WHITEPAPER

Digitisation of on-board electrical systems made easy

E-T-A®
ENGINEERING TECHNOLOGY

DIGITISATION OF ON-BOARD ELECTRICAL SYSTEMS

made easy

The increasing electrification in mobile working machines leads to a higher number of more powerful loads and more complex systems. The networking of different machine components is a basic prerequisite here. The CAN bus as a standard fieldbus in the automotive sector is the perfect technology for fast and simple data transmission. The digitisation of the on-board electrical system for different system architectures can be realised with CAN-capable, intelligent power distribution systems and I/O modules - and even reduce complexity at the same time.

Digitisation, sustainability and efficiency are buzzwords, that currently apply to many industries, including agricultural and construction machinery and specialty vehicles. Electrification, networking and condition monitoring accompany this trend.

The topic of efficiency plays a central role in construction machinery and specialty vehicles. Among other things, because many cities are introducing so-called “ultra low emission” zones. In the best case, excavators and the like are to consume as little energy as possible. Electrification takes place in smaller construction machinery right now. Sustainability is mainly about the integration of preventive protection mechanisms of the machine as well as maintenance support. Sensors can detect critical conditions to enable a switch off in time and before a breakdown. Hardly possible without an intelligent, digitised on-board electrical system.

In agricultural technology, the trend in recent years has been towards ever larger and more complex machines, such as combine harvesters with over 600 hp and cutterbars with a working width of 17 metres. At the same time, however, there is also a trend towards more compact, smart and autonomous tractors and implements. The basis for this is provided by digital on-board electrical systems that can collect and evaluate data.

With the increasing intelligence and flexibility required of a machine, the design of the control electronics also becomes correspondingly complex. Depending on the type of machine or vehicle, different system architectures are used in the development of the on-board electrical system.

A centralised system architecture is particularly suitable for smaller and compact machines with limited installation space. In this case, a single central and powerful node or control unit controls the entire machine. The power distribution is realised as compactly and with as few individual components as possible in one location. In this case, sensors and actuators are connected to the central control unit either directly or via the CAN bus. It controls and monitors all machine functions. Thanks to this centralised architecture, design engineers can build compact machines that need only little space. Figure 1 shows an example of the central system approach with E-T-A’s SCS3000 intelligent power distribution.

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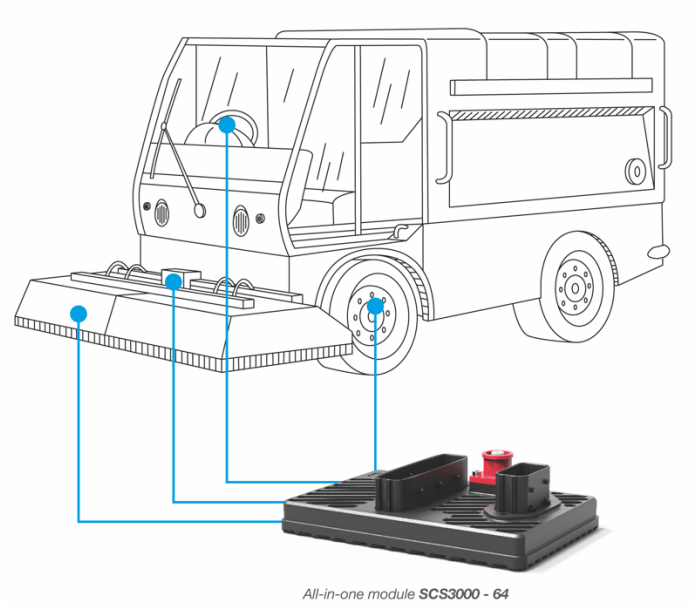

Fig. 1: Centralised system architecture for small, compact vehicles

The complexity of the on-board electrical system also increases for large and complex machines. High load currents and heavy, complicated wiring harnesses inside the machine are challenges that can result. For this reason, a modular, decentralised system architecture is preferred for this vehicle and machine type. Smaller function groups in the machine are optimally placed close to the loads to be controlled and connected via the standardised CAN bus in order to drastically reduce the wiring complexity. Thanks to the connection via standardised field bus, additional components can be easily integrated into existing systems when retrofitting at a later date. Figure 2 shows an example of the decentralised system approach with E-T-A's CAN-capable power distribution systems.

Especially the agricultural and construction machinery and the specialty vehicles sector rely on well-proven and widely used CAN protocols, such as SAE J1939 or CANopen. These are based on the CAN 2.0B standard and additionally implement higher layers of the OSI model. This ensures a generally valid, standardised transmission of commands and diagnostic data. The connection and control of various vehicle parts and loads via the CAN bus and the use of components that support the CAN standard, significantly reduce the wiring effort, save weight and provide easy scalability of the system, depending on the vehicle option.
However, a digitalised on-board electrical system is more than using a CAN bus to control different loads in a working machine. Such a system also includes the communication between the individual sub-systems or components and the creation of system transparency through diagnostic data.
Especially the collection and easy provision of data at all levels of the machine, as well as the evaluation in terms of condition monitoring and predictive maintenance, play a central role. When it comes to the digitisation and modernisation of the on-board electrical system, it can also be important to make already existing classic solutions and products simply smart.

Independent of the main control unit of a machine, there are products, such as intelligent power distribution or CAN I/O modules, to effectively implement the approaches described. They enable the approach towards digitisation of the working machine and provide considerable added value.

Especially when modernising the vehicle architecture and advancing the electrification of the working machine, the capacities in terms of ampacity and number of inputs and outputs of a control unit are quickly exhausted. Flexibly configurable CAN mini control units are a simple, decentralised I/O extension solution - even when loads require higher output currents than are available as standard from the control unit. Such I/O modules can be easily integrated via the CAN bus. In this way, they expand the existing system. This is particularly advantageous with many different vehicle and machine options when it comes to keeping complexity low in production and stock keeping.
Configurable CAN mini control units are also characterised by the possibility of flexible definition of the CAN structures. All CAN messages can be freely defined via configuration software. This includes the identifier of the CAN frame as well as the position, length and type of the CAN data. For the specialty vehicles and platform manufacturers in particular, this offers the advantage, in addition to the classic I/O extension, of collecting and further processing status data from the base vehicle provided by the PSM module.
The CAN mini control units from E-T-A cover the entire range from the SCS10 CAN relay, to the powerful SCS20 H-bridge module with two 10 A full bridges, to the SCS30 mini control unit with a multitude of digital and analogue I/Os, thus supporting the decentralised, modular system approach. All modules have one thing in common: Standardised hardware combined with flexible software for easy adaptability and scalability.

Especially with regard to condition monitoring and preventive maintenance, diagnostic data and analysis capability play a decisive role in modern working machines. Here, however, it is not only the data evaluation and projection by the control unit that are important. The prior collection and provision of data is essential, especially at the load level, in order to be able to implement condition monitoring, for example.
In decentralised system architectures, CAN-capable, compact power distributors take over the control of higher loads below the ECU. It is reasonable to collect valuable information on the status of the loads, especially at this level. This ensures a high level of transparency within the machine and allows conclusions regarding the condition of the vehicle or machine. E-T-A has responded to these requirements with the development of the intelligent, CAN-controlled SCS200 power distribution system. It has an ampacity of up to 30 A per channel and 150 A total current.
An integrated load current and voltage measurement per output channel as well as a total current and temperature recording enable the provision of comprehensive diagnostic data via the CAN bus that go beyond pure switching status messages.
Against the background of condition monitoring or preventive maintenance, the control unit can carry out evaluations at any time by means of the information about the actual current consumption of the load. Increasing contamination or wear of loads such as motors, pumps or fans becomes noticeable through increased current consumption. This is detected at an early stage by the data supplied by the intelligent power distribution system. In this way, the user can take preventive action before a failure occurs and ensure increased machine uptime.
E-T-A's decentralised SCS200 power distribution system can be controlled by the ECU via CAN J1939 and sends diagnostic information. The module also provides electronic load

protection per channel, which can be reset remotely via CAN. This function also helps reduce downtimes.

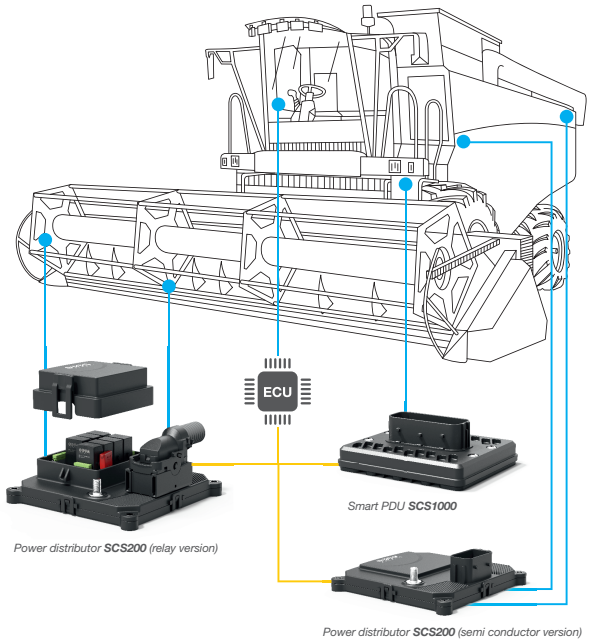

Fig. 2: Decentralised system architecture for complex working machines

In working machines and vehicles where energy is limited, efficiency, advanced load management and weight and complexity reduction play a crucial role.
The implementation of load management enables monitoring and control of the energy consumption of the total number of loads to avoid exceeding the system limits. In this way, less important loads, such as comfort functions, can be switched off in favour of essential loads, should the energy, provided by the battery, become scarce.
Not only limited energy, but also limited installation space is a general challenge that needs to be dealt with. Powerful high-current distributors with integrated logic can offer decisive added value in these application fields.
E-T-A's intelligent SCS1000 and SCS3000 power distributors also make an important contribution to digital switching. They combine the distribution of high currents with logic, control functions and CAN connection in one compact housing. Notably, the SCS3000 modules are suitable for a centralised system approach with up to 64 load outputs and 280 A total current. They replace many individual components with a single smart product. Reduced space requirements and reduced wiring complexity are just two of the advantages.
The user configures the modules according to the application via a graphical programming environment. The definition of inrush and warning thresholds, time functions as well as logical links help realise a comprehensive load management. Even larger inductive loads, such as motors or fans, can be started in a controlled manner without high inrush current peaks with the help of configurable soft start functions.
Unlike pure client modules, E-T-A's SCS3000 power distribution systems cannot only be controlled via the CAN bus. Independent switching of the power outputs without an external

ECU is also possible. This allows functionalities to be outsourced to the smart PDUs in order to relieve the control unit.

The digitisation of the on-board electrical network is omnipresent. Further innovations, such as developments towards higher measurement accuracy, intelligent power distribution for 48 V on-board electrical systems or even real-time capable systems, will certainly follow.

Fig. 3: E-T-A's SCS product group combines intelligent power distribution and I/O modules with the ability to communicate via CAN