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AUTOMATION OF A NUCLEAR MAGNETIC RESONANCE CONTROL SYSTEM OF THE SECOND-GENERATION ANALYZER

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Abstract: the paper describes the automatic control system of a Nuclear Magnetic Resonance (NMR) Second-Generation Flow Analyzer using the STK500 programmer, with firmware in the assembly language in the ATmega8515 controller.
Keywords: automated, control, electric drive, controller, programming, NMR.

INTRODUCTION

Development of an automated control system and power supply for electric drives for oil production processes, increasing oil recovery and oil preparation is a crucial task that one faces at a later stage of oil field development. Oil production and oil well fluid (OWF) preparation technologies require automatic control systems (ACS) based on flow-through express control of the quantity and quality of well products according to GOST 8.615-2002005 GSI. [1-4].

The aim of the work is to develop a second-generation NMR control system.

SECOND-GENERATION FLOW ANALYZER (NMR II)

In 2008, we received the patent No. 74710 [5] for **NMR II** (second-generation analyzer). Figure 1 shows the analyzer's sampling system, and Figure 2 shows the electrical circuit diagram of the sampler's electric drive, which allows the branch pipe to be installed at the required level in the pipeline during the sampling for oil well fluid analysis. [6]

In order to increase the measurement range of the flow rate and sampling representativeness, the design of the new system is based on a device characterized in that the measuring part of the pipe (that is built into the main pipeline) has a conical extension, and sampling registered by the NMR relaxometer sensor is carried out by a branch pipe that can move along the cross section of the cone. [6]

For automated control of the electric drive of the NMR II sampling branch pipe (Fig. 3), we used a microprocessor control kit from the *ATMEGA* 8515*L* microcontroller; as for the development of the microprocessor, we used an *STK*500 development kit and design system for *Atmel AVR* flash controllers (Fig. 4), marked *SCKT*3000*D*3on the panel.

To program the controller, a connection must be made to the computer via the *COM* port, which can be used for process monitoring and local control.

There are two three-pin connectors designed to connect optical sensors to the end position of the branch pipe on the power board (Fig. 5). The emitter and photo-receiver (simple or composite phototransistor) are securely fixed in the housing of the infrared reflection-type sensors; the optical axes of the emitter and photodetector intersect at a certain angle outside the housing. When the object to be detected is located at the intersection of the optical axes of the emitter and the receiver, the emitter signal reflected from the object is maximal in the receiving point. This leads to a sharp increase in the output current of the phototransistor, which, in turn, is fed to the terminals of the MC.

The *ATmega* 8515 ensures the capacity of 1 mln operations/ second due to the fact most instructions during one machine operation cycle, thus allowing you to optimize power consumption by changing the synchronization frequency. The *AVR* core combines a large instruction set with 32 general-purpose working registers. All 32 registers are directly connected to the ALD (arithmetic logic device), which allows you to specify two registers in one instruction and execute it in one cycle. This architecture has more code efficiency and is 10 times better in terms of production capacity compared to *CISC* microcontrollers. It is supported by a set of tools and software for application

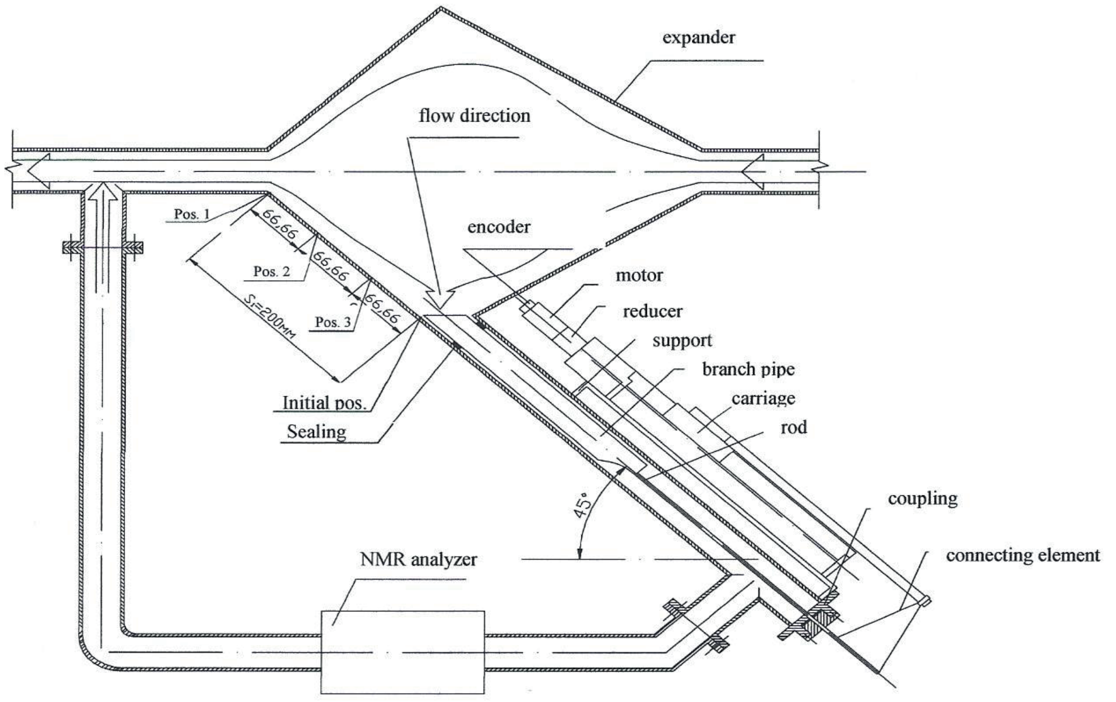

Fig. 1. NMR analyzer sampling system

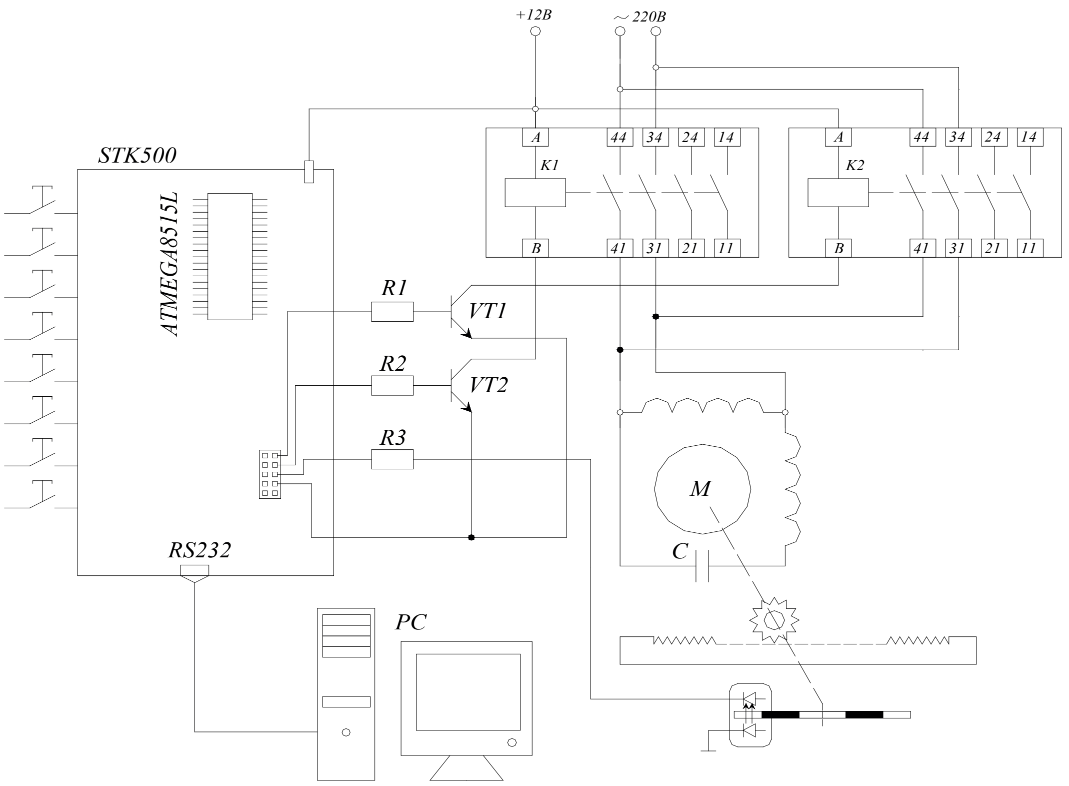

Fig. 2. Electrical schematic diagram of the electric drive of the NMR II branch pipe

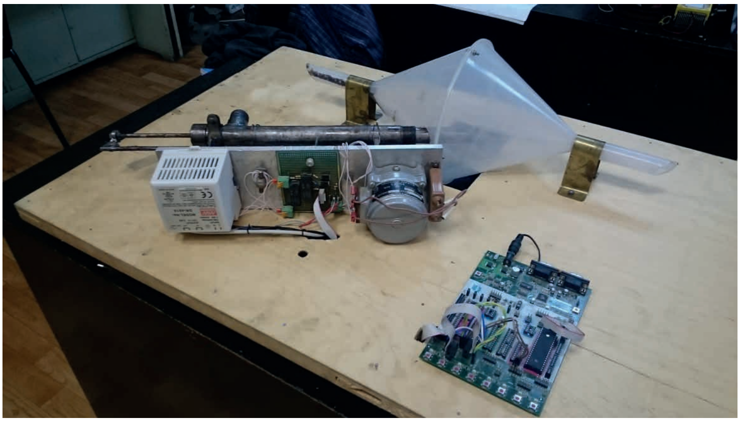

Fig. 3. Second-generation NMR stand

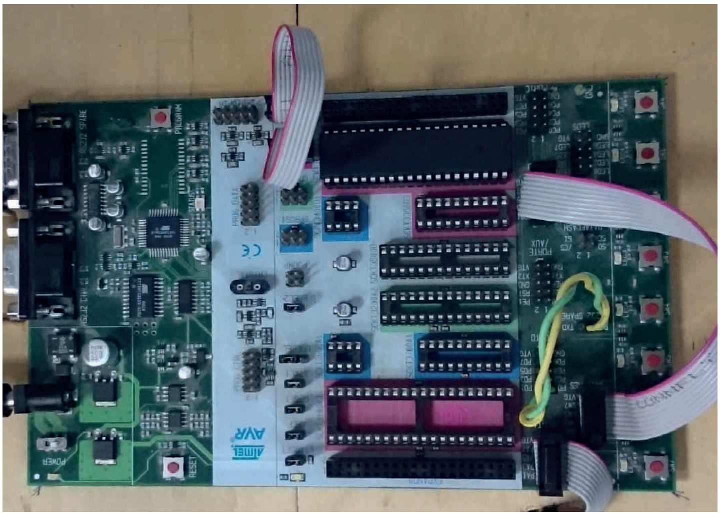

Fig. 4. Board *STK500.*

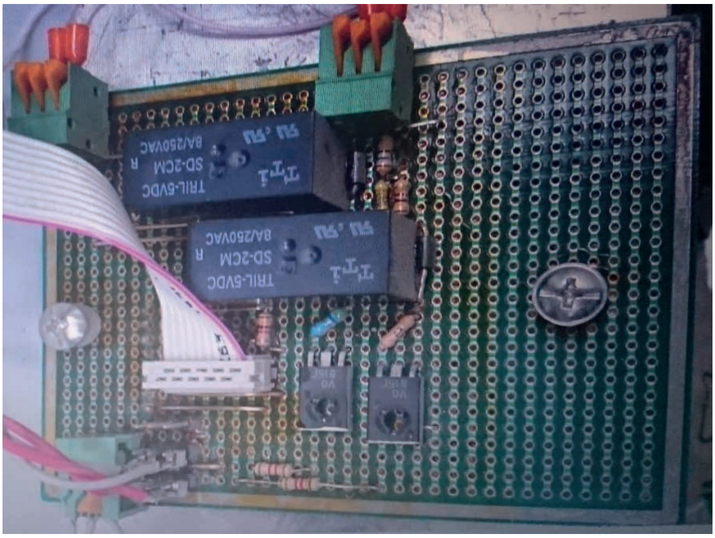

Fig. 5. Power assembly with the connection of a ten-wire cord to the relay.

development, including: C compilers, macro assemblers, debuggers/ simulators, in-circuit emulators, evaluation kits.

The *STK*500 requires an external 10-15V power supply to operate. After all the connections are made, ~ 220 V is to be connected to the *DR*-4515 voltage converter. When the LED indicator is red the power on; the LED status indicator will change from red to yellow and then to green. When the green LED is on the V_{CC} voltage (microcontroller power) is on.

The assembly language program in *ATMEGA* 8515*L* begins to perform the following operations: initialization of the microcontroller; initialization of ports *A* and *B*; timer/ counter 1, universal synchronous/ asynchronous transceiver (*USART*); going into the comparing routine of the accepted start-up code.

The MC receives the command and supplies the voltage of 5V, corresponding to the level of a logical unit, to the fourth discharge of port A, which, in turn, opens the transistor and supplies voltage to the relay coil, after which the drive comes into motion. After the "Forward" signal is produced, the controller carries out a delay slightly longer than an on-delay and conducts the polling of the fifth bit (in case of backward movement, it conducts the polling of the third bit) of port A connected to the second interlock relays.

When you press the *SW*4 button on the *STK*500 board, the branch pipe moves in the period. And when you press the button *SW*6 branch pipe moves back.

SUMMARY (CONCLUSIONS)

1. Controller programming allows you to diversify methods of control over magnetic resonance of a second-generation analyzer;

2. The methods, devices and model implemented for the measurement of the physicochemical parameters of oil well fluid using flow NMR analyzers have the following advantages according to our patents:

- The main pipe can be of any diameter, i.e. the upper range of flow measurement is almost unlimited, and the lower range will be $Q = 0$;

- The sample is supplied to the NMR analyzer by the differential pressure, which is regulated by the position of the branch pipe in the expander, thanks to which no pumps and valves are required, and you can "stop" the flow in the NMR sensor;

- The flow in the pipe is accompanied by following processes: preliminary determination humidity *W*, selection of the dependence of the relaxation rate on the flow corresponding to this *W* value from the computer database, measurement of the effective relaxation time, which can be measured with greater accuracy than the phase and amplitude of the signal and the flow velocity can be measured based on the relaxation rate.

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