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NEW DIGITAL CONTROLS outperform proportional electrohydraulics

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Modern world is driven by digital electronics, thanks to its typical benefits in comparison with analog technology.
In the motion control industry, innovative axis digital controls are now available, offering excellent accuracy, repeatability and full programmability, with simplified repairing and maintenance.
Some valuable applications of new digital controls on Atos line of proportional electrohydraulics are described below.

Modern world is driven by digital electronics: computers, automation systems, cars, aerospace, telecommunications and advanced network are all based on digital technology… …thanks to its typical benefits in comparison with analog technology: fast and powerful data processing, easy programmability, high immunity to electromagnetic noise, process signals and parameters data storage.
In the last decade digital electro-mechanic drives have been largely diffused and appreciated for axis motion controls in all the industrial automation fields owing to their ready to use configuration, easy interfacing with electronic control units and standardization of mechanical/electrical interfaces and performances.
Innovative digital axis controls are now available with excellent accuracy, repeatability and full programmability to any application, also ensuring simplified repairing and maintenance.

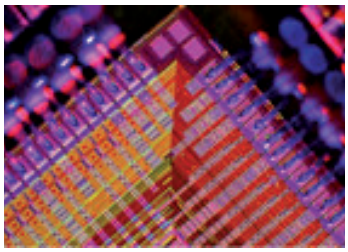

Fig. 1 - CMOS submicron technology

Recent developments in CMOS (fig.1) technology and new DSP processing units make feasible the integration of digital electronics in proportional electrohydraulics thus covering the gap towards electromechanic axis whilst adding the peculiarities of hydraulic technology: high power density, energy storage capability, intrinsic overload protection, low mechanical wear, long service life, direct realization of linear movement (simpler mechanics).

As a result of a 5 years R&D project, Atos has finalized the introduction of new digital controls on its line of proportional electrohydraulics already achieving hundreds of successful applications: some the most valuable developments are described in the following.

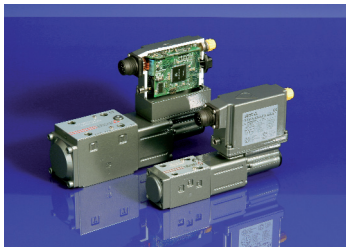

Fig. 2 - New digital electrohydraulic control unit

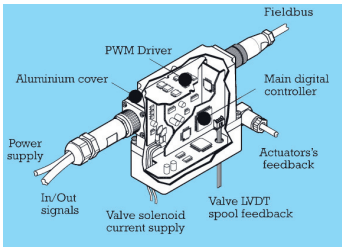

Fig. 3 - Digital driver architecture

Directional control valves

Proportional directional valves regulate the oil flow to oil ports of hydraulic actuator (cylinder) and with new on-board digital electronic (fig.2) perform any closed loop control (position, speed, acceleration), once provided with the appropriate position feedback signal by local electronic transducer on the controlled actuator.
The Atos innovative digital units provide signal acquisition, solenoid's current driver and valve's control (fig.3); they perform complex data elaborations in efficient way thus outperforming the traditional analog valves in terms of dynamics, repeatability, calibration, auto-protection and diagnostic functionalities.
The valve's functional physical quantities (external commands, spools position, solenoid current, etc.) are converted in numeric digital form by means of high performances 14bits A/D converter and they are elaborated at fast 200μs sampling time by new 40Mips/32bit DSP microcontroller. The use of innovative algorithms, specifically developed for hydraulic applications in cooperation with Polytechnic University of Turin, allows to overcome the traditional limits of general purpose digital controller.

Features

The user can freely adapt and customize the valve's behaviour to the specific application by setting the following main functional parameters in numerical form and then record and reproduce them on other valves :
– minimum and maximum flow regulation (bias and scale)
– max limited accelerations (ramps)

Fig. 4 - New digital electrohydraulic control unit

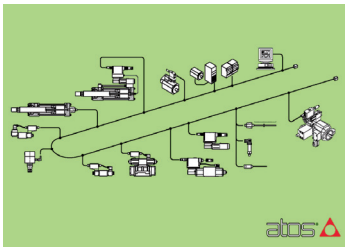

Fig. 5 - Fieldbus machine automation

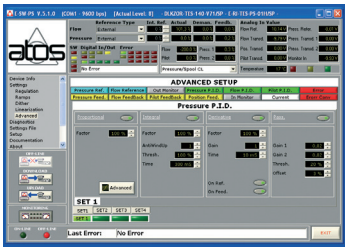

Fig. 6 - Atos software diagnostic & settings

Fig. 7 - Rugged digital pressure valve

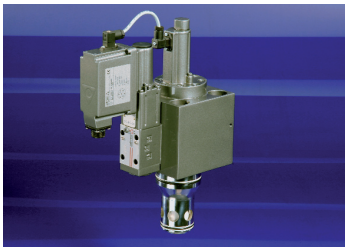

Fig. 8 - Digital high dynamic cartridge valve

– compensation of valve regulation characteristics (linearization)
– settings of the control loop dynamics (PID)
– anti stick-slip and friction compensation (dither)
– command signal range selection

New digital proportional valves are equipped with electronic communication fieldbus interfaces: at choice serial RS232, CanOpen or Profibus.
The basic RS232 data transfer gives access to valve's functional parameters and to external/internal signals by means of Atos unique pc software (fig.4). This software is multilevel structured to make simple the startup, tuning and troubleshooting operations on the valve and of the relevant electrohydraulic axis: thus it is possible to have a clear and immediate reading of any useful information like actual and trend values of command signals, feedbacks, control PID actions and status/fault conditions. In other words the working characteristics and status of the valve can be easily focused and the functional parameters correctly set.

Digital valves with standard fieldbus interfaces (CanOpen / Profibus-DP) can be integrated in the overall machine automation fieldbus network (fig.5) thus obtaining further benefits:
– use of standard and modular wiring solutions
– direct access from the machine control unit to all configuration parameters
– real-time digital exchange of all command, monitor and diagnostic signals

All these functions are basic requirements to implement on the machine tele-assisted services, thus allowing the remote diagnostic and troubleshooting for efficient on site repair and part substitution.

Additional functionalities are available for experienced users (level 3), like:
– life and working counters for system's preventive maintenance
– monitoring functions (fig.6) to check the presence of anomalous operation conditions like sticking spool, inadequate/lacking piloting pressure, over/under temperature, etc.
– real-time oscilloscope to display the time-dependent behaviour of all valve's significant quantities (setpoint, feedback, control action, alarms, etc.)

Pressure control valves

Pressure control valves with digital electronics realize improved performances and particularly closed loop versions with integral pressure transducer (fig. 7) minimize the influence of system condition (actual flow/rigidity) on regulation stability and accuracy, with following valuable features:
– anti-windup and limitation strategies of integral control action, when non-reachable pressure is requested
– differentiated damping factor for increasing and decreasing pressure
– multiple parameter sets to adapt the valve dynamics to different oil volume of systems

Digital valves are factory pre-set and ready to use; Atos software proves once more its friendliness in supporting the final user to get the optimum parameter tune if a fine-tuning optimization is required.

High Flow & Dynamic proportional valves (cartridge)

Digital directional and pressure control valves are available also in cartridge execution; the integration of digital electronics in high flow cartridges (fig. 8) boost their dynamic performances.
Proportional cartridge valves in pilot operated execution are capable of high flow instant regulation (up to 104 l/min) and can reach high dynamics (Tresponse < 30ms for NG80 size), with precision and repeatability similar to direct operated valves.
On-site adaptation of working dynamics may be required to avoid excessive shocks of mechanics; once more the Atos software allows users to obtain the best performances on the machine.

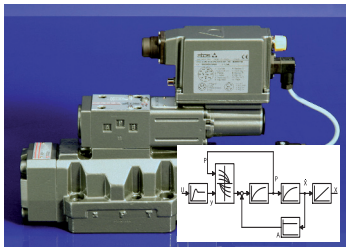

Fig. 9 - P/Q control valves

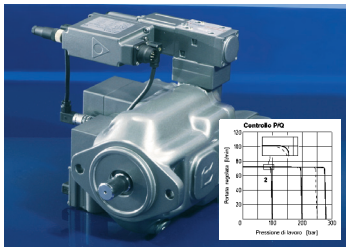

Fig. 10 - Digital P/Q variable pump

Fig. 11 - Digital servoactuator motion unit

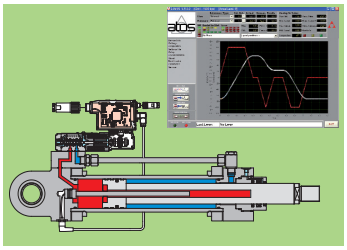

Fig. 12 - Servoactuator internal profile generation

Fig. 13 - Multiaxes system

Combined P/Q control components (valves and pumps)

Standard digital directional valves, additionally interfaced with pressure transducers (fig.9), perform multiple regulations (direction/flow with pressure and power) and simplify the hydraulic circuit, extending their field of application.
Following additional features can be added:

– regulation of the line pressure (single pressure transducer)
– regulation of the actuator's force (dynamometer or double pressure transducers)
– flow regulation independent from pressure disturbances, by flow electronics compensation

The multiple P/Q controls can also be applied to variable displacement pumps (fig.10) to obtain new intelligent power unit with further advantages:

– leakage compensation in front of pressure variation
– regulation of maximum power

Digital servoactuators (hydraulic motion control unit)

Digital servoactuators (fig.11) are smart machine elements integrating the hydraulic cylinder, relevant transducers and proportional directional valve to realize compact, pre-tested and cost effective solutions.
They are available in several execution and option to tailor electrohydraulic axis to the specific requirements of any application field: injection, woodprocessing, fatigue test, simulation/entertainment, press brakes, etc.

Through the assistance of experienced engineers it is then possible to select the right unit's configuration and setting to achieve:

– high dynamic/speed, up to 50Hz and 2 m/s with low-friction seals and high response valves
– improved precision/repeatability, up to 1μm with SSI/Encoder high-resolution sensors
– working force up to 700KN with standard cylinder execution

The "plug&run" mode of operation just requires the input of some basic working data (mass to be moved, working force, etc.) to achieve faster startup and maintenance operations, as required by modern machine manufacturers.
Digital servoactuators with internal motion profile generator (fig.12) manage all axis movements independently from the machine central unit thus further uncoupling the machine automation system from the specific hydraulic axis management.

System technicians simply to set the main motion parameters (position, speed, acceleration, etc.) and logic command/signal status (start, stop, delay, wait and/or conditional jump, etc.) for each axis working phase.
The same decentralized control architecture is applied in diagnostic and maintenance to implement robust and efficient overall machine's safety functionalities in front of alarms, fault or critical working conditions (i.e. disable the valve, stop the axis, hold defined position, etc.).

Conclusions

Digital controls are the present and the future of any electrohydraulic application from simple fast/slow positioning actuator up to sophisticated multi-axis system (fig.13) with complex synchronism controls.
Digital electronics do give strong advantages everywhere used, enhancing functionalities and flexibility of any element of machine and plant automation.