

Whistle



Sauer-Danfoss' concept machine shows how electronics and hydraulics interface.

Collaboration between OEMs and suppliers leads to new advances, and challenges, for electrohydraulic system control.

by **Barry Rosenberg**

Off-highway OEMs have found that electrohydraulics are particularly suited to platforms where there is a high degree of coordination required between the propulsion and work functions, as well as those where functional complexity or repetition of task is more suited to an automated approach. Now, they are turning to the technology to help them meet emerging emissions regulations in the U.S. and Europe.

"A major development has been the rapid and increasing demand for hydraulic-hybrid propulsion systems that are highly reliant on electronic controls and software functionality to allow them to deliver better fuel savings, reduce mechanical wear, and improve emissions in conjunction with the mechanical and fluid power subsystem," said Clyde Thomas, Senior Manager of Technical Services at **Eaton**.

An example of electrohydraulic technology being employed to improve engine efficiency is with fan drives.

"It used to be oil was cheap and you just ran the fan all the time," said David Ewel, Director of Engineering, **Mico**. "Well, you don't need to run the fan all the time; you only need to run it under certain conditions. Electrohydraulics can reduce the requirement for the fan to be driven, and, hence, lower the requirements of the engine.

down the wire



Sauer-Danfoss pumps, motors, valves, joysticks, and graphical display terminals are engineered for electronic interface using PLUS+1 microcontrollers, I/O modules, and GUIDE software.



Electrohydraulic brake systems use electronics to provide control flexibility, while the hydraulics supply the power. Shown is a variety of electronic pedal configurations and sensing options from Mico.

"I think what you saw before was an electrohydraulic brake system over here and a [non-integrated] electrohydraulic fan drive control over there. Now, we're looking at integrating these two manifolds to make one manifold that's lower in cost, and we can take advantage of the extra flow from the brake systems to run the fans. We're starting to see how they can make use of the various systems for a better overall performing vehicle."

Electrohydraulics can even help to compensate for the loss of engine power associated with emissions controls.

"Engineers modify engines to meet emissions standards, which can result in a drop in rpm and more heat in the system, taking away power," said Branko Horvat, Product Portfolio Manager for Propel Products at **Sauer-Danfoss**. "With electrohydraulics, you can put the system into its best state and use energy only when it's needed."

Besides off-loading complex and repetitive functions, there are other reasons why the industry is transitioning away from electromechanical interfaces and discrete analog/digital connections such as hard-wired point-to-point cables to more digitized approaches that include programmable controls, CAN and other field busses, and software-configurable functions.

Providing more flexibility in platform design for space savings and weight reduction by using a networked architecture reduces the assembly and maintenance costs of systems relying on mechanical or fluid power pilot controls, or older-style electrical interfaces.

Integrating electronic operator interfaces such as joysticks and display panels can allow for a more manageable machine, as well as more capabilities in the areas of machine configuration, troubleshooting, and overall operation.

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The use of an electrohydraulic system can more easily enable data logging, remote monitoring, and troubleshooting, in addition to upgrading a platform by using the system's electronics, intelligence, and communication functions to support these capabilities.

There are also demographic and human-factors issues associated with the use of electrohydraulics. Lack of experienced operators is an issue, so automating some tasks provides less reliance on individual operator skills. Automating repetitive functions also reduces operator stress while potentially increasing consistent performance and efficiency. Keeping the operator in a safe environment while still being able to control and monitor the activity of the equipment is often more achievable with electrohydraulic approaches that remove hydraulic lines from the cab.

Collaboration of design

The introduction of electrohydraulics to off-highway equipment can create a ripple effect across platform systems, necessitating close design collaboration between OEMs and suppliers to achieve technological advances and to differentiate end products.

"Designers of OEM machines can't just look at individual systems like drive systems or steering systems or loader systems; they now have to look at those systems all together because of the interaction between them," said Horvat.

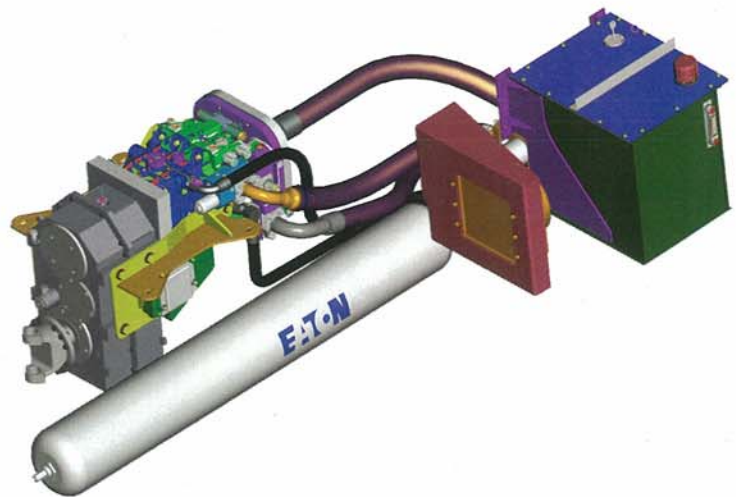
With electrohydraulics, design engineers have to approach a platform's architecture from the perspective of master/slave, peer-to-peer, or some form of hybrid approach of the two.

"Peer-to-peer systems, sometimes referred to as distributed control systems, probably offer the most flexibility with the least impact be-

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Electronics are being integrated into hydraulic components such as pumps or valves. In this image, controllers have been integrated into a valve block—the Eaton Ultronic ZTS16 valve system, developed jointly by Eaton and TTTech.



Hydraulic systems store energy in pressurized accumulators while electric systems store energy in batteries. Both can be configured in series or parallel architectures. In this diagram from Eaton, the reservoir is in blue/green at the right, the accumulator is the tube at the front, and the transfer case is in gray.

tween subsystems as each subsystem can be optimized for its own function while providing the necessary interfaces between subsystems,” said Eaton’s Thomas. “In this approach, conformance to a standard or de facto interface and communication standard to ensure effective communication is important.

“Master/slave configurations—a single control device or ECU [electronic control unit] for all I/O devices—require a thorough understanding of the necessary performance and timing needs of each subsystem and how this may be affected by the loading on the controller or unforeseen functions being handled by the control system at any given time.”

There are also interoperability and environmental factors to address, such as ensuring compliance with the CAN and SAE J19139 protocols.

“A system where one component that was optimized for one end of the standard range of acceptable performance and another that used the other end of a range of acceptable performance may see intermittent problems based on these two components trying to communicate with each other when things like temperature changes occur, or the loading of the CAN network changes when devices are added or removed from the network,” said Thomas.

The issue of developing, adopting, and using a standards-based approach for electrohydraulics to allow for better plug-and-play potential, leverage research and development across the broader industry, and to let OEMs integrate best-in-class components, will gain increasing importance as electrohydraulics become pervasive on off-highway platforms.

“Increasing adoption of IEC 61131-based programming methods,

more refined use of CAN-based networking technologies, and standardization in training and certification for the people who will need to design and support these systems has been increasing, and will continue to be important elements in adoption of electrohydraulics for the foreseeable future,” said Thomas.

There are a number of other areas that OEMs and suppliers need to address to properly collaborate. One is software, which is getting more complex but also becoming a main differentiator for OEMs.

“Many vehicle manufacturers do not have a dedicated software development team,” said Christiana Seethaler, Team Lead—Off-highway Electronics, at Italy’s **TTControl**. “Instead, hydraulic engineers, who are usually not software experts, do the programming. Therefore, programming the electrohydraulic system needs to be as easy and as user friendly as possible for engineers who are not experts in the area of software and electronics.”

Another area is in the integration of new electrohydraulic systems with legacy mechanical ones.

“A common problem is having a clear understanding of what the existing system’s functional limitations and specifications are and how to transfer this into an electrical or software-based implementation,” said Thomas. “Although the industry as a whole is improving in using more advanced design validation processes, many mechanical and hydraulic-system designs in the mobile space have often been achieved through trial-and-error approaches and/or iterative prototypes.

“Another factor is that electronic-control latency is often much shorter than mechanical and fluid-power latencies, and this can affect the dynamics of how the hydraulic components respond to a command signal or how the hydraulic response affects the mechanical systems.



This diagram from HydraForce shows a typical electrohydraulic vehicle control system with PC-programmable ECU.

“However, even with those challenges, the flexibility in software application, plug-and-play components, and configurability and use of an open architecture approach can often make integration of the old and new easier.”

The future

As seen in other industries where electronic and software technologies converge with mechanical systems, the potential for further capabilities afforded by electrohydraulics is only limited by the imagination of design engineers.

Today, for example, most vehicles are equipped with a single ECU that controls the whole vehicle. In the future, there will be more distributed solutions.

“Several small- to mid-sized ECUs will be positioned close to the implements they control, performing specific tasks,” said Seethaler. “Networks such as CAN and Ethernet will become more and more important. Advantages of a distributed solution include less cabling costs and support of modular architectures.

“And for vehicles on which special implements are not mounted, there is also no need for the dedicated electronics to be on board.”

Another clear trend is the continued integration of intelligence into the lowest level of component until it will be possible to configure a truly distributed control hydraulic architecture where each component not only optimizes its performance but is self-aware, able to provide a level of redundant control for safety or performance needs, and will allow even greater flexibility in physical machine/platform design.

Bringing intelligence right to the motor or pump itself is also expected to pay dividends in equipment reliability, maintainability, and

fleet management. That will come when operators can use that intelligence for system diagnostics, pulling health and usage data directly from the motor or pump, as opposed to the one-way communications now where operators can use electrohydraulics to direct a system to go into its best state—whether that be work or travel or standby—but have only a limited ability to receive.

“With electrohydraulics, hydraulic lines are removed from the cab and replaced with signals over electric wire harnesses, but OEMs constantly struggle with wire harnesses,” said Jim Pick, Vice President of Engineering, **Arens**. “Shooting a screw through a wire harness is the kind of thing that will bring an electronic system down.”

Because of the reliability problems inherent in wires, Pick said it is only a matter of time before electrohydraulic systems are controlled wirelessly.

“The challenge 10 to 15 years ago was to convince the engineering base that electronic controls were reliable. The next challenge is to convince them that wireless communication is more reliable than communicating through a wire.”

Wireless technologies such as Bluetooth or Wi-Fi are not reliable enough to put on a vehicle to control a drivetrain, for example, but Pick believes that there is a future in the off-highway industry for ZigBee, a wireless technology based on IEEE 802.15.4-2006 standards that is considered both reliable and secure. **sohe**