CHRISTIAN BUCHHOLD-TOMAZIC

FARMER GILES CATCHES THE BUS

SERIAL BUS TECHNIQUES OFFER MANY POSSIBILITIES OLD-TIME FARMERS COULD ONLY DREAM OF, SUCH AS THE INTEGRATION OF HYDRAULIC FUNCTIONS WHILE ENABLING OPTIMAL ERGONOMICS AND ENVIRONMENTAL PROTECTION

Multifunction grip with LINbus

Back in the good old days, Farmer Giles would climb into his tractor, drive into his fields and start his daily work. Every day he would pull on one of the several handles at exactly the right time to operate the hydraulic valves controlling the attached equipment. This was a straightforward way of working, and it was easy and second nature. Although he found the way his operations were converted into mechanical actions convenient, he soon became bored by the repetitiveness of these activities with each and every furrow he had to plough. How good it would be, he thought, one particular day, if he could just tell his vehicle to do the right thing at the right time and it would be done...

It took several years and many requests from farmers like Farmer Giles until such functions became automated. With these advances came an additional demand for better ergonomics and other improvements to their operating environment – after all, the tractor is a second home to farmers for many months in the year. This, combined with newly introduced legal regulations governing, for example, air pollution, meant that the time for electrohydraulic valves to replace the pure hydraulic valves had arrived.

At the same time and as a direct result of this topology change, electrical-command systems began to make an appearance in tractor cabins. Such systems, typically consisting of electrical switches, joysticks, foot pedals and analogue rockers were used to generate the necessary electrical control signals to operate the electrohydraulic valves. At this time, one of the pioneers leading the design, development and implementation of such control systems was ITT, the predecessor of today's DeltaTech Controls – now renowned in the marketplace for providing market leading command-system solutions for off-road applications, including complete armrest and joystick solutions to tractor manufacturers.

Direct interface

These command systems or human-machine-interface devices (HMI) were initially directly connected to the electrohydraulic valves. However, it was soon discovered that this configuration did not give the flexibility that such a system was potentially capable of.

A topology was introduced whereby the HMI devices were connected by an analogue-electrical interface to an ECU to process the operator input, while at the same time taking the vehicle state into consideration before generating an output signal to the hydraulics.

As this topology became popular and its flexibility and expandability recognised, more and more HMI devices, sensors and ECUs were added to the vehicle's system. The result was the necessity for extensive wiring.

This had a direct impact on Farmer Giles and his ilk, because as well as the obvious advantages of this new design philosophy, this configuration also brought with it increased costs, longer reaction times of tools and implements to a direct command and an overall decrease in reliability. To address these issues, which had arisen as a direct result of the increased wiring, field buses were introduced, which concentrated the numerous HMI commands into digital signals on only a few wires.

The CANbus evolved as the fieldbus of choice not only for off-road vehicles but also for the automotive industry, where it is now very well accepted.

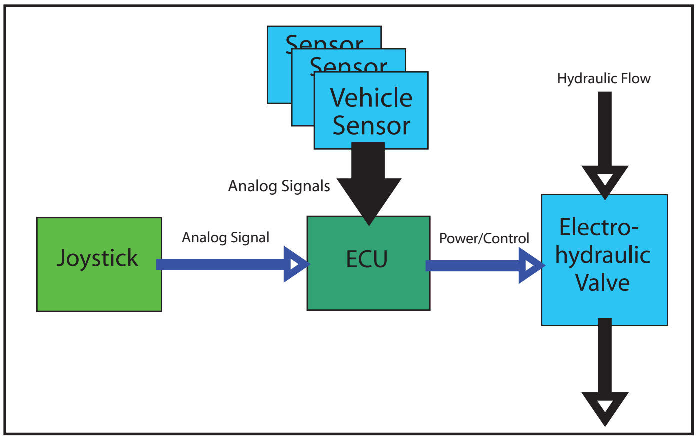


FIGURE 1: **ECU controlling an electrohydraulic valve by processing a joystick command under consideration of other vehicle-sensor inputs**

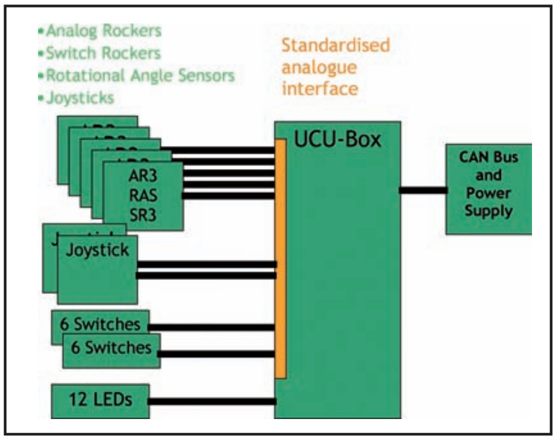


FIGURE 2: **Example topology of an UCU system**

CANbus and CAN protocols

One of the criticisms of the CAN standard has been that it only specifies the physical layer and the data link layer, meaning that at its introduction diverse proprietary protocols popped up like mushrooms. The direct result of this was that either the OEMs had to adapt their vehicle communication to the supplier's telegram structure or vice versa. Also, although these protocols normally provided for the transmission of processed data and basic diagnosis, they did not provide the means for program or parameter download or network management.

Such a restrictive system was feasible for low complexity systems with just a few partners involved in a project. However, as complexity increased, it became hard to set up and maintain the CAN communication structure.

Advanced CAN protocols were developed to standardise the upper layers of communication. By harmonising the contents of data telegrams for specific devices, it became easier for OEMs to get data from, and send data to, HMI devices from different suppliers.

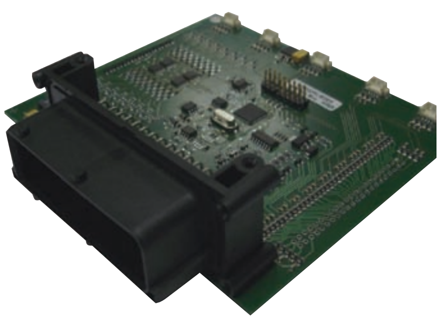
This opened the possibility of configuring complex CAN systems including the dynamic connection of devices to the bus system, the gathering of diagnostic information and the downloading of parameters or firmware via CANbus even when the vehicle is already in the field. The two most popular of these advanced protocols are SAE J1939 and CANopen.With J1939, several communication layers are defined: J1939/11: physical layer; J1939/13: offboard diagnostic connector; J1939/21: data link layer; J1939/31: network layer; J1939/71: vehicle application layer; J1939/73: application layer – diagnostics and J1939/81: network management.

Device-specific information is collected in standardised messages. As an example, the process data information of a joystick is defined in standardised telegrams; one of them being called the 'basic joystick message 1' (BJM1). There are also messages for diagnostic information, download handling, parameterisation and configuration.

Not all J1939 services are used by every application. As an example, the standard contains a requirement for a so-called 'arbitrary address capability', which means that the node-address of the device may be changed dynamically during runtime. This is potentially useful for applications where devices are attached or unattached during run-time as, for example, when a trailer is coupled to or decoupled from a tractor.

Unfortunately, this feature can require a longer system start-up time as all CAN devices in the system have to negotiate their own addresses during this time, which, for a system with many CAN nodes, can take some time. Because start-up time is critical to cost efficiency, most J1939 applications tend not to implement this feature. Instead, such applications use fixed addresses.

Such examples show how the need for a system solution based on the J1939 protocol arose so that the services could be tailored to only the features which are really needed in the application. To address this, as part of its standard offering, DeltaTech Controls provides a configurable J1939-Software-Kernel, where a customer can easily select the desired features for their system.



DeltaTech Control's standard UCU module

The CANopen protocol (CiA, EN 50325-4) has also been widely accepted in the market. While there are some basic differences in the philosophy between CANopen and J1939, both have a similar approach especially with regard to standardised messages, configurability, network management and diagnosis.

Both standards are used extensively in the off-road and automotive markets. To address this 'bi-CAN' world, DeltaTech Controls has designed a modular software solution, whereby the same application software may be equipped with either a J1939 or a CANopen kernel-module (or any other future protocols, in fact) thereby allowing maximum flexibility for the system designer.

Connecting small devices

The flexibility of the CANbus system means that engineers like to link up more and more devices onto this bus, including individual components. But this implies that every switch, indicator lamp or analogue rocker would need its own CAN interface – not a very practical or cost-effective solution. One solution would be to wire these devices directly to a vehicle's ECU – but this would have a direct effect on the system wiring, bringing with it all the disadvantages mentioned earlier.

A better solution, and one favoured by DeltaTech Controls, is to have a 'concentrator' to collect the signals of these individual devices and send them over the CANbus, using one of the advanced protocols described above. Its Universal CAN-I/O-Unit (UCU) is such a concentrator and is a low-cost, microcontroller-based device. The advantage of the UCU-concept is that the vehicle application does not need to take care of the attached devices and components; it just uses the desired functions via CANbus. The UCU has input channels for up to 16 analogue or digital devices and an output capability of up to 12 indicator lamps.

Additional devices may also be added via a LIN sub-bus. The LINbus is a serial bus, as with the CANbus, but is much simpler. It was designed for sensor/actor buses in automotive applications with the focus to reduce wiring for remote clusters such as car-door controls.

The LINbus is standardised by the LIN consortium (www.lin-subbus.org) and well accepted in the automotive world. DeltaTech Controls was the first solution provider to use this bus technique for off-road systems. LINbus technology has much lower requirements with respect to controller resources. The CANbus requires specialised CAN controllers, but the LINbus has the ability to be implemented by virtually every microcontroller that is equipped with a serial UART-controller. Because CANbus controllers typically consume more space on silicon than such microcontrollers, controllers for CANbus solutions are invariably more expensive.

In other words, LIN nodes can be built at a lower cost than CAN nodes. This makes the LINbus ideal for those applications where a lot of switches have to be read in or light indicators need to be set. The cost of the extra electronics for such a solution is compensated by the savings in the wiring, thereby delivering greater flexibility at no additional cost.

The LINbus also opens the door for applications where conventional wiring would be impossible to use. For example, DeltaTech Controls uses the LINbus within its Multi Function Grips (MFG) solutions, in applications where internal space is extremely limited.

Whereas MFGs can require many functions in their head (up to 20 being typical), the space available for wiring these functions internally in the head is relatively small, because the overall grip area can not be too large for ergonomic reasons. As the LINbus requires only three wires to supply the head with power and to feed the information between the head and the attached control-equipment, it is the only practical solution.

Get on the bus

Today's serial bus techniques offer many possibilities to the designer of modern vehicles, allowing the integration of hydraulic functions in vehicles while offering optimal ergonomics and environmental protection; offering a high level of standardisation thereby lowering the effort and risk for both OEM and supplier; increasing system flexibility; ensuring complex systems operate reliably by providing standardised methodologies for system diagnosis, download and configuration and offering low-cost sub-bus systems for easy system expandability.

And what does Farmer Giles think of all this? Well he's probably sitting on his cloud looking down on the tractors of today and comparing them with his, smiling and thinking, 'Now that's better, a step in the right direction, but if only…' **iVT**

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