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DISTRIBUTED SYSTEM FOR MONITORING ELECTRO-HYDRAULIC DRIVES

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Abstract: *The paper presents a short-overview of a distributed monitoring system designed for hydraulic drives that allows immediate access to system performance measurements, behaviour analysis over time, and maintaining the hydraulic systems in the most efficient working manner. The monitoring system was implemented on various applications in industry (metallurgic field), in training equipment for aircraft personal and in laboratory equipment.*

Keywords*: Monitoring, process data, programmable controller*

1. Introduction

Monitoring hydraulic equipment, respective components, can be achieve in two different ways: a simple approach that mean simple measures for component monitoring, and an advanced way based on the methods of signal acquisition and conditioning.
Conceptually, the monitoring system was designed as a distributed system which allows users and other applications outside it to interact with it in a uniform and coherent manner. The system components are placed on interconnected processing units, in both hydraulic and informatics levels, and their actions are communicate and coordinate by messaging. The convenient and secure online access to system condition allows taking the best decisions regarding system operation.
The monitoring system functionality is implemented on a programmable controller at hydraulic level, on computers network at information system level and the software application created is based on event-driven approach.

2. The monitoring system architecture

The monitoring system is designed for electro-hydraulic drives so the main support for it is a processing unit placed on hydraulics, that mean electronics, microprocessors, PLCs or process computers. These process units have implemented both control and monitoring application for hydraulic drives using.
At the information system level there is a one or more PCs running a software application - Operator Console and standard DBMS. The operator console provides data reception from the hydraulic drive, stores the data in the database, and displays the process data locally in numeric or graphic form.

2.1 Hardware architecture

The system concept was implemented on various applications and for each one on the hydraulic level the hardware support chosen was a common PLC (figure no. 1). For the informatics system it was used a PC running the operator console and one or more PCs running the DBMS. The process data transmission at the PLC level was ensured by a serial data line: Ethernet, RS485, and Wi-Fi.

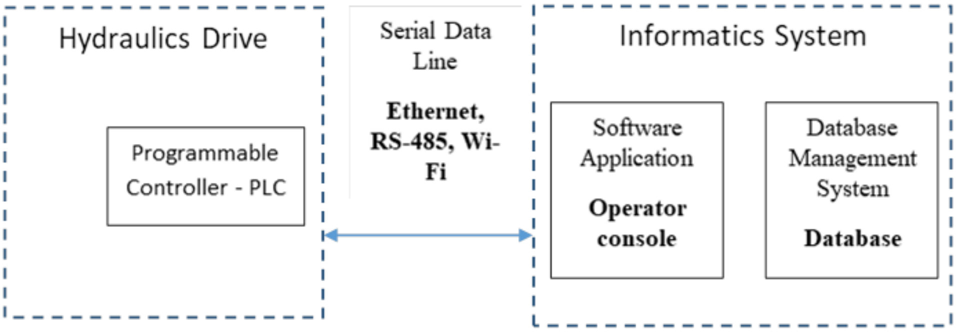

Fig. 1. Hardware architecture

2.2 Software architecture

The functionality of the monitoring software is provided by three components: first is the monitoring level running on Programmable Controller, the second component is Operator Console that's running on the PC System and the third component is the DBMS. It have to say that this paper refers only to the first two components mentioned below (figure no. 2).

The monitoring software running at the programmable controller level consists of a program loop that runs at within 20ms. This allows a monitoring rate of 50 samples/s for each monitored process quantity. Within these loops are packed the process data that will be transmitted to the operator console application.

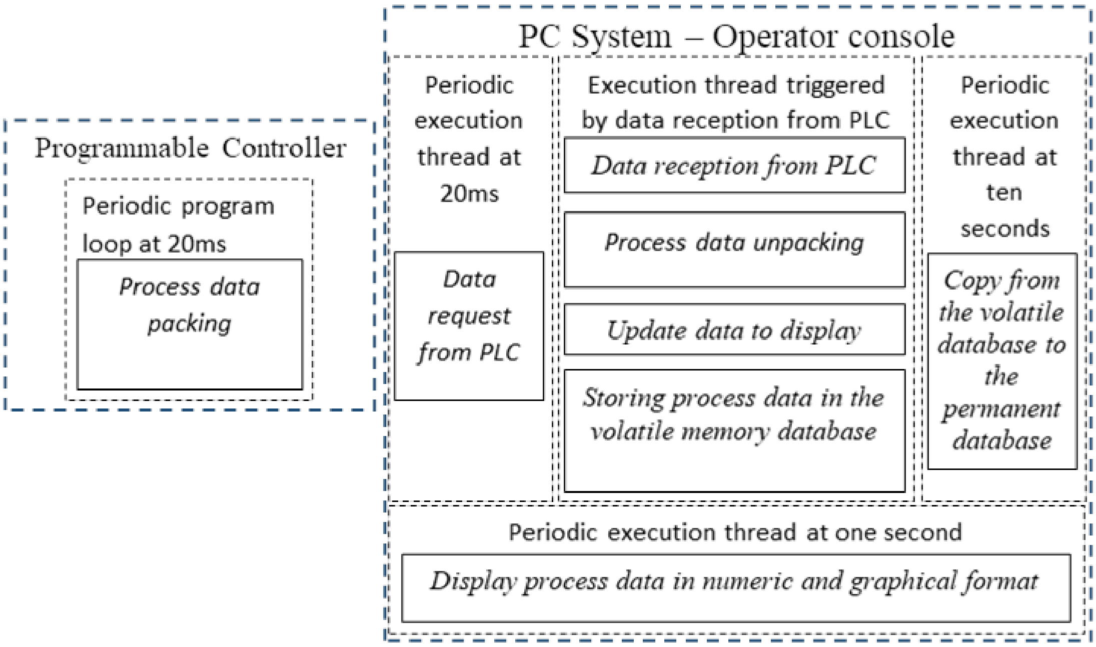

Fig. 2. Software architecture

The operator console software application has a 4-thread parallel execution structure. A thread executes periodically at 20ms to make a data request to the PLC through the data line. The second thread is triggered by PLC data reception and its functions is to unpacks the received process data, prepares data for display (PLC formats in real units), and stores data in a local database in volatile memory and PC. The third thread executes periodically at a time of 1 second, displays the process data in numeric or graphical format in the application panel. The fourth thread is executed periodically at a time interval of 10 seconds copies the data from the temporary database to the permanent one.

3. Practical implementation of the monitoring system

3.1 Electrohydraulic system for winding rolled wire

The concept of distributed monitoring system was implemented on various applications in industry, in training equipment for aircraft personal and in laboratory equipment.
In the metallurgy field the monitoring concept was used on the electrohydraulic system for winding rolled wire (figure no. 3). This ensures wire stringing on spool coil by coil, by controlling movements of the debugger head, adapting itself to changes in spool rotational speed; spool rotational speed is dictated by the rolling process parameters and also the wire load of the spool that is diameter of the coil being wound[1].
This electrohydraulic system contains a linear axis consisting of a bilateral rod hydraulic cylinder, on its liner being located the debugger head, controlled with a proportional flow distributor. H*ardware components* of the monitoring system contains *sensors* for monitoring spool rotational speed and the speed of the debugger head, *electronics* necessary for interfacing the execution elements and transducers with the *programmable controller* (figure no. 4)
Software components consist of *software* application that running on PLC and the operator console and the DBMS. The PLC software implements both the control of the mechatronic system and the monitoring features. This application has two data communication lines, a serial RS485 line with MODBUS protocol implemented to connect the PLC with the operator console, and an Ethernet line, that allows TCP / IP networks connection between the operator console and the company server where the DBMS was implemented [1].

Fig. 3. Winding roller

Fig. 4. Electric cabinet

The operator console (figure no.5) displays the process data locally in numeric or graphic form and allows connection with the DBMS to stores the process data in the database. The graphic shown in figure no. 6 is obtained with DBMS stored data.

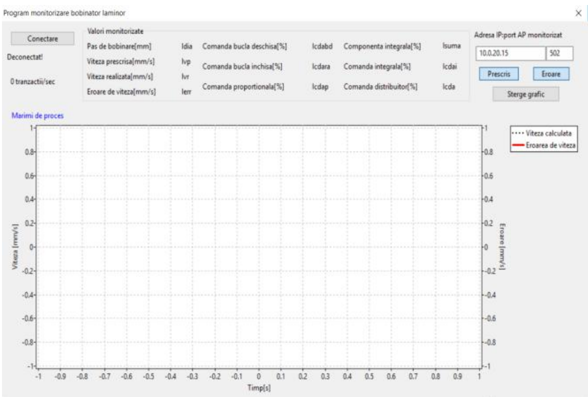

Fig. 5. Operator console

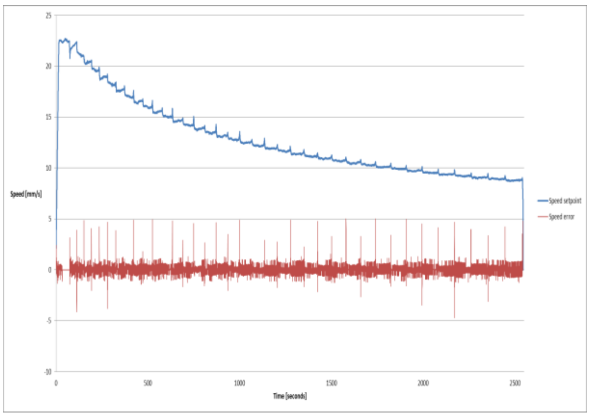

Fig. 6. Data process for one coil

3.2 Electrohydraulic actuation system for Cabin Emergency and Escape Trainer CEET B732

The electro-hydraulic actuation system is used on the Cabin Emergency and Escape Trainer CEET B732 for the Sea Survival School Tuzla (figure no 7) [3], and also implements the concept of distributed monitoring system. The monitoring system hardware contains sensors and PLC (figure no 8) at the and a single PC that contains the operator console and DBMS. Interfaces with data communication networks, namely the master-slave network implemented on RS485 communication line and the TCP/IP network implemented on Ethernet line. The PLC software application allows parameterization of the control system and updates both pseudo-analog (Pulse Width Modulation) and discrete outputs. The arithmetic on PLC is based on 16 and 32 bits words; for this application the calculus is made only with 16 bits signed words. Taking into account that the PLC arithmetic operation has only two operands, for the calculus of the error value (one of the monitored parameter) was used the PLC feature that could execute the program loop in fixed program execution time (for this application it was used 50ms scan time)[2].

Fig. 7. The Cabin Emergency and Escape Trainer

Fig. 8. Electric cabinet

The electro-hydraulic system has been tested for two command inputs types: for a ramp type and for a step type and the monitored value was positioning error. In figure no 9 is shown the experimental results obtained for a ramp type excitation signal (the dashed line) with a 17mm/s speed value. The positioning error (the continuous line) is 4 mm for a positioning range of 500mm; this error can be minimized by introducing in program a derivative component of error. In the figure no 10 is shown the results obtained for a step type input signal. The settling time for a 250mm step value is 2.5s. In this case introducing in command a derivative component of error would worsen the system response; respectively the settling time and the overshooting value would increase [2].

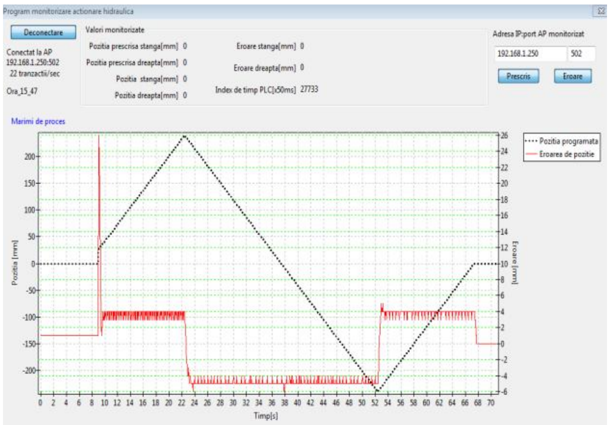

Fig. 9. The operator console – ramp type input signal

Fig. 10. The operator console – step type input signal

4. Conclusions

The distributed system for monitoring electrohydraulic drives is designed to be used in various application in different field form heavy industry to laboratory equipment, and its main advantages are:

- Changing and adjusting the operating algorithm, for each kind of application, only requires rewriting software in the PLC, operator console and updating DBMS;

- Due its communication capabilities via Ethernet it can be integrated in a tracking IT system;

- Using new devices coupled to the serial bus, additional functions can be implemented on the process units, namely new parameters monitoring or control;

- The PLC that implements the monitoring program may be equipped with HMI console (human machine interface).
- Continuous monitoring allows early detection of potential issues and prevents unnecessary downtime for unneeded maintenance.

Acknowledgments

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