Integration of the Hydraulic Linear Axes in a Computerized System

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Abstract

Hydraulic drives offer advantages in terms of precise control of forces and couples shareholders involving large values and aggressive working environments. Another advantage of hydraulic power drive is getting some great value in a very small geometric volume. Using principles of mechatronics development enables the obtaining of hydraulic drives consisting of mechanical components, hydraulics, electronics, sensors, software that can be naturally integrated into computerized testing stands.

The material presented refers to experimental research conducted by authors focused on integration of linear hydraulic axes into a computerized system.

The original contribution regards the development of a digital servocontroller for monitoring and control of the position and force of a hydraulic axis and introduces the concept of "mechatronic tier" for an easy connection of a mechatronic device, hydraulic drive, with a computer system.

Keywords

Hydraulic drive, robotics, mechatronics, position control, servocontroller

Introduction

Hydraulic systems uses as work environment a liquid under pressure. They have appeared and developed rapidly, mainly due to the need to control and regulate the forces and moments large and very large with high precision, while they allow control of load position and velocity involved. Need to integrate the hydraulic systems is justified by the increasing complexity of automated technological facilities, increasing efficiency and productivity requirements ever higher rates as well as computerization of the manufacturing process.

Widespread use of hydraulic machinery in manufacturing combined with production tracking systems requires complex measurements of parameters to be sent computerized systems. Integration of mechatronic assemblies in the hydraulic equipment allowing to measure and transmit the measurements to computer systems facilitates the manufacturing process.

The evolution in "embedded systems" linked to the emergence of new types of sensors and methods of measurement of physical quantities specific hydraulic machinery allow these assemblies mechatronic approach in cooperation with European research units that have interests in these areas. Were developed technologies to build a computerized system that includes a layer of hydraulic equipment interface and a electronics "digital servocontroller" that monitors and controls the hydraulics.

Based on original technology was implemented a multitier IT application layer containing a "mechatronic tier" that integrates hydraulic linear axis, the hydraulic axis is controlled and monitored by a digital servocontroller. The experimental results confirmed the achievement of outstanding performance in terms of static positioning accuracy.

Figure 1 shows the functional block diagram of the hydraulic stand used for experimental research to demonstrate the functionality and usefulness of the proposed solution. The hydraulic stand shown in figure 2 was purposefully created for testing dampers in order to determine the characteristics force speed, force stroke. The stand comprises a linear hydraulic axis controlled in position by means of a flow servo valve on the base of the data supplied by the position and force transducers. The stand electronics is realized as a standard electronic module with assembling on DIN track, providing all the required operations for the control and monitoring of the hydraulic axis and the interface with the computer system.
The hydraulics

The driving ensemble, fig. 2, consists of a hydraulic cylinder with double rod. The cylinder is driven by a flow servo valve. Parameters of driving in the hydraulic cylinder rods are 200mm stroke, speed 0.66m/s, force 1100daN. Hydraulic power has the following parameters pressure 150bar and flow 90dm³/min.

The sensors

On the rod of the hydraulic cylinder are mounted two sensors, fig. 3, one for measuring the rod position and another one for measuring the driving force. Position sensor is the LVDT (Linear Variable Differential Transformer) type having a fixed body and a sliding rod. The sensor body has two magnetically coupled coils by the rod. Coupling factor is altered by rod movement. The measuring range for the LVDT sensor is 0...200mm. The force transducer is a strain gauge load cells type with built-in electronics in the -5000daN...5000daN range.
The electronics

The electronic module, the digital servocontroller fig. 4 and 5, is based on an 8 bit microcontroller.

![The electronics - functional block diagram](image)

The main functionality of the servocontroller is to provide the driving signal for servovalve to minimize the error between setpoint value and the measured value for the position (or force) of the cylinder rod. Another function is to interfacing the servocontroller with the position sensor and the force transducer and to converting the values of position and force in a numerical form. Force setpoint and position setpoint signals, is also converted into numerical values. Finally the servocontroller assure the physical link with informatics system.

The software

Multitier applications are used in implementing information systems that allow multiple users simultaneous access to the system and the data and the processing programs are separate, are a typical example web application. Multitier system architecture refers to a physical structuring mechanism for software modules (where the program runs).

The servocontroller runs a software that I ensure functionality. The software is build using event-driven technique in C programming language. At servocontroller level is assured a PID regulator for position and force. Also software calculates the speed value for cylinder rod.

![Software](image)

The PC software is designed as a multitier application, fig. 6. The top tier is “client tier” - the operator panel. The bottom tier is “mechatronic tier” which is a server application for the client tier. The mechatronic tier

is developed using DCOM (Distributed Component Object Model) technology from Microsoft as an ActiveX component. The mechatronic tier assures the interface with the servocontroller.

The development of the applications operation client and parameterization of the hydraulic stand is substantially simplified through the incorporation of the implementation details of the physical and logic interface in the software components of the mechatronic tier.

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Experiments

Figure 7 and 8 shows the experimental characteristics of the rod position - positioning error at 1mm/s rod speed value.

![Figure 7: Sinusoidal excitation with a frequency of 2.5mHz value. On X axis is the rod position in mm](image)

![Figure 8: Triangle excitation with a frequency of 2.5mHz value. On X axis is the rod position in mm](image)

Conclusion

The experimental results confirmed a positioning accuracy of 0.1mm (0.05% of the actuator race), field monitoring of velocity of 1mm/s ... 1000mm/s and a link speed between computer and servocontroller of 50transactions/s. Experimental research conducted by the authors confirmed that the hydraulic axis performance allowing its use in robotics and informatics systems for manufacturing.

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