

# Web Server for Command, Control and Monitoring of Industrial Equipment

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**Abstract-** The paper presents the design and experimentation of a Web server for command, control and monitoring of industrial equipment.

The server has the following main components: Atmega2560 microcontroller as a CU and the W5100 network controller.

The user is connected to the Web server through the Internet. The equipment is connected to the server ports, analog or digital. For the Web server command and control, we have created a virtual panel. The experiments have shown the correct operation of the server and its utility in various applications.

**Keywords:** Web Server, command, control, equipment

## I. INTRODUCTION

With globalization, while witnessing a movement of personnel and equipment, we consider of particularly importance that specialists may be able to command, control and monitor real-time industrial equipment located in another part of the world from the one in which they are located at the time.

In this respect, meetings of experts and equipment allocated to them under professional appearance can be done through computer networks as intermediate components of the connection specialists - equipment [1], [2], [3]. One of the main components of this bond is formed by the Web Server [4].

It connects via Internet to a technical support specialist (PC, Laptop, Smartphone, etc.) and by its digital or analog ports, to industrial equipments.

## II. DESIGNING THE WEB SERVER

### A. The general structure

The general structure of the designed server is shown in Fig. 1, where the components were identified, considered definitive for the main server tasks:

- the CU is performed with ATmega microcontroller 2560 [5];
- the network controller is built around the W5100 network controller [6];
- the SPI interface, through which there the communication between CU and network cards;
- the communication between server ports and industrial equipment which are ordered, controlled and / or monitored. These can be inputs or outputs, analog or digital. Ports connect directly to industrial equipment.
- the interface with the internet network, symbolized by the RJ45 connector, through which there is carried out the communication between the server and the specialist (client);

- the physical indicators of communication networks control signaling (LED).

The network controller is galvanically separated by the Internet network (Fig. 2), thus being made protect the W5100 circuit of voltage peaks and accidental electromagnetic interference, that can be induced by other transport media or the vicinity of electrical equipment toward the UTP cable.

The Atmega 2560 microcontroller, which, by its ports communicates with industrial equipment can be connected via the interface adaptation and the appropriate that equipment so as to ensure and protect its power. Some possible solutions are discussed below.

### B. The SPI communication between the CU - network card SPI

The block diagram of the Atmega2560 microcontroller [5] used is given in Fig. 3 and with the W5100 network controller [6] in Fig. 4.

The communication of two main components, CU and network controller, in SPI mode [7], is shown in Fig 5.

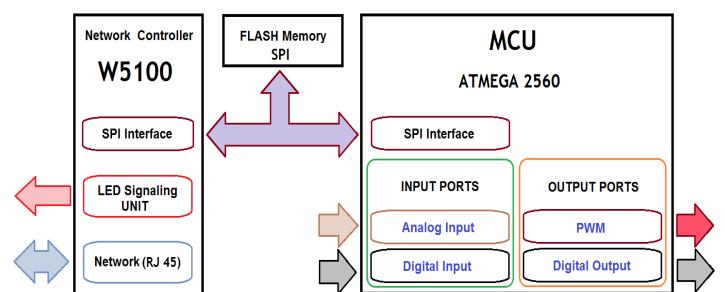


Fig.1 The general structure of the Web server

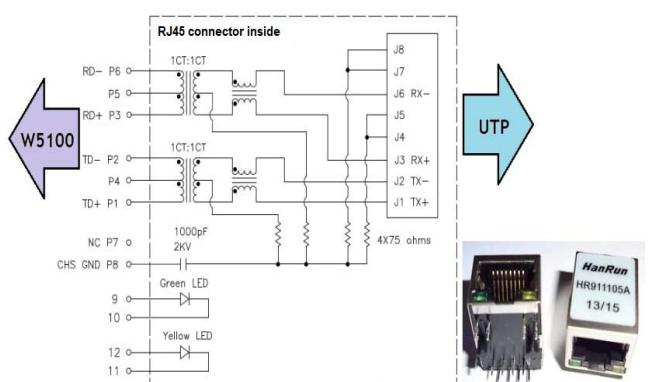


Fig. 2. The connection "Internet - network controller"

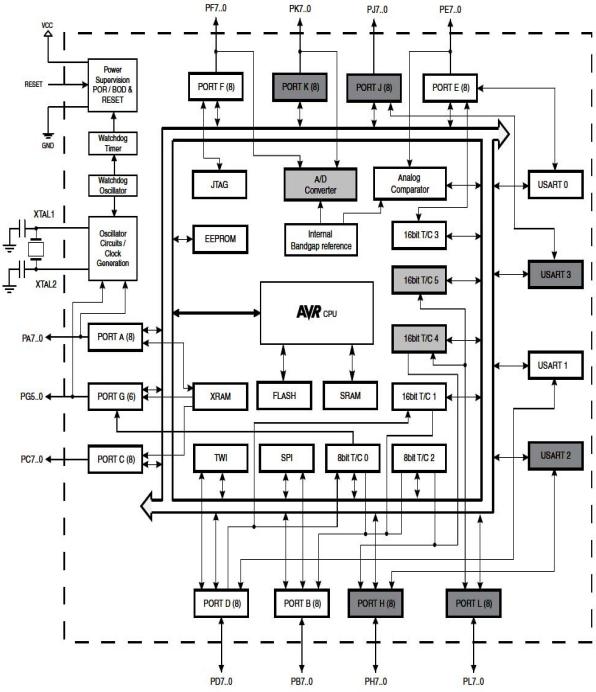


Fig.3 The block diagram of the Atmega 2560 microcontroller

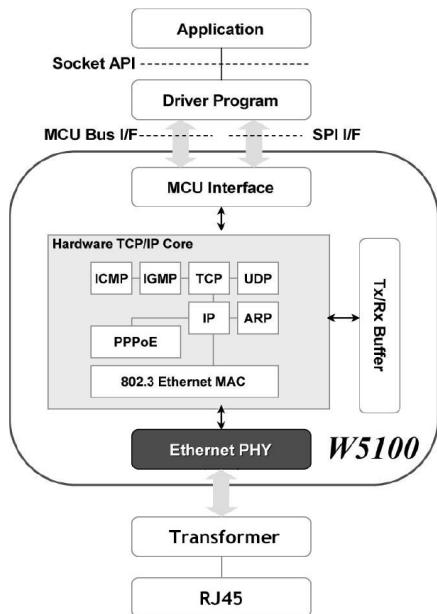


Fig.4 The Ethernet Controller Block Diagram

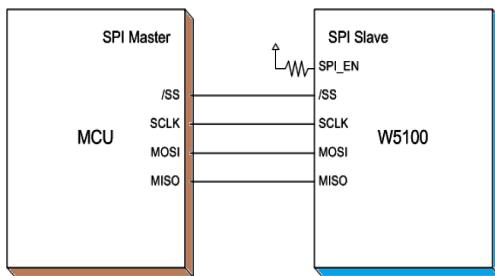


Fig.5 SPI communication between Atmega2560 and W5100

Data is sent from the "Master" to "Slave" on the MOSI line, while the "Slave" to "Master" sent by MISO line [5],[6], [7].

Data transfer is performed in full-duplex mode according to Fig. 6. Available 7-speed transfer programmable flag signal type for data transmission completion or interruption of transmission, collision, avoidance control signal output function even in "SLEEP".

### C. The Server Software

The server communicates with the user (client) via the Internet and the equipment to be commanded / managed / monitored via LAN. For this purpose a program was written in Arduino 1.0.5 [8] which currently has 730 lines and includes software routines required to initialize the server, client communication, communication equipment and management of used ports .

### III. THE LEVELS EXTENSION OF VOLTAGE AND CURRENT, ITS CU PORTS

The server communication ports with the industrial equipments only supports voltages in the range  $U = 0 \dots 5$  V and a few mA loads, while many of the equipment require higher values of tens and hundreds of volts and current with a few amps.

In this context, it is necessary to extension the voltage and current levels of CU ports platform. The designed and simulated analog and digital extension ports, with role of power amplification, of circulating signals to the server and adapter circuits between the output equipment and the input ports in server.

#### A. The digital ports extension of output

Increasing the voltage and current of the digital outputs is required if type operations are executed on / off, set / reset of high power equipment or of parts thereof. Fig. 7 presents the circuit diagram designed and simulated, which connects to a digital output.

The scheme provides galvanic separation between the server and the equipment by optocoupler U1, amplifying the output signal to values of the order of volts and currents of tens of milliamps through amplifier the transistor compound Q1; when necessary values currents and / or voltages of higher output J1 (hundreds of volts, amps), which a suitable relay control transistor Q1. Signaling Server line output logic state is indicated by LED D2.

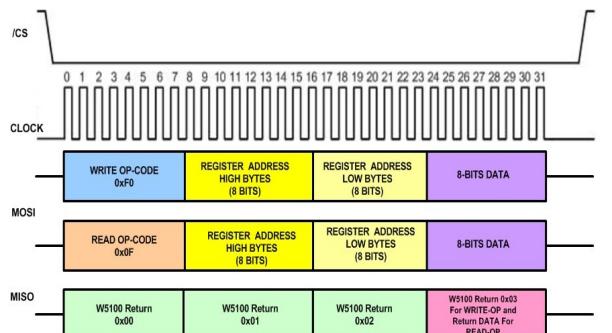


Fig.6. Transmission frames on SPI ports

### B. The PWM output port extensions

The PWM ports were created to order equipments that require it as static converters, electric ovens etc. The powers of control required by this type of consumers are higher than the possibilities offered by the server ports. For this reason, the extension shown in Fig. 8 comprises a MOS FET-amplifier Q1, which performs well in the switching mode, requires low power of control, and is capable of providing, to the J1 output high levels of voltage and current. Protection of the server is ensured in the case of the digital outputs by means of an optocoupler U1.

### C. The digital extension input ports

If digital input ports, use of adaptive circuits with galvanic separation, especially if the signals coming from the various equipment that must be monitored are greater than 5V. The diagram of Fig. 9 shows an extension, the role of adapter between the LAN input, J1, and the input port on the server. Specifically, the scheme presented, alternating voltage, of high value of J1, 220 V, for the values of the components scheme is reduced to the input terminals, the optocoupler U1, to a maximum pulsed DC of 1.2 V.

The proper dimensioning of the resistors R1, R2, R3 circuit simulation results indicates the presence of voltages from 4.5 to 5 V, to input port of the server.

### D. The analog input extension ports

The analog input ports, as well as digital, allowed a maximum voltage of 5V, so that the voltage range 0-5 V input, the microcontroller's internal ADC provides at its output, 10-bit binary codes between 00 ... 0:11 ... 1.

If the input voltage range port is low (eg some signals from transducers), set conveniently inside the programmable microcontroller amplifies the range:  $A = 1 \dots 200$ . If the voltage coming from the equipment is high, is inserted between the equipment and input port, a precision resistive divider. The galvanic separation equipment - the server is carried out also in this case, with an optocoupler, as shown in Fig. 9.

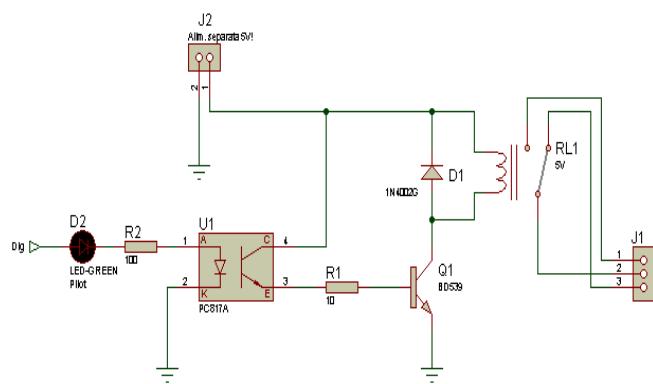


Fig. 7 Extension line of the digital output port

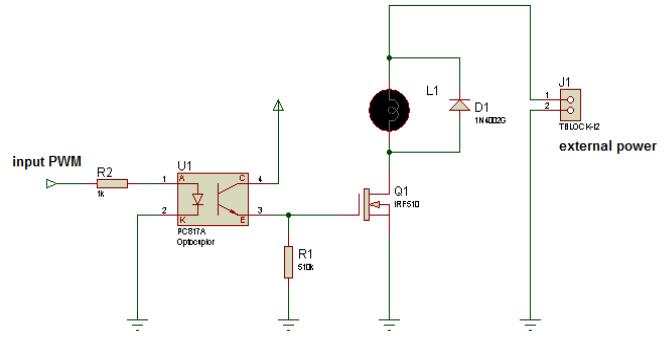


Fig.8. The Extension of a PWM output port

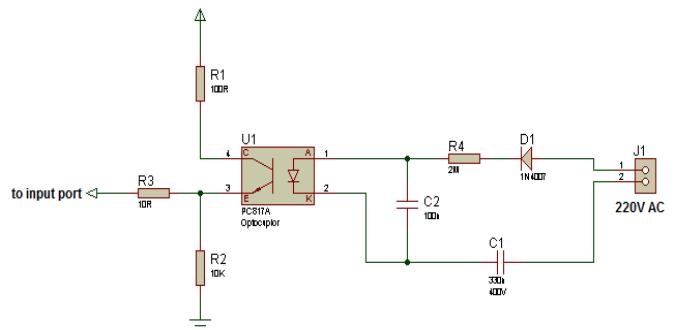


Fig.9 Extension digital input port with galvanic isolation

## IV. THE SERVER IMPLEMENTATION

The block diagram of Figure 1 has been implemented by means of two platforms, shown in Fig. 10 and Fig. 11.

The platform extension output ports is given in Fig. 12.

For effective use of the server, we have created a home page (Fig. 13), interactive form of a virtual panel, which ensures remotely via the Internet, control Atmega microcontroller ports 2560 and thus implicitly, command, control and monitoring of the equipment industrial to which it is coupled.

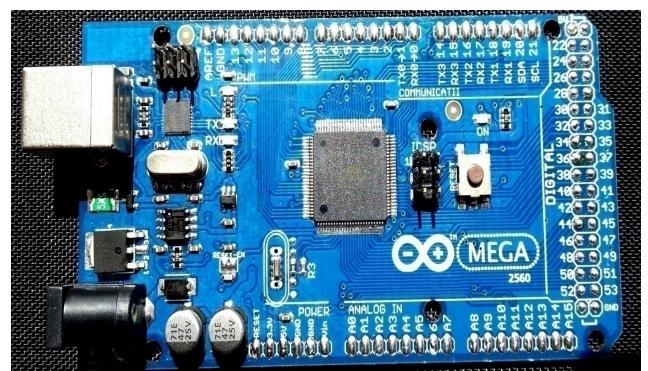


Fig. 10. The CU Web server with the Atmega2560 microcontroller

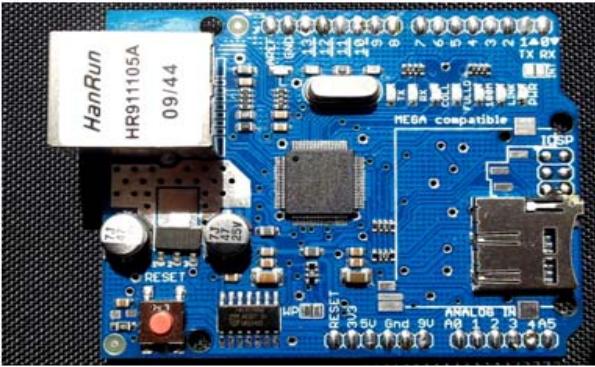


Fig. 11. The network card to Web server with W5100 controller



Fig. 12. The Web server Extension output ports

At this time, the homepage, or "main page" offers the user an interactive panel with a discount rate of 10 s (if applicable, the discount rate can be changed in the source code) if the client does not generate any request the server and when the user interacts with this panel, updating occurs precisely. Experiments conducted have shown that the minimum discount rate server designed to operate correctly was about 2s.

It appears that the current application was designed for command, control and monitoring of 32 independent programmable lines, belonging to four 8-bit ports. Two ports are used for inputs or digital outputs; status of each line, 0 or 1 is indicated on the main page via a virtual LED assigned to each line. For outputs the settings for each line are buttons ON (logical 1), OFF (logical 0). Each of the 8 port analog input lines can be brought voltages in the range 0-5 volts through a successive approximation ADC with internal 10-bit Atmega 2560's that are converted into digital signals by multiplexing. The eight analog output lines of the port are used to generate PWM signals ordering the idea of a three-phase static converter. Each output can be generated a pulse train of amplitude  $U = 5V$  with variable duty cycle can be changed from the "+", "-".

The left panel shows a black band (Fig. 13), which gives the user full auxiliary rights opening pages dedicated to amend additional names of ports, network configurations, modifying data logging and the bottom of the strip there is presented the output path or logout action.

The interconnection of the three platforms has led to a first embodiment of the server, in a prototype form as shown in Fig. 14. The front panel of the built server prototype, is shown in Fig. 15.

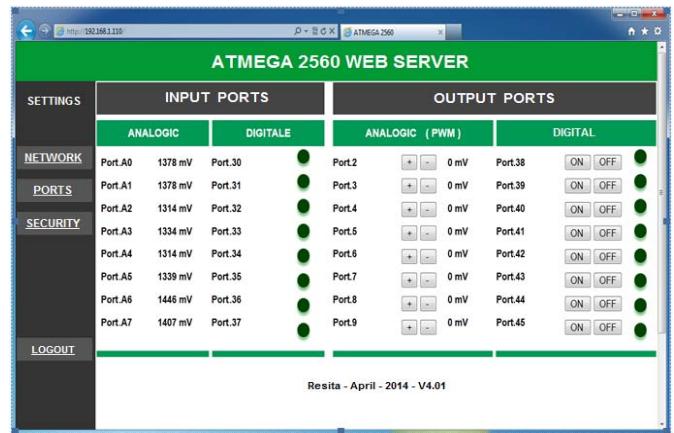


Fig. 13. Main page of the built Web server



Fig. 14. The interconnection of hardware components of the Web server



Fig. 15. The front panel of the prototype built Web server

## V. EXPERIMENTS

Several experiments were conducted on the Web server built. Below is shown, test input and output ports indicated on the front of the Web server. (Fig. 13).

In testing, we used a precision voltmeter to verify the correct voltage on the server, a signal generator for testing analog and digital inputs, an oscilloscope to view all waveforms.

### A. Testing the PWM ports

To test the 8 PWM ports after user login it is necessary to connect an oscilloscope to one of the 8 ports and buttons are pressed analyzing the corresponding ports (Fig. 16), incrementing or decrementing the PWM pulse period.

The Fig. 16, shows the PWM waveform for three control cases by the progressive increment for adjusting the PWM voltage at the output port P.2.

The program server at this time was designed to provide a PWM voltage control at a resolution of 98mV, ie on a scale of 50 steps.

The frequency of the PWM signal is  $f = 490\text{Hz}$ , the frequency corresponding to a cycle complete with a duration of  $T = 2.04\text{ms}$ .

In the first case ( $U = 98\text{mV}$ ) the PWM impulse lasts  $40.0\mu\text{s}$ , in the second case ( $U = 490\text{mV}$ ) PWM pulse duration is  $200\mu\text{s}$  and the last case ( $U = 2552\text{mV}$ ), the Pulse PWM equal to  $1.04\text{ms}$ .

The maximum measured PWM pulse amplitude is  $5.12\text{V}$ .

#### B. Testing of analog input ports

This test involves applying a voltage whose maximum value should not exceed  $5\text{V}$  ADC pin (Fig. 17), which corresponds to port A.0.

The voltage applied A.0 the port is  $3.3\text{V}$  with the value calculated by the server, the web page is displayed in the right port A.0. The error, as shown, is  $8\text{ mV}$ .

#### C. Testing of digital output ports

Digital output ports, generate two logical states. For logical 1, the voltage present at the port pin is equal to  $5\text{V}$ , and in this case the virtual panel color signal is green (Fig. 18). For the logic state 0, the pin voltage of the current is close to  $0\text{ V}$ , in which case the color of the signal will be dark green.

#### D. Testing of digital input ports

Similar to digital output ports, for the digital input ports, two logic levels are indicated on the virtual panel, all differentiated by color, light green for logical 1 (about  $5\text{ V}$ ), dark green for logical 0 (about  $0\text{ V}$ ). Fig. 19, shows testing for the P30 port.

Indication of these ports is achieved by changing the color of the circles, beside each port, and these circles, with LED mimic are virtually displayed.

#### E. The energy consumed by the Web server

Measurements have shown that the Web server itself has a low power consumption tested  $2\text{W}$ , which makes it to be portable. In terms of energy sources were tested, both rechargeable battery and charger from a stabilized.

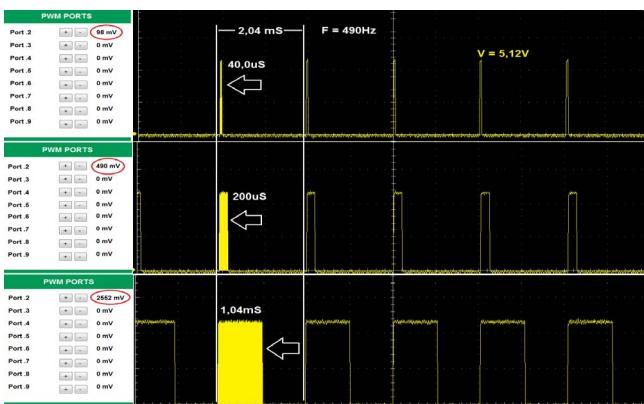


Fig. 16. The shape of the PWM signal generated by the Web server



Fig.17 Display the voltage of to ADC, input port, A0

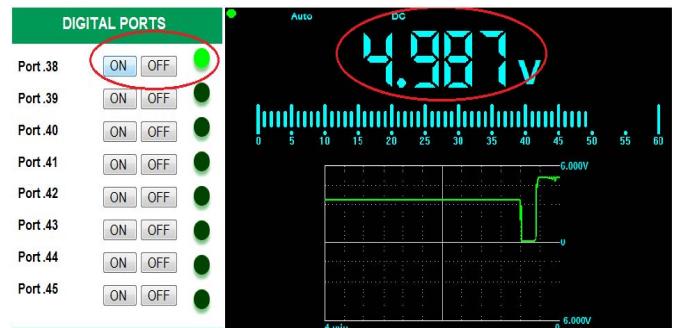


Fig.18 Displaying the logical 1, digital output port, P38



Fig.19 Displaying the logical 1, digital input port, P30

## VI. CONCLUSIONS

The Web server, is part of modern equipment for command, control and remote monitoring of the industrial equipment. Server software is written in C Arduino 1.0.5 and the specialist (client) to connect to the Web server by PC, tablet, laptop, via Internet, devices that can run on operating systems Windows, Mac X, Android, etc.

Web Server control and command, remote control and monitoring are shown by web pages generated in HTML.

They designed, simulated and tested power extension to digitals and analogs ports server ensure the server protection from surge which could come either via Internet or LAN networks.

The Web Server has a low consumption rate  $2\text{ W}$ , being so portable.

The main disadvantage in this moments is insufficient memory that did not alone the creation of HTML corresponding pages.

In the future it is envisaged to increase the customising degree of the Web server [9], [10] by adding some option for the rapid setting of the network parameters: IP, network mask, gateway etc., setting the loging data and security.

We study the developements of the Web server based on multiprocesor system.

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