AUTOMATION OF A PUMPING STATION FOR LOW POWER APPLICATIONS

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Abstract: *The paper shows a solution of automation and monitoring for a pumping station. The monitoring and control is performed locally using a PLC and remotely using a PC.*
Remote transmission of information from local equipment to computer is performed on a serial RS232 communication network.
The experimental results were obtained in real conditions of operation and showed good functioning of the monitoring system

1. Introduction

Starting and stopping the pumps in a pump station can provide manual, semi-automatic and automatic. Due to the high consumption of electricity, the need for continuous surveillance and danger of malfunction, start and stop manual pump is completely abandoned.
Automating of starting and stopping pumps can be based on the following parameters:

- Automation a function of time;
- Automation a function of fluid level;
- Automation a function of pressure;
- Automation a function of flow.

This paper presents a solution of automation based on fluid level out of the tanks. Also, the solution provides the user with a choice of pump control: automatic, semi-automatic, or manual.

2. PLC hardware description

2.1. Requirements of PLC design

PLC of pumping system must meet the following requirements:
- development will be around a microcontroller;
- it must be possible to purchase 10 digital signals;
- programming will be in a higher level language;
- keeping settings will be in an internal EEPROM memory;
-user interface will be provided by tandem liquid crystal display and keypad minimum of three buttons;
- microcontroller programming will be provided via a connector on the PCB;
- it must be possible to link information between it and a PC in RS232 standard;
- it must be possible to acquire a unified signal 4-20mA;
- order will be provided four relays

2.2 PLC structure

Ensuring the requirements mentioned above is possible using a structure developed around a microcontroller product type ATMEGA ATMEL 8535 (Fig. 1). It can identify nine functional entities: microcontroller module, the reference voltage block inputs and digital outputs, TTL-RS232 adapter, keyboard, alphanumeric display, analogue input block and power supply. The output voltage of industrial power supply is 12 V DC.
Figure 2 shows the final board components corresponding to PLC. Also it can see electrical circuits located on the back of the PCB board.

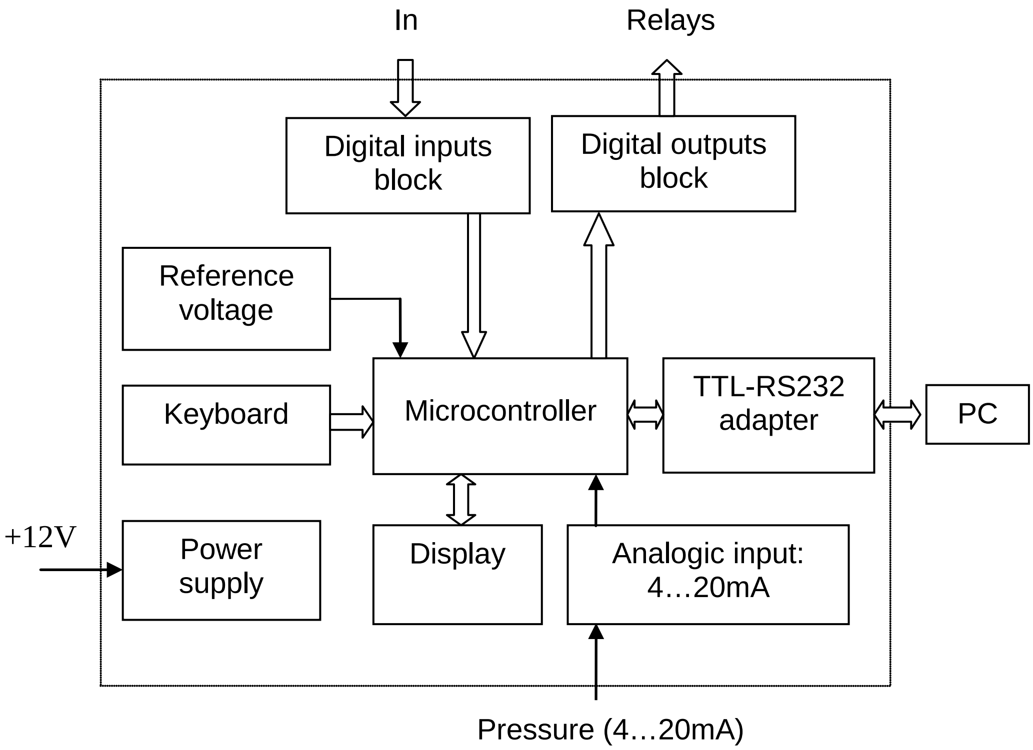

Fig. 1. Block diagram of the PLC for pumping plant

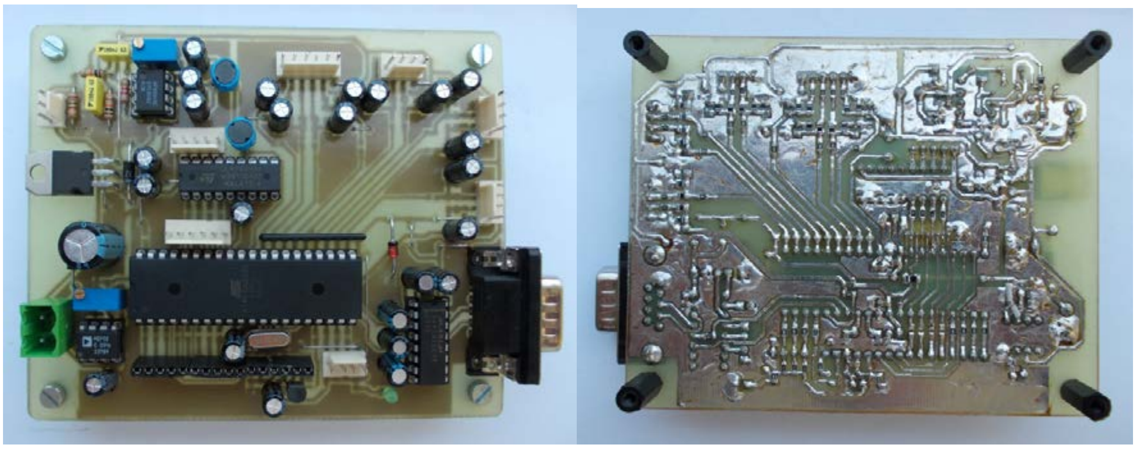

Fig. 2. *PLC for pumping system.*

The ATMEGA is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the microcontroller achieves throughputs approaching 1 MIPS per MHz, allowing the system designed to optimize power consumption versus processing speed. The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.
The fluid level sensor is likewise in the form of an electronic module (fig. 3). It consists of two identical cells developed around two NPN transistors. Common electrode has a +5 VDC potential. We analyse the block built around transistor Q1. The diode D2 serves to limit the amplitude of the signal received via the limiting resistor R2. The capacitor C1 acts as a filter to acquired signal. Transistor Q1 is then polarized by means of resistors R3 and R4. Diode D3 protects transistor Q1 against external voltages induced.

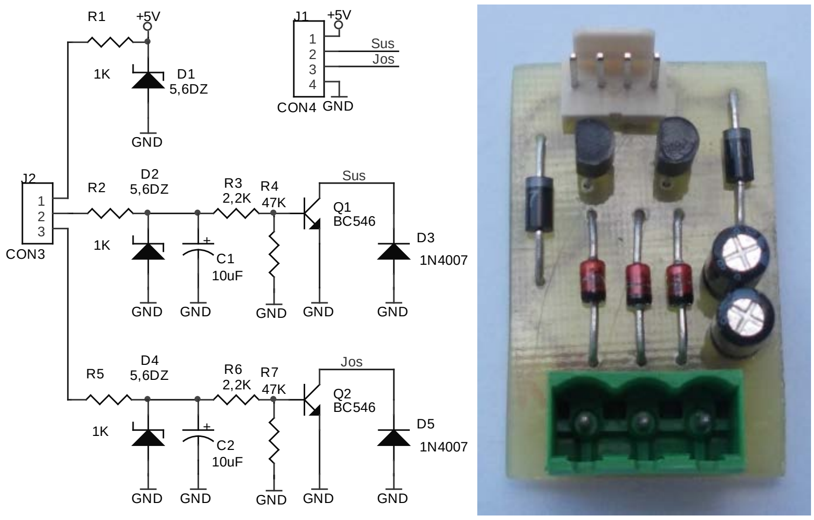

Fig. 3. Fluid level sensor. a) electronic diagram; b) components board.

3. PLC software description

3.1. Requirements of microcontroller software

The software must assure:
- Scanning of analogue inputs;
- Reading ten digital inputs;
- The status of system will be signalled by a LCD display;
- Acquisition of signals from a keyboard with three buttons;
- Interconnection of electronic computer serial port via a UART;
- Transmission of data packets to PC organized by a predetermined protocol;
- Reception of the PC data packages organized by a predetermined protocol.

3.2 General description of microcontroller software

The program (Fig. 5) starts with the initialization of the microcontroller and the variables used. Making various timings is possible by using a sequence of decrement all counters used. Afterwards follows the analogue input acquisition, the ten digital signals and signals associated of keyboard. It then set and printed messages through LCD display.

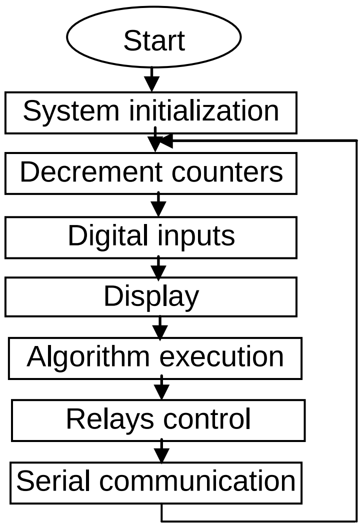

Fig. 4. Flowchart of microcontroller program

The implementation of the algorithm contains all interactions between input quantities and corporate output. The program continues with relay control and processing serial communication.

Except block, execution algorithm consists in all other fundamental elements of program elements that do not change from one application to another. In according to desired application obviously will change the content block ‘’algorithm execution’’.

4. PC software

One of the most important is code sequences which enable data transfer between PC and PLC of pumping installation. The following flowchart (Fig. 5) captures such a procedure.

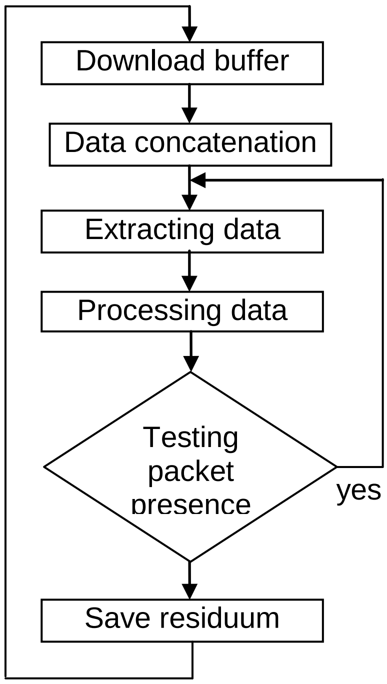

Fig. 5. Flowchart corresponding to serial communication procedure

Chosen software for application development is Visual Basic. It is commonly encountered in industry, is extremely quick and easy to use interface construction equipment - user. Noteworthy is the fact that it contains an object specializing in serial liaising with other digital equipment, ensuring virtually the only convenient way to transfer data between the PC and the technological processes involved.

5. Electrical plant of pumping system

For electrical installation of the pumping system has started from the premise that the pump can operate in two modes:
- Manual mode (controlled by operator);
- Automatic mode (controlled by PLC).

The electric scheme that allows operation in both regimes is shown in figure 6, and electric box of automation is shown in figure 7.
Operating mode selection is done by the operator through the three-position switch (Q).

Manual mode operating
For the manual operation switches position 1 of the Q switch and the control contactor coil supply k is by with the Bp button. Normally open contact k, connected in parallel with the Bp start push button serves to maintain the start command. Cancellation of command is made with the Bo button.
Pump operation indication is made by L lamp, which is supplied as standard pump is running.
The last circuit on electrical diagram is the power part of the electrical installation. It contains: F1 fuse for short circuit protection, thermal F2 relay for overload protection, K power contactor for pump drive motor.

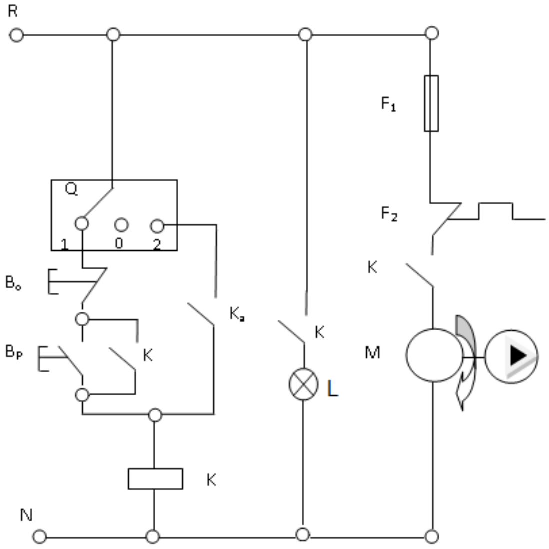

Fig. 6. Electrical diagram of pump station

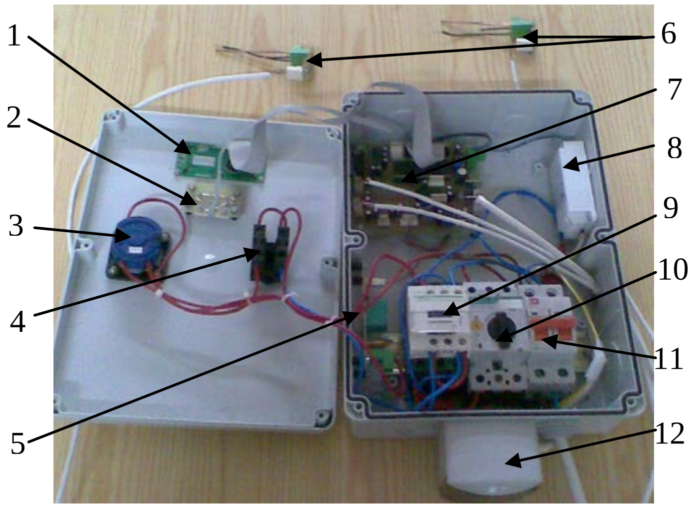

Fig. 7. Electrical box of automation

1-LCD display; 2-keyboard; 3-switch; 4-on-off pushbutton; 5-output relay; 6-lichid level sensors; 7-automaton (PLC); 8- DC power supply; 9- contactor; 10- thermal relay; 11- fuse; 12- output to pump.

Automatic mode operating

For automatic operation mode switches Q switch in position 2. In this way the work of operator is taken by PLC.The PLC will be mounted on output a Ka additional relay. Its coil will be supplied at a voltage 12 VDC.

Normally open contact relay Ka will be mounted in series with the K contactor coil that powers the pump drive motor.

Enabling corresponding of output power coil Ka, will be made based on the protocol required for automatic operation of the pumping system.

6. Experimental results

The experimental results were obtained using the automaton (PLC), a serial cable, a PC and the pumping system. The components of the entire automated pumping system are shown in figure 8.

Fig. 8. Automated pumping system: 1- automation box; 2- laptop (PC); 3- sensors box of storage tank; 4- storage tank;5 – sensors box of supply tank 6- submersible pump; 7-supply tank.

As has been observed in the implementation of programs for the microcontroller and for PC, the automation system was performed according to the water level in the two tanks.
Protocol for automatic operation of the pumping system is as follows:
1. The PLC will control the pump starts when the water level in the storage tank is low (Down level storage tank = 0);
2. The PLC will control the pump stop if the water level in the storage tank is at maximum (Up level storage tank = 0);
3. The PLC will control the pump starts if the water level in the supply tank is at maximum (Up level supply tank = 0), and if the water level in the storage tank is not maximum (Up level storage tank = 1);
4. The PLC will control the pump stop if the water level in the supply tank is at minimum (Down level supply tank = 0).
To demonstrate the functionality of automation achieved, the system has been experimented in the next cases:
1. Both tanks filled (fig.9);
2. Storage tank being discharge (fig.10);
3. Storage tank empty (fig.11);
4. Both tanks empty (fig.12).
The print screens of the PC graphical interface shown below demonstrate operation of the automatic system in all four practice experimental cases.
Graphical interface window of PC contains the following areas of monitoring and control:
- the area of analogue input (an analogue channel of pressure);
- the area of digital inputs (10 inputs);
- the area of outputs relay type (4 outputs);
- the area of control program;
- the area of display control;
- the area of semi-automatic control mode
In implementing programs for the microcontroller and PC, has been associated negative logic inputs related to PLC (active input = 0; inactive input = 1) and its outputs, has been associated positive logic (active output = 1; inactive output = 0).
The experimental results for the cases considered are shown in figures 9 ... 12.

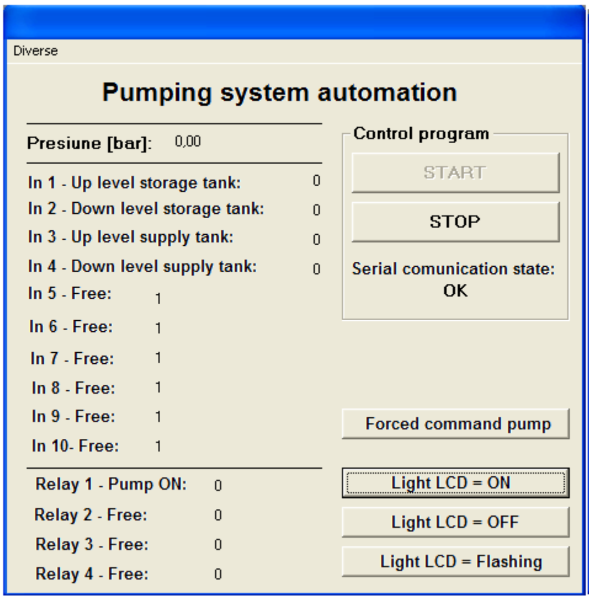

Fig. 9. Storage tank full, the pump is OFF

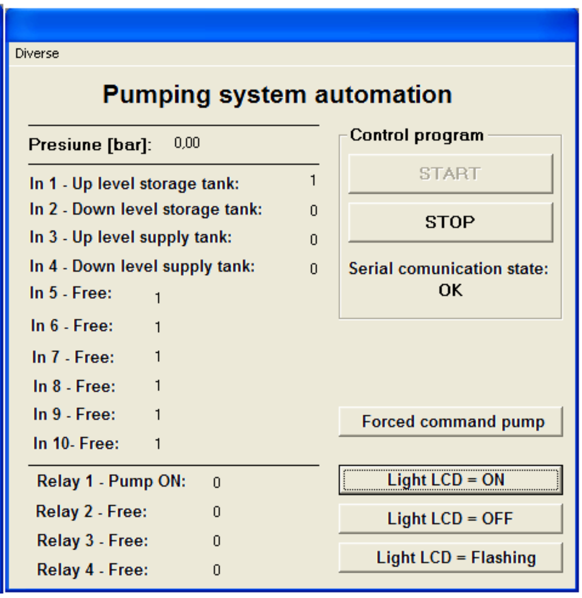

Fig. 10. Storage tank being empty (Up level sensor inactive)

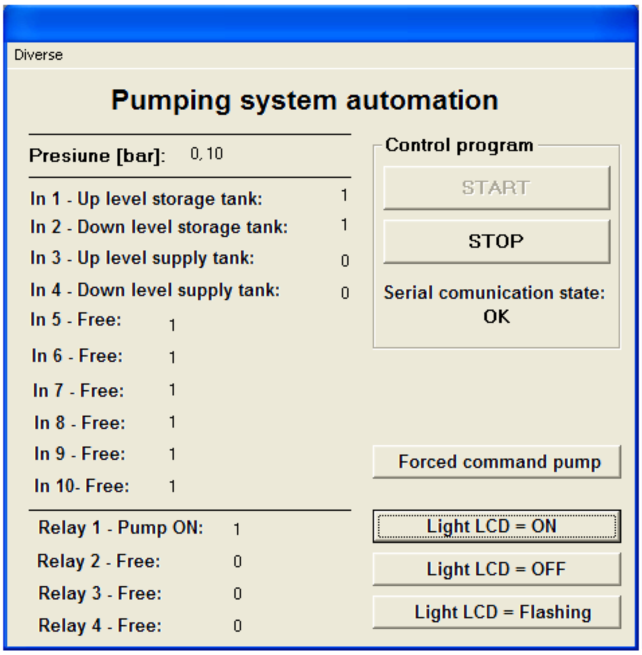

Fig.11. Storage tank was emptied. Pump is ON

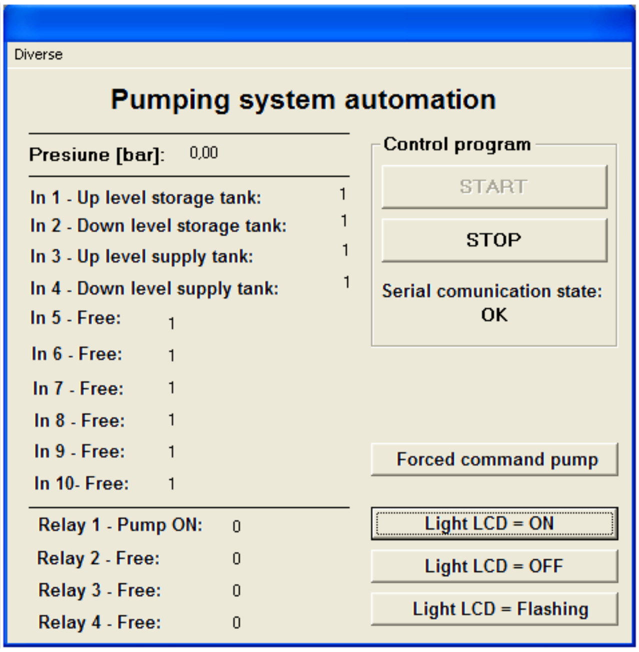

Fig. 12. Both tanks are empty. Pump is OFF

As can be seen from the above figures projected PLC has resources for expansion of application. It has 6 digital inputs and 3 outputs unused. Also it offer the opportunity to achieve the automation by pressure, PLC acquires an analogue signal from a pressure sensor.

7. Conclusions

Infrastructure hardware and software used allows monitoring and control of pumping system in real time.
Sensors, electrical equipment and electronic components used in the pumping system have a high degree of accessibility and performance using software and standard interfaces.
Using a microcontroller for automation and monitoring of pumping system is a solution that can significantly reduce the number of electronic components and cost of design and development of the made equipment.
The results of the experiments carried out of the local and remote automation-monitoring system of the pumping system have emphasized the functionality of all elements and of the overall system.

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