Beniamin **ANTONCZYK**
Leszek **NOWAK**

MODERNIZED VENTILATION CONTROL SYSTEM

Abstract. The paper describes the modernized control system for ventilation system installed in the JBR-15M mobile radar station. Previous arrangement is presented along with its deficiencies. Proposed solution options are shown in block diagrams. The effects of the new solution are summarized in conclusions.

Keywords: control system, ventilation system, JBR-15M mobile radar station.

1. INTRODUCTION

This paper describes the ventilation control system in the JBR-15M mobile radar station. Harsh operating conditions and the wide range of operating temperatures require the use of a ventilation system to ensure proper operation of electronic equipment. The station is installed on a TATRA-815 4-axle chassis. A Transmitter-Processing Cabinet (KNO-15) which houses electronic equipment and control system for all units of the station is installed on the frame. Operating conditions of the station meet the requirements specified by the Armament Inspectorate of the Ministry of National Defence. The operating temperature range of JBR-15M is from -40°C to +55°C, wind velocity up to 30 m/s. Maximum precipitation up to 200 mm/h, max. humidity 98% at +25°C [1].

The station is equipped with a complete 3-axes radar with an antenna system enabling automatic detection and tracking of up to 120 objectives at an altitude of up to 30 km. Radar operates in the S band, a fragment of the electromagnetic spectrum within the microwave range (2-4 GHz), which is typical of the 10-cm radar systems (1.55 to 5.2 GHz).

Control systems of the mobile platform governs all units, both electric and hydraulic, and the total time to prepare the platform for operation is 20 minutes.

Fig. 1 shows the JBR-15M station with indicated dampers and air inlets of the ventilation system.

Beniamin **ANTONCZYK**, Leszek **NOWAK** – Ośrodek Badawczo-Rozwojowy Urządzeń Mechanicznych „OBRUM" Sp. z o.o., Gliwice

Fig. 1. JBR-15M radar station with indicated ventilation system inlets

2. VENTILATION CONTROL SYSTEM

The JBR-15 series is provided with two versions of ventilation control systems. Each of the systems consists of relays, electronic systems mounted on printed circuit boards and automation system components installed in the control box for damper movement (SRK), mounted inside the KNO-15 cabinet. The cabinet includes, depending on the version, a PLC controller and/or a set of electric relays. These are responsible for operation of electric actuators that move the external and internal dampers to modify the flow of cooling air. Correct operation of this system is necessary to ensure proper operating temperature for the electronic equipment that makes up the radar system. However, the existing solutions provide insufficient control of damper position, failures, jams, as well as annunciation of damage in mechanisms affected by atmospheric conditions. In order to solve the problem a new modernized control system for the ventilation system was designed (implemented in the SRK control box), equipped with the new control unit and new electrical components, as well as new control software for the whole system.

2.1. Identification of control system problems

The current control system was examined in order to identify existing problems in the control system.

The most important requirement was the limited power consumption by the control system. The limit value is 5A at 24VDC, of which, depending on the temperature, approximately 0.5A is necessary for the operation of the programmable controller (PLC). When power consumption exceeds 5A, the PLC or the motor of the linear actuator may be permanently damaged.

The second extremely important requirement is the tight closing of the external dampers (2 upper dampers and 2 lower dampers - Fig. 1) in order to seal off the KNO-15 cabinet for the filtration and ventilation system.

Damper jamming detection is also desirable. Particularly important is the detection of damper locking as a result of damper freezing to the seal, which can occur when the station becomes frosted at low ambient temperature.

Customer's principal specifications indicate that the new control system should:

- be based on the existing electrical system and wiring of existing connections;
- prevent current rise above permissible value;
- operate in unmanned mode;
- automatically repeat damper opening and closing operations in case of blocking.

2.2. Control system – current status

In the first production series of JBR-15 stations a simple electric system based on two-conductor power supply wiring for each of the actuators was used. Opening and closing of the dampers was effected by means of a time relay which allowed operation of each actuator for a set time. This system, however, was prone to frequent failures. Relays and actuators responsible for ventilation damper movement often broke down. There was no information in the system about the positions of the dampers. The wiring system used did not allow obtaining more information on the positions of external dampers. Internal dampers, each provided with two common limit sensors, placed in opposite positions, warranted correct operation of the system only when both actuators operated in a uniform and concurrent manner, which was difficult to attain.

After the first upgrade, the JBR-15M vehicles were provided with an expanded control system installed in the SRK box. That system was fitted with a Compact-F PLC from INTER CONTROL [2], which controlled operation of the actuators via relays. That controller is a device designed for use in mobile equipment. It has an IP66K protection rating and its lower operating temperature limit is -40°C. A pictorial diagram of the control system is shown in Fig. 2.

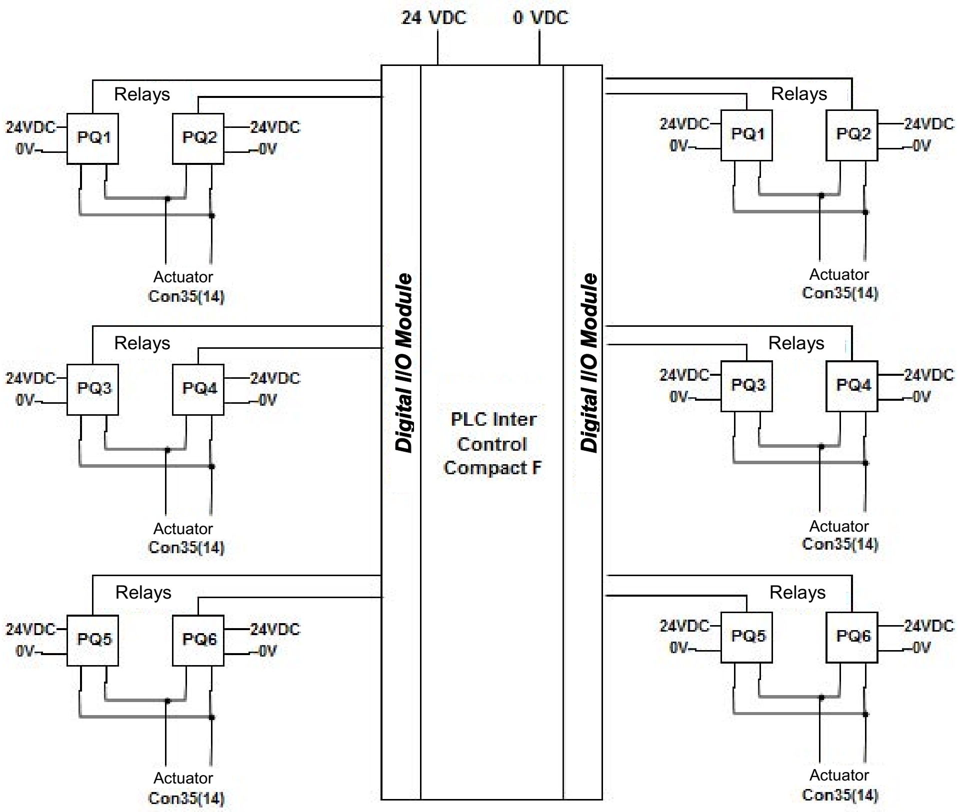

Fig. 2. Control system - first upgrade (block diagram)

The PLC could not directly control the actuators in the system due to permissible current load of controller outputs. For this reason intermediate relays were introduced to energize the ventilation damper actuators. In addition, connectors were installed in the KNO-15 cabinet to enable connecting Hall sensors of the electric actuators. Despite these changes, the control system still did not work properly. Damages occurred in the actuator drives and in relays due to jamming of the actuators during operation, which in the case of direct current motors resulted in short-circuit operation. The PLCs themselves were also damaged occasionally. High current input of ca. 4A in each actuator during low ambient temperature operation posed a risk of failure of the actuator drive electrical system.

2.3. Proposals for the modernization of the control system

Work on a modernized control system began with intensive testing of the mechanical system of the dampers to locate problems and possible sources of faults. Tests were carried out for the following system components:

- Inter Control Compact-F programmable controller [2];
- Concens Con35(27) linear actuators [3];
- Concens C2-10 microprocessor control systems (printed board with a microprocessor system) [4];
- Electromen Oy LTD EM-241A-V1.5 microprocessor control systems (printed board with a microprocessor system) [5].

After preliminary testing of each component in a climatic chamber, three independent solutions were developed in parallel in order to observe the results.

First of the proposed solutions [6] included ventilation system control based on the PLC system clock. By incrementing or decrementing a counter corresponding to a ventilation system damper, it was possible to obtain information on the relative and approximate position of the damper. In addition, Concens C2-10 [4] controllers were used which had a limited current input and which provided a warning when a set limit was exceeded. This happens when the damper becomes jammed forcing a short-circuit operation of the actuator. However, the delays generated in the control system caused summation of position errors. This led to inaccurate closing of the dampers, which is one of the key requirements needed to maintain the tightness of the KNO-15 cabinet. Tests were carried out for three various clock values: 10, 25 and 50 ms. The best results (dampers operated in a symmetrical manner during both opening and closing, damper position calculated by the controller matched the actual position of the damper) were obtained for the value of 25 ms, which could be due to the clock frequency of the microprocessor on C2-10 board [4].

Block diagram of this solution is shown in Fig. 3.

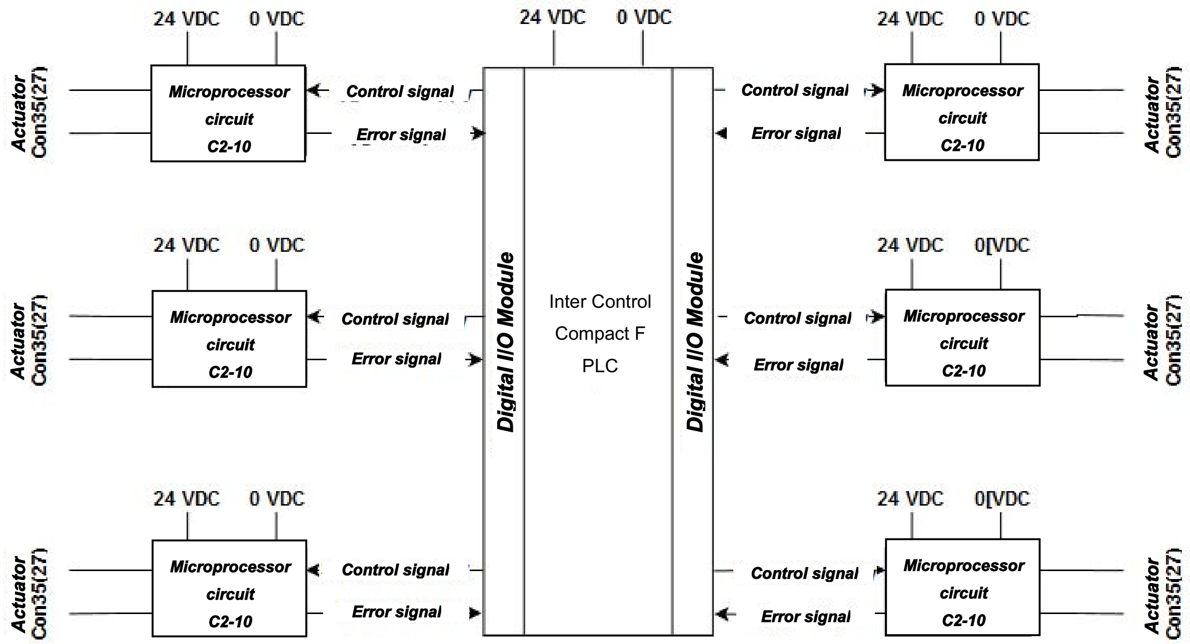

Fig. 3. Modernized control system – proposition no. 1 (block diagram)

The second of the proposed solutions was similar to the first one (Fig. 3), with the additional use of the error signal (short-circuit operation) as information on the closure of external dampers. Such a system makes it possible to calibrate the basic (closed) position of each of the external dampers. The problem arising with such arrangement is the possibility of blocking the dampers during closing, which may be misinterpreted by the controller as the correct closed position.

The third proposed solution includes modified enclosures of actuators of external dampers. The proposed location of Electromen EM-241A-V.5 [5] controllers is under the enclosure of each external damper. This solution enables the use of signals from Hall sensors even in the old radar station models. This system makes use of two separate control systems. PLC and microprocessor control systems exchange messages on incorrect operation of the actuator or information about the completion of the flap opening or closing process. EM-241A-V1.5 controllers [5] control the movements of each ventilation damper, and the PLC supervises the operation of the ventilation system and generates control signals in case of failure or mechanical jamming of any of the dampers.

Block diagram is shown in Fig. 4.

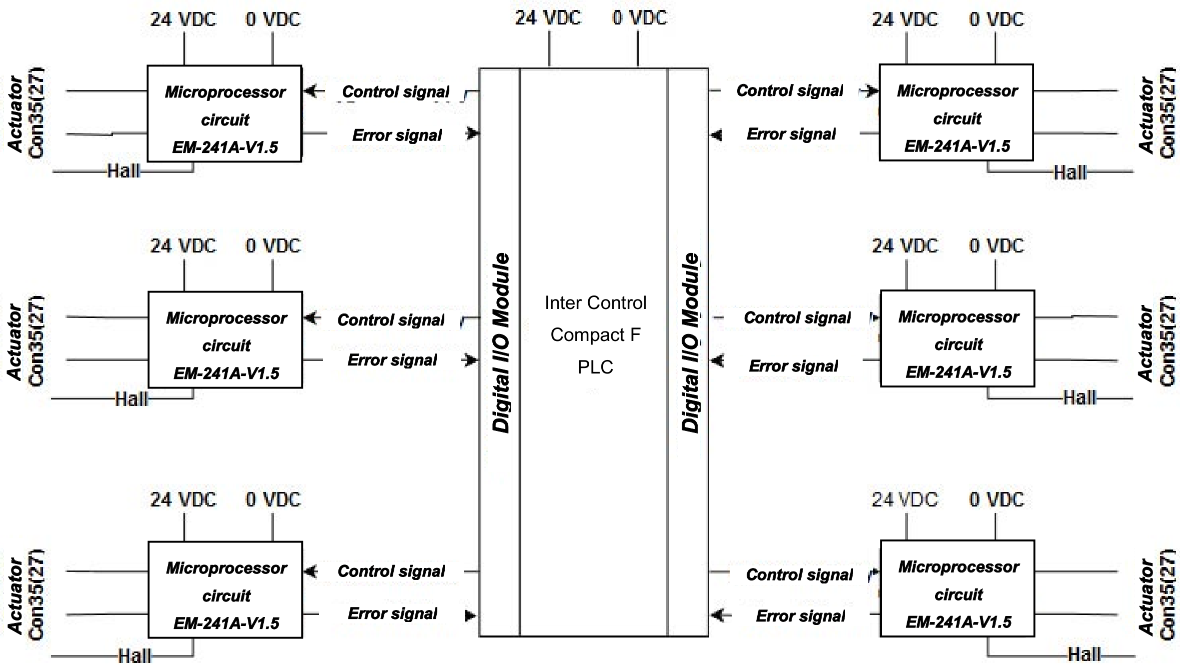

Fig. 4. Modernized control system – proposition no. 3 (block diagram)

2.4. Modernized ventilation control system selected by the procuring agency

As a result of analysis of the advantages and disadvantages of each option, solution number three was selected as compliant with the requirements set and approved for implementation in JBR-15M in the form of an upgraded SRK box. The modernized control system currently includes INTER CONTROL Compact F controller [2], six CONCENS C2-10 microprocessor systems [4] and an electrical current adjustment system.

The modernized control system installed in the SRK box is shown in Fig. 5.

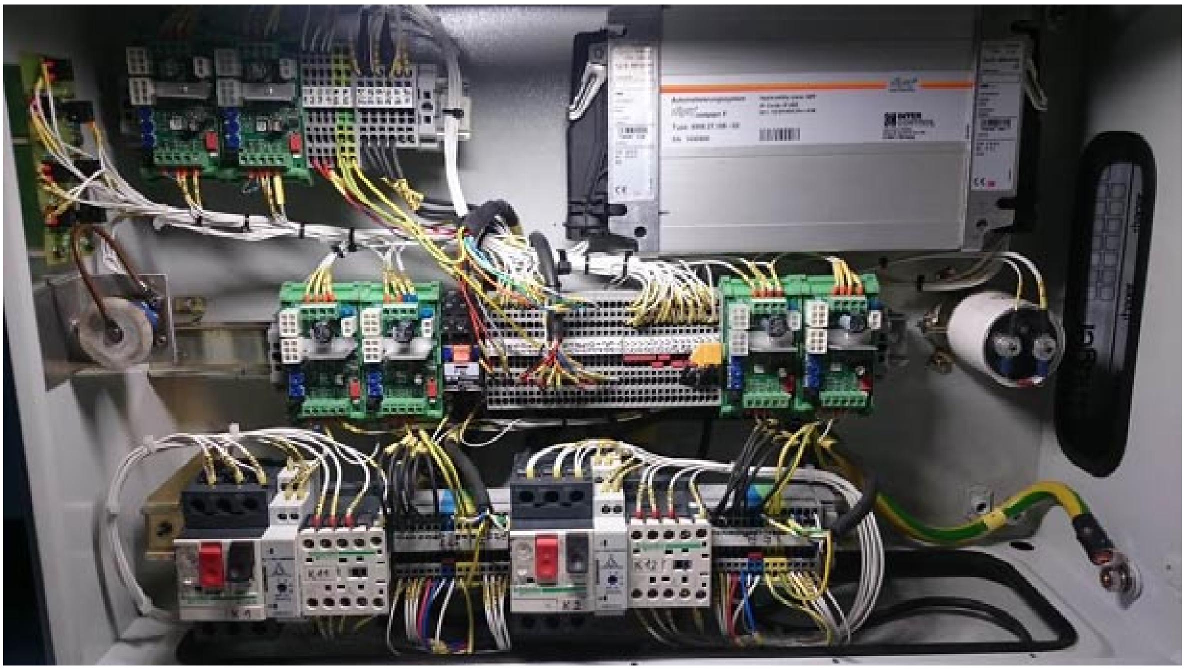

Fig. 5. Modernized control system installed in the SRK box

3. TESTING OF THE MODERNIZED CONTROL SYSTEM

The control system was tested in accordance with the programme included in the Test Log [7] developed by the authors of this paper and accepted by the client. The tests comprised:

- checking proper operation of the SRK control system at ambient temperature;
- checking proper operation of linear actuators under equivalent load;
- checking of vibration resistance;
- checking of resistance to variable climatic conditions between -40° and +50°C;
- checking operation of actuators at low ambient temperature of -40°C;
- practical checking of the modernized control system on the JBR-15M station.

The modernized ventilation control system passed the control tests. The new control system, the layout of which is shown in Fig. 5, was approved for series production.

4. CONCLUSIONS

The adopted solution meets the requirements for electromagnetic compatibility standards of the platform. Changes in the existing wiring system may result in a failure to meet these requirements.

The developed, tested and implemented solution:

- improves the failure rate of the control system;
- improves the safety of the system operation;
- ensures high mechanical and electrical reliability due to a number of safeguards (thermistors, microprocessors, current input control);
- facilitates calibration of the control system;
- ensures detection of damper opening errors and automates reopening of dampers.

5. REFERENCES

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