CONTROLLER RP-2001

GENERAL CHARACTERISTICS

The RP 2001 controller is a universal microprocessor controller intended mainly to work with frequency converters that supply induction motors.

The main function of the controller is to stabilize a given physical parameter e.g. pressure, liquid level, or flow. In a suitable sensor the value of this parameter is transformed into a current signal of 4÷20mA. Then the parameter can be affected by changing the rotational speed of the induction motor supplied from a frequency converter.

In the basic version the controller is used to stabilize one physical parameter e.g. pressure or liquid level, through the regulation of rotational speed of one pump.

In more advanced versions the controller can control the operation of set of eight pumps with a common output collector. The frequency converter smoothly regulates the speed of one pump, whereas the other pumps are controlled in a two-mode manner (switch on/switch off).

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THE STRUCTURE OF THE CONTROLLER

The main component of the RP-2001 controller is the H8/3048F microprocessor. It is a modern 16-bit processor with analog inputs, a well-developed system of internal means of protection from interference, enabling a freedom of choice in terms of controlling port lines.

This microprocessor receives external information in the form of analog and digital inputs; then processes it and sends out in digital (two parallel ports) or analog form (two analog outputs).

The controller is equipped with RAM static memory and EEPROM, a real time clock system and a well-developed system of inputs and outputs. Optionally it can be equipped with a LCD display that enables easy visualization of chosen parameters of the technological process.

There are the elements of the RP-2001 controller:

- the controller's mainframe with the microprocessor,
- front panel consisting of the external panel with keyboard, panel with light-emitting diodes (LED) and the display,
- additional panel for enlarging of the pump set (optional).

The technical specifications (inputs and outputs) together with the corresponding functions are listed in the table below.

6 analog inputs 4÷20 (0÷20) mA	WA 1 for the pumping pressure WA 2 for the measurement reading of the flow from the flowmeter WA 3 for the measurement reading of the suction pressure or of the level of water in the tank WA 4 for the external signal of given pressure WA 5 ÷ WA 6 additional inputs
8 digital inputs	WC 1 for the controller's start/stop signal WC 2 for the technological interlock WC 3 control of the frequency converter's proper operation WC 4 ÷ WC 8 additional control inputs
2 separated current outputs 0÷20 mA or 4÷20 mA	WYI 1 signal of the given frequency for the converter WYI 2 additional signal (any internal parameter)
8 contacts of output transmitters	K 1 additional contact - special functions K 2 signaling of emergency situations K 3 signaling of the regulation system's proper operation K 4 control of the converter working with the controller K5 ÷ K8 pump control
control of the additional panel	the additional panel can hold up to 16 transmitters, which control up to 8 pumps in a follow-up system, and 16 inputs confirming the pumps' proper operation
pulse input	the water meter's pulse output is to be connected to this input, the controller converts the impulses into a value proportional to the flow
two systems of galvanically separated serial ports	WYJSZ 1 (RS485) for working with the master controller and the frequency converter WYJSZ 2 (RS232) for working with an external computer, telephone modem or radio modem
option	Measurement of active power drawn by the pump set

There are information and control elements located on the controller's front panel:

- LCD text display,
- 3-digit LED display,
- 5 diodes K1 ÷ K5,
- 4 control keys:
  - ENTRY,
  - SELECTION,
  - VALUE CHANGE (+ /–),
- 8 system configuration switches,
- 24 diodes for indication of the mode of operation (8 drives).

The controller is adapted to being mounted in switching stations, on control desks and in the switchboxes.

THE CONTROLLER'S SOFTWARE

The RP-2001 controller's software consists of a few basic blocks:
- block for receiving external information (analog and digital inputs),
- block for display and LED control,
- controller of the stabilized parameter (PID or fuzzy logic),
- block of output relays,
- block of CPU control,
- block for external communication - MODBUS standard.

The controller's software was developed utilizing our wide experience in industry applications, mainly water pressure control systems. As a result a new structure of PID regulator with nonlinear amplification factor and variable integration time was introduced. Such a new structure of the regulator allows obtaining good stability of the system with a minimum regulation error. Also the method of activating and deactivating of the pumps is based on rich experience in operating of pump sets.

The controller's software gives the following new possibilities. It enables:

1. **collecting information regarding the value of pressure, flow, frequency and power from the last 7 days;**
2. **storing all the changes of the modes of the controller's operation e.g. switching on, switching off through a technological interlock, starting of a pump etc., together with the exact time of the event. The system can store up to 1000 event entries;**
3. **collecting information regarding the operation time of particular pumps; switching off pumps that are working too long, equalizing time of operation of particular pumps; switching on particular pumps at a given time, etc.;**
4. **the operation of the pump set without the use of the converter, during fault of the converter or in systems without frequency converters at all;**
5. **making the given pressure dependent on the instantaneous value of flow or on time or on a signal from an external input;**
6. **transmitting data in MODBUS format or the other format, through the serial port to an external receiver e.g. radio modem, telephone modem or laptop;**
7. **for the RP-2001: performing the function of a slave controller in complex control systems using MODBUS as the communication standard.**

AUTOMATIC PRESSURE REGULATION SYSTEM

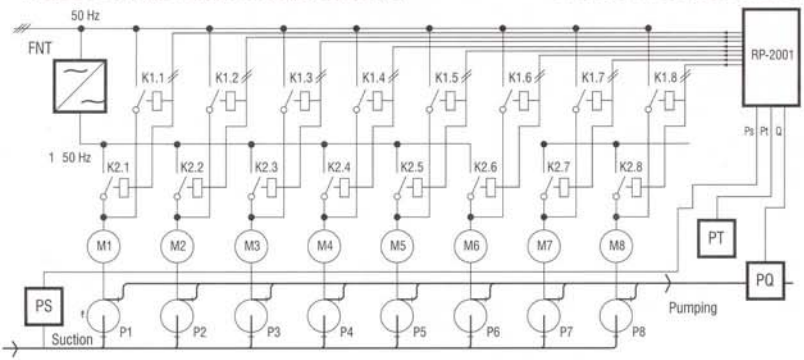
The automatic pressure regulation systems can be applied in the hydrophore plants, pumping stations and water intakes. The presented solution ensures the stabilization of pressure at a level given by the user, in the full range of water flow rate. This is obtained through the smooth change of rotational speed of the pump. The motor is supplied from a frequency converter.

The structure of the system is depicted in the block diagram below.

The common output collector is supplied by eight pumps P1-P8. The FNT frequency converter supplies the one of the pump motor. The motors of the remaining pumps can be supplied with unregulated voltage from mains. The number of working pumps corresponds with the current water flow rate. The pressure in the output collector is measured by the pressure transducer PT. The controller produces the signal of reference speed for the regulated pump. In case, when the measured pressure is lower than the reference pressure, the outgoing signal from the controller increases the rotational speed of the pump until the pressure reaches the given value.

The RP-2001 controller also decides when switching on and off the motors of the remaining pumps. The RP-2001 controller switches the unregulated motors using intermidient relays and contactors.

The functioning of the automatic pressure regulation is as follows: when there is a single pump P1 working (K2.1 contactor switched on) and the pressure in the output collector is lower than the given pressure, the controller through the frequency converter increases the pump's speed, thus increasing the pressure. In the case when the pump reaches its rated speed and the pressure is still lower than the given value, the controller switches the K2.1 contactor off and the K1.1 contactor on. This will cause the M1 motor to be connected directly to mains. Then, by switching the K2.2 contactor on, it will cause the M2 motor of the P2 pump to be supplied from frequency converter. The increasing of speed of the P2 pump will lead to a situation where the given pressure in the output collector has been reached. If, after a certain period of time, it turns out that the P2 pump has reached its rated speed, and the pressure is lower than the given pressure, the M2 motor will be connected directly to the mains and the P3 pump will be activated by the frequency converter.



In a similar way the pressure regulation takes place. When the real pressure is higher than the intended, the unregulated pumps are being switched off. The speed of regulated pump is brought down to a minimum value and the unregulated pump is switched off, in order to obtain the value of real pressure smaller than the given value. Afterwards, the regulated pump's speed is being increased until the given pressure value has been reached. Of course, the pump switched off is the one that was in operation for the longest period of time.

In the presented method of regulation, the water pressure in the output collector of the pumping station is stabilized. The given pressure value is chosen in a way to ensure the continuity of water supply to a recipient whose location with regards to the pumping station is the most inconvenient.

The most inconvenient location of the recipient corresponds with the biggest pressure drop in the network during the maximum water flow rate.

In the time of minimum flow rate the pressure drop also reaches its minimum level. In the network, there is overpressure at the recipient's location. This causes the increase of water losses, as well as increases the failure rate of the network and of the deliveries. The failures are sources of additional losses, it means, that during the increase of pressure above a necessary level, the water losses grow faster than the pressure does. The power consumption is approximately equal to the product of multiplication the values of pressure and water flow.

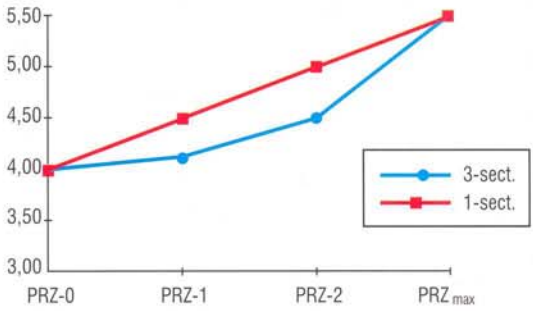
The Compensation of Pressure Drops in the Network

The best solution to do this is the pressure regulation at the recipients' locations. In the case of an extensive network it requires the pressure to be measured at a chosen regulation points and the control of the pumps located there (or through valves system). This solution has to be based on well-developed telemetric and remote control systems linking the remote facilities and the main computer.

The intermediate solution, which is just slightly worse but much simpler and cheaper than the model solution mentioned above, is the automatic pressure regulation in the pumping station's output collector, with the compensation of pressure drops. This is achieved by making the given value of pressure to the controller dependent on the instantaneous value of the flow.

The pressure controller is designed to work with the PQ flow sensor. The given pressure is dependent on the instantaneous value of water flow. The minimum given pressure depends on the minimum water flow, as well as the maximum - with the maximum water flow, which has been set during the configuration of the controller's parameters. The increase of flow causes the increase of given pressure. The characteristics, given pressure/flow, can be set as linear or broken line characteristics with maximum 7 breaking points, depending on the needs.

Example linear and three-segment characteristics are illustrated on the chart.



PRZ-0 - zero flow,
PRZ-1 - flow at the first breaking point,
PRZ-2 - flow at the second breaking point,
PRZ_{max} - maximum flow value set during the setting of the controller's parameters.

In this case the setting of pressure is based on:
- the adequate selection of the minimum pressure, that guarantees satisfactory pressure at extreme points of the network during the minimum flow rate
- the adequate selection of the maximum pressure that guarantees inflow of water in the case of maximum flow,
- determining the maximum water flow at maximum water flow rate and setting this value as a percentage of the maximum measuring range of the flowmeter.

OTHER APPLICATIONS OF THE RP-2001 CONTROLLER

1. Liquid Level Regulation

In this case the regulated parameter is the level of liquid in the tank that is supplied or emptied by a single pump or by set of several pumps. The regulation method and the structure of the system are identical as in the case of pressure regulation. The controller receives a measurement signal of 4÷20 (0÷20) mA from the level transducer.

2. Stabilization of the Percentage of Oxygen in the Sewage

The system is frequently used in water treatment plants. The measurement signal comes from an oxygen probe. The stabilization of the percentage of oxygen is obtained by controlling a set of blowers that are driven by asynchronous motors. One or two of the blowers are smoothly regulated; the others operate in a two-mode manner. There is a possibility for one regulator to work with many oxygen probes. The control is based on fuzzy logic methods. In a system containing up to 6 blowers, the RP-2001 controller provides the control of additional drives (shield ventilators and fan of driving motors).

3. Simplified Regulation Systems

There is a possibility of simplifying the described regulation system. The motor of one drive is supplied from the converter whereas the remaining motors can only be supplied directly from mains. In such a case, the number of contactors and intermediate relays used is lower. The simplified version of the RP-2001 controller can be employed to regulate the pressure of a single pump with smooth speed regulation, most often in water intakes.