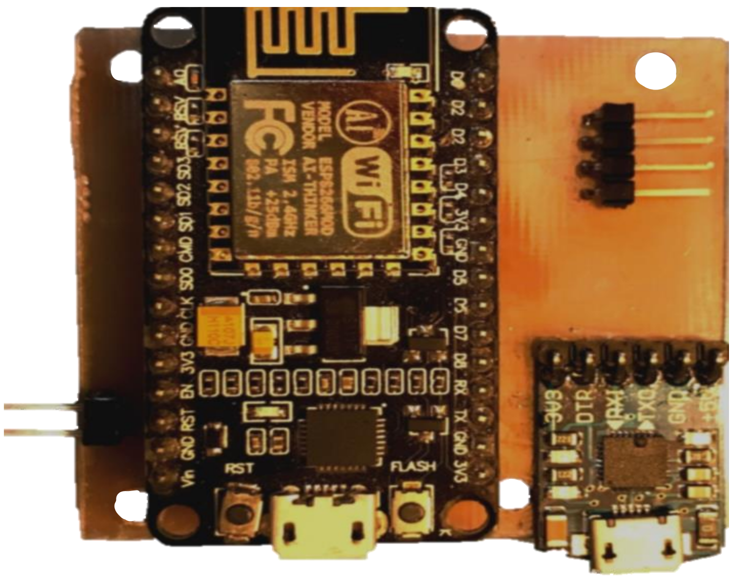

Fig. 3 Placing elements on a real printed circuit board

The control microcontroller is connected to the printed circuit board by a socket into which the control microcontroller is locked. The final form of the IoT device is shown on Fig. 4.

Fig. 4 Final form of IoT device

The IoT device offers two ways to control the entire system - HMI (local control) and web server (remote control) control. The control methods vary slightly depending on the features they offer. For instance, only with the local control method - HMI control, the IoT device can be restarted.

A. Controlling via HMI

The local control is via a built-in touch screen that can be understood as an HMI. Overall, the IoT device contains three screens. Initial, which is displayed automatically when the IoT device is switched on (Fig. 5a) and two control screens (Fig. 5b). After successful connection of the IoT device to the Wi-Fi network, the URL address on which the web server runs is displayed on the start screen (Fig. 5a-1.). On this screen it is also possible to set access to system control via the web server using the checkbox (Fig. 5a -2.). The strength, quality of the received Wi-Fi signal (Fig. 5a-3.) is also shown on the initial screen. Monitored variables for which the screens provide information are:

- Real rpm [revolutions per minute]
- Set rpm [revolutions per minute]
- Temperature inside the motor [°C]
- Absolute current value [mA]
- Torque [mN/m]

This data are cyclically updated approximately every 7 seconds. Touch-sensitive active elements – buttons (Fig. 5b-8.) and slider (Fig. 5b-9.) are located on the controlling screens. On the right side of these screens are the directional buttons "Back" (Fig. 5b-7.), which allows to get back to the home screen as well as the engine on / off button (Fig. 5b-5.). The bottom of the screen is made up of active elements used to set the desired speed. You can use either the slider or one of the "-10 rpm", "0 rpm" and "+10 rpm" buttons to set them. The buttons "-10 rpm" and "+10 rpm" are similar in meaning. By pressing them, it is possible to adjust the currently set motor speed slightly (on the tenth level). The task of the buttons is to add (button "+10 rpm") or to decrease (button "-10 rpm") the current value of the set rpmr and then round the new value to the level of tens (nearest tens). For instance, if the current set rpm value is 1653 rpm, pressing the "+10 rpm" button causes the change to 1660 rpm. The "0 rpm" button is used to set the zero speed. After pushed any buttons which is for setting rpm, slider value is updated. The desired set rpm value can be set within the range of <-3000; 3000>, where negative values indicate a counter clockwise rotation. Approximately in the middle of the screen is a red inscription "Updating" (Fig. 5b-6.) It signals the updating of the monitored variables. During this cycle, all screen elements are inactive to touch. The description of IoT device screens is shown on Fig. 5.

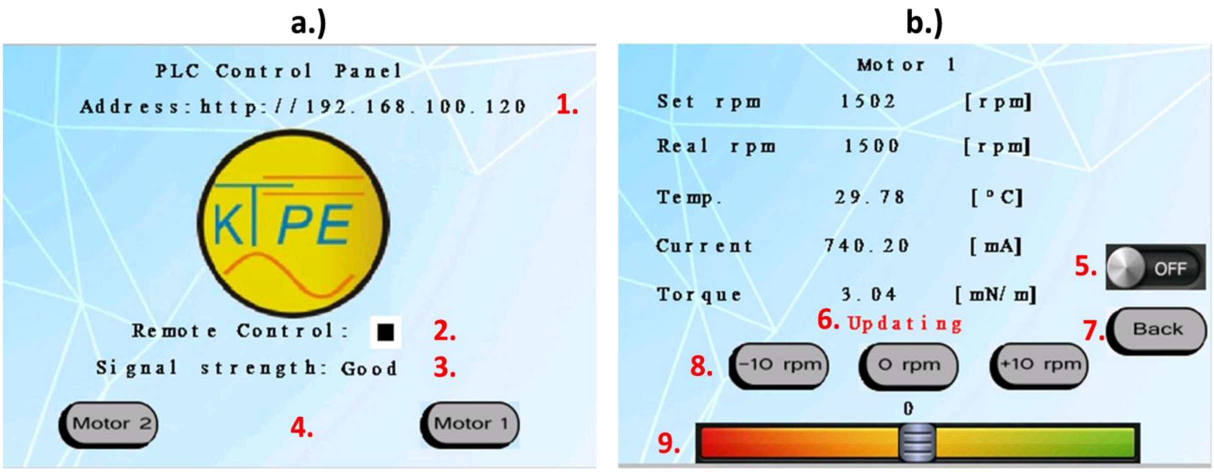

Fig. 5 a.) Initial screen b.) Controlling screen

B. Controlling via web server

Controlling via web server does not offer such a quick response and overall this way of controlling is slower than the first. Its speed is determined by several factors. One is the power, the quality of the received Wi-Fi signal, but the biggest and most limiting factor is the lack of control microcontroller performance, which is not optimized for web services. The practical consequence of insufficient performance of the microcontroller is for instance slower website response.

After entering the URL address displayed on the IoT device's initial screen into the web browser, it is possible to load a website that runs on the web server. This website has the same meaning as the controlling screens mentioned above. These screens allow set the desired set rpm value, change the motor status (on / off) and also include the information about the monitored variables. However, content of website varies slightly, depending on the selected web server access control mode. If web server control is enabled, elements such as toggle switch (Fig. 6-1.), text box (Fig. 6-2.) and "Set" button (Fig. 6-3.) are available on the website. The whole website is very intuitive, so using is easy, even for new user. The toggle switch status indicates the state in which the respective motor is - on (green) or off (gray). The current value of the set speed is displayed in the text boxes. The desired motor settings can be set using the switches and by changing the numeric values in the text boxes. After confirmation, desired values are (switch status and speed value in the text field) sent to the microcontroller and after 5 seconds is user redirected to the main page, now with the updated data.

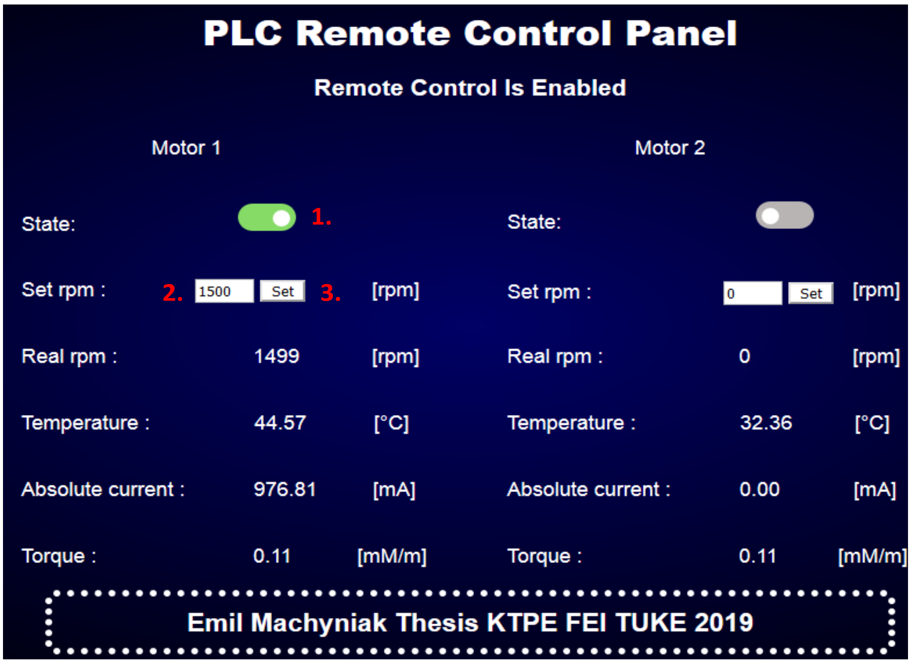

Fig. 6 Controlling via web server is enabled

Similarly like with local control, when using the web server, it is possible to set the set rpm value within the interval <-3000,3000>. If remote control is disabled, there are no control elements (mentioned above) on the website. Information about motors (state, set rpm) are shown in text form. Regardless of which access mode is selected, the website is automatically updated every 25 seconds. It is possible to update the website manually even before, but it is not recommended to do it more than once every 10 seconds.

V. Conclusion

The technologies used in industrial automation are constantly improving. That is why we are not yet able to say exactly how enterprises of the future will look like. However, we know that Industry 4.0 intends to create decentralized enterprises, which will themselves decide and control the enterprise. The basic element that enables them to do so is the IoT and its implantation into the industry labeled as IIoT. IIoT opens the door to completely new forms of monitoring and regulating production processes.

In this paper was introduced design and realization of IoT device usable for remote control of PLC regulation system. It is possible to look at this IoT device like an alternative to the traditional PLC control using computers and operator panels.

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