Michael GARSTENAUER, Bernhard MANHARTSGRUBER,
Rudolf SCHEIDL

THE "SMALVE" – AN INTEGRATED DIGITAL CONTROL SOLUTION FOR HYDRAULIC SERVO DRIVES

1. Introduction

Modern digital control has revolutionised the use of hydraulic drives (see e.g. [1]). Digital sensors provide high robustness and excellent accuracy, controller implementations in the digital domain feature excellent adaptability to application specific demands. It is also easier to implement more complex control structures, such as state feedback control or fuzzy control.

Still, there are several problems with current implementations of digital control. First of all, there is a large variety of interfaces, thus meaning lots of wiring, adapters, and connectors. They also cause high costs for commissioning, maintenance, and troubleshooting. To overcome these problems we propose an integrated solution as shown in Fig. 1.

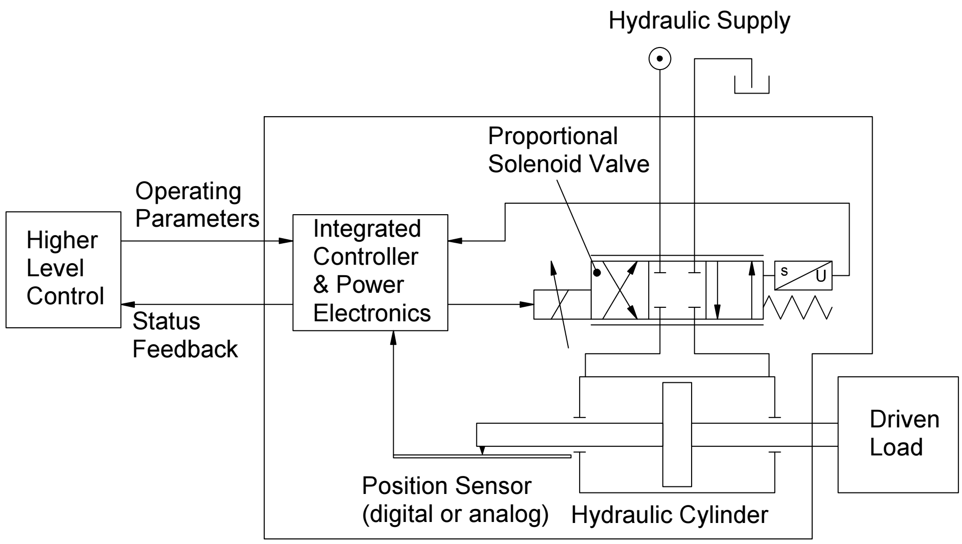

Fig. 1. Proposed Integrated Drive Structure

The user can treat the drive as a functional unit with only a few and well defined interfaces, i.e.

- mechanical connection to the driven load
- hydraulic and electric supply lines
- field bus (e.g. CAN) connection for information transfer

Field bus data transfer via CAN, which already finds widespread use in automotive applications, becomes more and more popular in industrial applications as well. There are several efforts to standardise this medium, and device profiles for hydraulic applications are under development (see e.g. [2]). It features the following advantageous properties:

- communication hardware and protocols are standardised and well supported by other components (e.g. external sensors, etc.), due to the widespread use of CAN devices in cars they are widely available at low cost
- high speed allows real time data monitoring
- robust bus hardware provides high immunity to environmental influences

The control implementation can be split up into two main tasks, i.e. the control of the proportional solenoid valve and the hydraulic drive itself. An important restriction was that the overall control concept needed to be feasible to implement in a medium cost 16 bit microcontroller.

2. Valve Control

A commercially available directly driven proportional solenoid valve was used. These valves feature good control properties at reasonable cost. [3] and [4] discuss modelling and control of such a valve type. Our goal was to use the valve without any hardware modifications such as additional sensors, etc.

To digitally control the valve spool position, a state feedback controller was implemented. A sampling time of 0.4 ms was used. To overcome the non-linear characteristics of the valve's solenoid (saturation effects in the magnetic loop), it was necessary to implement gain scheduling to achieve equally good response at all valve positions.

3. Drive Control

For load position control, a simple P-type controller with velocity feed forward was implemented. Of course, one is now able to implement other control concepts, as long as they do not overload the computational capacities of the microcontroller.

4. Results and Conclusion

A benchmark experiment was carried out to compare conventional and integrated control. A mass of 500 kg was positioned along a working stroke of approx. 350 mm. The integrated control concept proved to be well suited, and experimental results were very similar between both cases.

Integrating cylinder, valve and controller of a hydraulic drive yields a more user friendly system that forms a compact functional unit. Commissioning and maintenance can be alleviated drastically.

Literature & References

1. Leutner, V; Müller, U.; Feuser, A.; Köckemann, A. (1998): Elektronik in der Fluidtechnik. Ölhydraulik und Pneumatik, Jahrgang 42, Nr. 6; ISSN 0341-2660
2. Baldy, M. (1998): Geräteprofil für elektrohydraulische Zylinderantriebe am InterBus-S. Ölhydraulik und Pneumatik, Jahrgang 42, Nr. 4; ISSN 0341-2660
3. Gamble, J. B., Vaughan, N. D. (1996): Comparison of Sliding Mode Control With State Feedback and PID Control Applied to a Proportional Solenoid Valve. Journal of Dynamic Systems, Measurement, and Control, Vol. 118, September 1996; ISSN 0022-0434
4. Vaughan, N. D., Gamble, J. B. (1996): The Modeling and Simulation of a Proportional Solenoid Valve. Journal of Dynamic Systems, Measurement, and Control, Vol. 118, March 1996; ISSN 0022-0434