Tomorrow's mobile machinery

Control systems usually do not consist of only one ECU anymore – they are composed of a number of different units. The first and obvious idea – connecting all devices to the one and only bus – is often not the ideal solution.

Figure 1: Example for a modular system architecture (Photo: TTControl)

For various reasons, such as reliability, safety, and bandwidth, it might be necessary to:

- connect two ECUs with one (or even more) separate bus(ses) (point-to-point),
- separate "safety relevant" and "comfort features" by different busses,
- offer a debug/monitor interface to the system that is separated from the operational bus.

Aspects like these lead to systems that not only consist of multiple ECUs but also of multiple bus systems for connecting those ECUs. CAN (and its higher-level protocols like CANopen, CANopen Safety, J1939, Isobus…), as a well-established standard for this purpose, is used in uncountable systems today and still is the number one choice control network for mobile machines. This article will not only concentrate on this technology, its strengths and its limitations, but will also point out other technologies that complement the capabilities of CAN.

Why is one ECU not enough?

Many reasons can lead to architectures with more than one ECU. The most common are:

Not enough I/O-pins for the system available on one ECU: The typical solution for this problem is to extend the I/O capability of the master device with as many slave devices (operating as intelligent I/O-modules) as necessary. Even high-end ECUs like TTControl – Hydac International's HY-TTC 580 with its 96 I/Os – reach their limits in very complex applications. Based on a powerful network concept, this can easily be handled with distributed control systems.

Sensors/actuators spread over long distances: In order to reduce wiring costs or to increase measurement accuracy, it can be helpful to place I/O-modules as close as possible to sensors (this also applies to EMC-sensitive actuators) and connect this unit to the supply and bus lines of the system. This does not only increase the signal quality because of ▷

less noise due to shorter analog connections, it also reduces the wiring effort significantly.

Modularity – usage of existing blocks: Based on already existing modules (such as a multiple-valve block with a CAN-interface), it might be easier and more cost efficient to use a proven-in-use component for a specific purpose and just connect the master control unit via CAN. A generic device optimized for this purpose is the HY-TTC 30 IO-module. If functional safety is required for the I/O slave, the HY-TTC 30XS or HY-TTC 48XS can be used providing CANopen Safety communication.

What has to be taken into consideration when using such an architecture is the fact that for high-dynamic control applications not only a high-performance control unit for executing the control algorithms is needed, but sufficient bandwidth also has to be provided between the master control ECU and multiple I/O-modules. If the CAN bandwidth limitations do not allow for multiple I/O-modules connected to one CAN interface, the master control ECU has to provide multiple CAN interfaces.

Increasing system robustness

For increasing the robustness of a CAN controller network, it is a common practice to separately connect groups of devices to different CAN networks, sometimes even only two devices in a point-to-point-connection to make sure no other device can disturb the communication between the others, for example because of a malfunction.

By following this architecture pattern, it is easy to define several shutdown-levels that – depending on the devices that show a malfunction – can offer at least a „limp home"-mode performed by a couple of high-reliable devices responsible for the core functions of a system. The number of separate CAN networks definitely should not depend on the number of available CAN ports on the master device, but should be based on system architecture and safety aspects. Therefore, a master device with sufficient CAN interfaces is a mandatory precondition.

There are uncountable devices available on the market that can be connected to a CAN network, but still there are some differences, not only when it comes to pure operational functionality, but also concerning commissioning support, variant handling of devices, and enabling easy servicing, to mention just a few of them:

Auto bit-rate detection: With this feature, setting up a network as well as exchanging a device due to maintenance reasons becomes much easier. If, for example, the master device has a preset bit-rate and all other devices then adapt their settings to those defined by the master, it then becomes unnecessary to configure every single participating device upfront to prevent a communication breakdown (bus-off) on the whole network, which happens if there are different participants with different bit-rates in the network. Automatic bit-rate detection also makes it much easier for a debugging/diagnostic interface to connect to a system without any need of communication parameter setup.

Configurable termination: A CAN network needs termination at both ends. Those are usually built into ECUs but if for example three I/O-modules are used (which are 100 % ▷

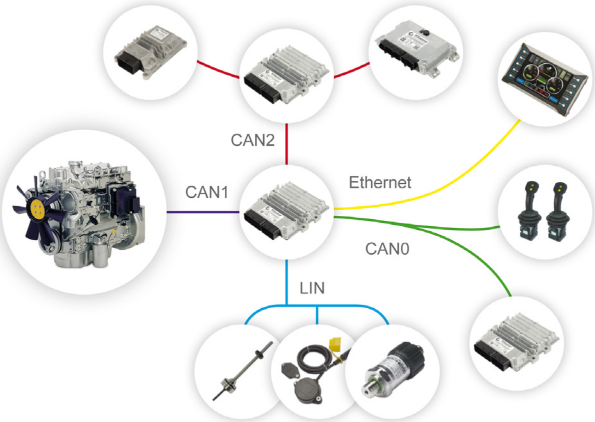

Figure 2: Separate CAN networks for increased robustness (Photo: TTControl)

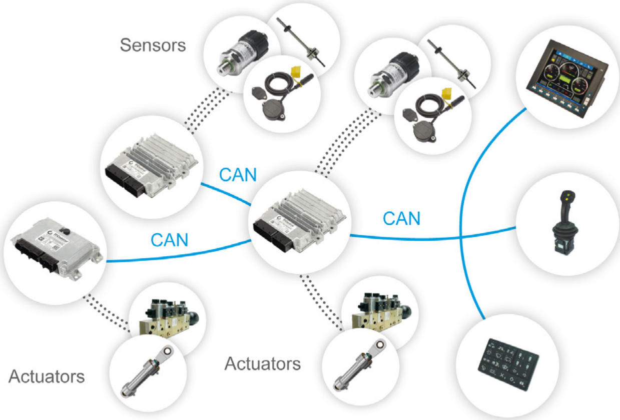

Figure 3: Combining bus technologies – a win-win situation (Photo: TTControl)

identical and decide which messages to send and receive based on a location ID that is dependent on the system wiring) but only one of them shall terminate the bus, one can either integrate the termination resistor in the system cabling or the intelligent I/O-module can – again based on the connector wiring – activate or deactivate the integrated termination resistor.

Complementing a CAN network

CAN is a well-established standard for connecting automation devices, but there are other technologies with their individual advantages that can add value to a automation system:

Ethernet: Two aspects make a high-bandwidth connection a good choice in an automation system: First, for debugging, downloading, logging, and a lot of additional supporting activities besides the operational mode of the system, the bandwidth available on an Ethernet connection reduces cycle time for development and maintenance drastically. Second, for the operational mode of a system, higher bandwidth can for example be demanded for visualization, process monitoring or video streaming for rear-view cameras of vehicles.

Combining the advantages of the easy and cost-effective wiring of CAN and the high-speed data communication of Ethernet, automotive physical layer technologies like BroadR-Reach will also soon emerge in off-highway or mobile applications. Demand for deterministic communication technologies can also be fulfilled by Deterministic Ethernet standards such as TSN (Time-Sensitive-Networking) and Time-Triggered-Ethernet (SAE AS6802).

LIN: The network offers a cheap and easy-to-implement bus connection for low-cost-devices with reduced bandwidth demands.

The ideal master control unit therefore not only supports multiple CAN interfaces, but also connectivity for all other communications technologies that are used in the system, at least for the high bandwidth technologies. For example, TTControl – Hydac International's HY-TTC 580 is equipped with seven CAN channels, as well as Ethernet, a serial interface, and LIN.

CAN is nowadays a well-established standard for connecting control units in distributed control systems and will also stay one of the main technologies for connectivity for the near future. There are other communication technologies that can – and in modern systems gradually will – support and complement the CAN interconnectivity between electronic control units for several reasons. One of them is the need for higher bandwidths that also make very powerful ECUs necessary to be capable of handling this large amount of data and also perform gateway tasks in the background while executing controlling applications. ◀

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