Machines on wheels

Controllers and sensors for vehicles

We cannot imagine life today without electronics in modern motor vehicles and mobile machines. Many necessary and convenient functions could not be implemented without electronic systems.

Example: Mobile shredder
Extreme mechanical strain by impact and shock

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In contrast to electronics in consumer goods and „normal“ industrial applications such as packaging machines and conveyors the requirements for components for mobile use are much higher in order to achieve operational reliability in all situations.

The mobile machines and installations are often specially tailored to the applications and thus relatively expensive. High uptime of these cost-intensive machines and installations thus requires an extensive, easy and safe system diagnosis for fast direct fault location by the operators.

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Market requirements

Safe and clear operating concepts via displays adapted to the respective operating situation can help to avoid incorrect operation. The operating and system states must be stored for statistics and documentation via a process data acquisition.

Furthermore, networking the system components by a bus system is required to reduce wiring complexity. This enables a decentralized arrangement of the powerful input/output modules in direct vicinity of the sensors and actuators. This means they are mounted where the data are produced or needed. In addition, the components must be easy to handle for mounting and in case of service. The mechanical design and an easy and clear integration during programming achieve this. Last but not least the components and devices used must withstand the extreme mechanical, climatic and electrical requirements and reliably fulfil the assigned tasks for a long period. All above-mentioned requirements aim at developing reliable, competitive and cost optimized machines.

Electronic requirements

Mainly the extreme mechanical stress caused by impacts and shocks and the use at low and high operating temperatures require a careful selection of the components. Since often a direct influence of dirt, moisture and water cannot be excluded locally, a high protection rating and a special selection of the materials are needed for the devices. Let us for example look at a shredder for wood recycling. When the recycling material is processed the complete machine and electronics are exposed to high impacts. Protection can only be achieved by special housing and mounting concepts. As the electronics are mounted inside the machine the components are exposed to high temperatures caused by the diesel engine. They increase even more when the machines are used in hot climatic zones.

In addition to the mechanical and environmental influences electrical interference which affects the whole system and the individual devices must be taken into account. A wide supply voltage range and optimised application measures allow a safe operation of the devices even in case of high fluctuations of the supply voltage of the battery/generator system and for high conducted and radiated interference.

For networking the devices the CAN bus has been successful in the last few years. While for cars produced in high volumes specific, optimised and precisely matched protocols are used we cannot imagine life today without the CANopen protocol in mobile machines. Via gateways manufacturer and industry-specific protocols

such as the 'Landwirtschaftliche Bussystem (LBS)' (agricultural bus system) or the truck-trailer interface of the trucks can be coupled to the machine process.

Modern mobile machines consist of different segments. The automation components from ifm electronic suitable for mobile use can be used in these segments for a variety of tasks. Depending on the requirements, they perform a controlling, monitoring or indicating function. Networking is done via the CAN bus with the protocol CANopen. The mobile crane can be roughly divided in the following segments:

Vehicle drive

As opposed to vehicles consisting of a truck chassis from one of the large manufacturers and a truck body, the superstructures (e.g. garbage truck special machines or mobile crane) are made by individual elements. The drive is therefore exactly adapted to the vehicle and its dedicated task. It must perform two major tasks. In road traffic it must be possible to drive the mobile crane safely. When it arrives at the construction site the vehicle becomes a construction machine. The requirements are then completely different. Off-the-road suitability and good maneuverability are now required. The control components used are switched over to the respective operating situation. The certification of the devices, e.g. by TÜV allows use of the control components in road traffic.

Diesel engine

In construction machines mainly industrial engines are used. These are machines, which are optimized to the needs of the machine constructor. Due to their mechanical structure they can be used for different tasks depending on the performance class. Modern engines are also fitted with a CAN interface accessible to the user. It is mainly rated according to the US American standard SAE J 1939. In J 1939 the individual CAN identifiers are combined with the specific engine data, e.g. operating temperature, oil pressure, starting torque or rotational speed. To control the operating process these data are filtered by a gateway and if necessary processed by the program. When there are different baud rates a gateway can be used for conversion between the different networks.

Operating elements

To control the machine different operating elements are used. Via special signal collecting nodes, i.e. input/output modules for use in the control or operating panel the information of the joysticks, switches and push buttons is transmitted to the process controller via the CAN bus and then processed. The graphic display informs the user about the operating states of the machine. In case of a fault illustrative symbols and text allow a fast fault location and elimination. In addition the operating and diagnostic data can be stored on memory cards in accordance with the PC card standard. In case of service meaningful information about the application and cause of interference is provided. If furthermore a radio GSM modem is integrated into the network, fault messages can be transmitted directly. It is also possible to set up an online connection to the machine and to read data from all connected devices and machine parts (gears, engine, etc.) via the CAN network or to update the software. Specially for machines which are used worldwide this results in substantial savings of service cost.

Working process

In this segment the actual working process of the machine is controlled. The process controller is increasingly set up with CPU's and decentralized input/output modules suitable for mobile use. The sensors and hydraulic components, e.g. valves and pumps are then directly connected to these decentralized modules. For the proportional valve and pump functions these modules have current-controlled pulse width modulated (PWM) outputs. To trigger these outputs the respective current value for the valve or the pump is transmitted in a PDO via the bus and controlled by the module. Thus thermal influence in the hydraulic circuit can for example be compensated for or movements can be kept constant. Via the CAN bus the working element is networked with the other components of the machine controller. In the last few years the CANopen protocol has become a standard for mobile machines. Due to its flexible protocol structure the exchange of data can be optimized to the respective needs. As compared to older machine controllers with conventional structure, wiring complexity, for example for the operating elements in the control panel are considerably reduced.

In the future it will be possible to increasingly implement safety functions via the CAN bus. The certification of the add-on protocol CANopen Safety (CiA DSP-304) by the German Health and Safety Association (Berufsgenossenschaften) and Technischer Überwachungsverein (TÜV) provides the manufacturers of automation components with a safe platform to manufacture devices up to the maximum control category according to EN 954. Then the load moment limiter for the crane boom, the stability safety check for the outriggers or emer-

Complex functions of the working elements in a drilling unit

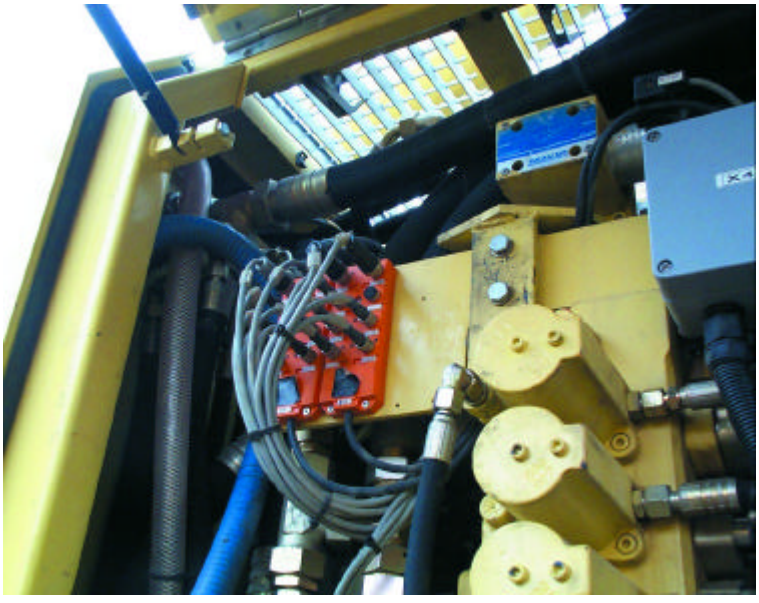
Intelligent gateway for J 1939 and CANopen

gency stop functions can be handled directly via the CANopen protocol without additional wiring.

Software for parameter setting and programming

None of the above-mentioned devices could be operated without one of the most important parts, the software, which is however often very difficult to handle. Without a software adapted to the respective application or function of the device none of the devices described above would operate. Concerning this point the system integrator has to cope with one of the most essential tasks for the project implementation. It is therefore absolutely necessary that easy to use programs which are well suited to each other are available for software design and parameter setting. This is why ifm electronic has based the programming tool ecolog 100^{plus} on the IEC 61131 standard for many years. This standard for PLC application software design established on the market offers the programmer different languages. Depending on the task and personal preferences the programmer can select between different programming languages: function block diagram (FBD), ladder diagram (LD), sequential function chart (SFC), instruction list (IL) and structured text (ST). As opposed to programming systems which only work with high-level languages (e.g. 'C') beginners can easily and reliably design their application software with programming systems according to IEC 61131. But for the full-blooded programmer the programming language ST (structured text) is a language very similar to the high-level languages. The advantage is that the assigned task can be quickly implemented. In addition, software interfaces are available to integrate special functions which were not designed with one of the IEC languages. The editors for the individual programming languages are combined into a powerful platform as the programming software ecolog 100^{plus}. In addition to the pure software design projects can be managed and software parts for use in several projects can be compiled in libraries. A powerful visualization module for the graphic display of the machine and plant functions rounds up the package. For the service engineer on site visualization can be used as a pure „operator's version". This prevents access to the program code but offers a powerful and economical online access to the machine with its functions.

If the programming system is connected to the machine controller via a CAN interface, you have immediate access to all programmable units and can directly configure the other CAN modules depending on the design of the application software. Irrespective of the programming software other software tools which are well suited to each other such as a CANmonitor software are available for monitoring and recording the CAN bus data.



Decentralised I/O modules for machine control

Conclusion

The examples given above show how the individual parts of a machine are „networked". Only with precisely matched hardware and software components can a powerful and economical automation system be set up. In principle, the projection times become shorter and due to the various service and diagnostic options, interference-related downtimes are reduced.

Depending on the requirement in the application special focus is placed on programming, handling or service friendliness of the devices. Oft-the-shelf available software tools and standardized protocols in accordance with the CANopen standard give the user safety and flexibility for the construction of new machines and installations as well as for modernizing or expanding existing systems.