and executes, in real-time, the paths for all of the axes, which must be coordinated exactly. This is the domain of Ethercat combined with powerful industrial PCs. Special ASICs (application specific integrated circuit) process data quickly and keep node costs down. Users may have to be patient while, for instance, their Gigabit Ethernet is adapted and a new ASIC version is ready, but Ethercat interfaces have the advantage that the resources – those of the slave system, for example – are burdened much less than with a pure software solution. Because of the summation frame method it uses, Ethercat transmits data particularly efficiently. With its minimal overhead, the entire bandwidth is used even for small amounts of data. It is also possible to modify data while running, so that hold-ups are only short. Ethercat is also suitable for numerous different topologies and combinations thereof, which makes many things easier when wiring complex plants. And, what is especially important for motion control applications is that Ethercat also handles the CANopen protocol, which means that making a switch is not difficult.

Drive solutions

Lenze has in its portfolio a suitable solution for every kind of architecture and communication buses. For example, in company's L-force automation world the 9400 frequency inverters have a communication module for Profinet RT. The company mainly uses Ethercat interfaces for its PC-based control systems. These are already available for the 9400 inverter family and other series of devices. The new series of L-force inverter drives 8400 will also provide Ethercat and Profinet RT facilities.

www.lenze.com

Integrated safe drives

Ralf Moebus (Safety Network International)

Today's predominantly used safety solutions for automated machinery are designed to keep the operator away from the dangerous movements of machine parts. These are often realized by safety fences and safety gates. Safety switches are monitoring that the safety gates are closed during the running manufacturing process. In areas where material has to be feed frequently to the process, optical protection devices are often used. All these measures have in common that if a person is getting inside the dangerous area the dangerous movement has to be stopped immediately by a safety function. But sometimes the machinery has to carry out movements even when a person is inside the dangerous area. This is often found, when maintenance personal has to setup the machinery and machine parts have to be moved. In this case the machinery must run with a safely limited speed. The safe monitoring of the speed is done by devices, which are monitoring the drive system. Also in this application the power supply of the drive is switched off. The supply switch-off is done with a contactor. These proceedings have the disadvantage that the drive system has to carry out a reference drive on restart. The mentioned problems can be avoided by integrating the safety monitoring functions directly inside the frequency converter. If a malfunction occurs the driver signal for the power amplifier is cut and the motor is stopped. The drive control is still energized. The external safety relays and the contactor are not needed anymore. In addition the reaction times can be reduced because the monitoring of the motion is done directly, where it is generated and the external safety devices like safety relays or safety PLCs do not ad additional reactions times to the system reaction time.

Also new safety functions as specified in IEC 61800-5-2 can now be realized:

Safe torque off (STO): With STO the power to the motor is safely removed directly within the servo amplifier. The drive cannot generate torque/force and thus cannot trigger any hazardous movements. If any external forces influence the drive (e.g. suspended loads), additional measures (e.g. mechanical brakes) are required in order to eliminate hazards. If the STO is activated when the drive is moving, the motor will run down in an uncontrolled manner. For this reason, the "Safe stop 1" function is generally preferable because the shutdown is preceded by a controlled stop.

Safe stop 1 (SS1): With SS1 the drive is brought to a controlled stop and then the power to the motor is safely removed. Once at standstill the drive cannot generate torque/force and so cannot trigger any hazardous movements. The SS1 function corresponds to controlled braking in accordance with IEC 60204-1, category 1.

Safe stop 2 (SS2): With SS2 the drive is brought to a controlled stop and then safe standstill monitoring is triggered. The drive's control functions are maintained in full (power is available on the motor). SS2 corresponds to controlled braking in accordance with IEC 60204-1, category 2.

Safe operating stop (SOS) monitors the stop position that has been reached and prevents any deviation from this position outside a defined range (position window s_1-s_2). The drive's control functions are maintained in full. If the position strays outside of the monitored window, the drive is shut down safely and an error message is triggered.

Safely limited speed (SLS) monitors the drive to check that it stays within a defined speed limit (v_{max}). If the speed limit value is exceeded, the drive is shut down safely and an error message is triggered.

Safe speed range (SSR): With SSR, the drive's current speed value is monitored to ensure it stays ▶

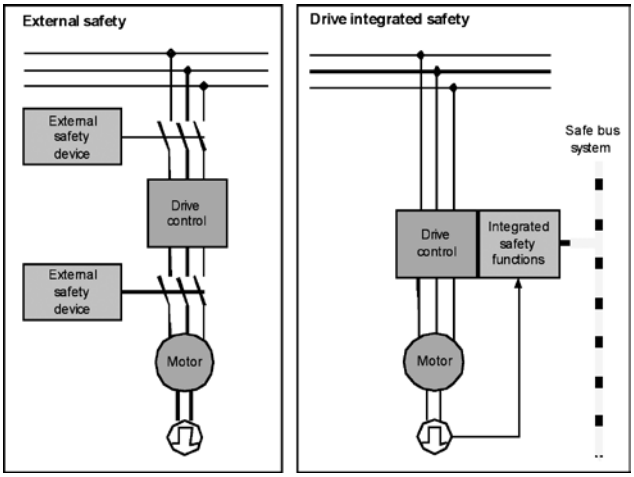

Fig. 1: External vs. drive integrated safety

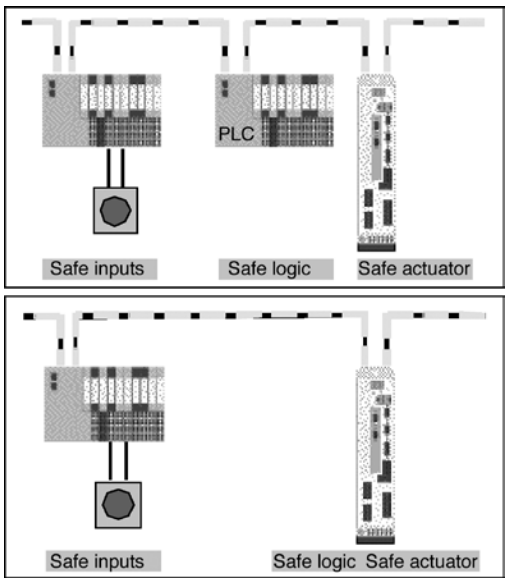

Fig. 2: Safe drive system architectures

within a maximum permitted limit value. If the speed limit value (v_2) is exceeded, the drive is shut down safely and an error message is triggered.

Safe direction (SDI) guarantees that a drive can only move in one (defined) direction. If the specified direction is violated, the drive is shut down safely and an error message is triggered.

Safe brake control (SBC) prevents suspended loads from falling. Because the drive torque no longer affects the mechanics when the output stage is shut down, on some applications (e.g. suspended loads) it is necessary to drive an external service brake. For safe brake control, the approvals body will always specify an additional safe brake test.

There are several possibilities to activate the drive integrated safety functions. For local activation it is possible to integrate digital inputs into the drive and connect sensors directly. In distributed systems, where the safety functions shall be integrated in a safety system, a field-bus system can be used. This can be done with a communication system. The real-time Ethernet communication system Safetynet p with cycle times of 62,5 µs and a jitter of lower than 1 ns able to work as a system bus for drives. It has an integrated safety layer that is suitable for SIL 3 (safety integrity level) applications. With the safety layer of Safetynet p the safety functions of the IEC 61800-5-2 can be realized. Safetynet p uses publish subscribe communication, even for safety, and has cross communication capabilities for direct data interchange between all subscribers, which reduces safety reaction times. A Safetynet p network can have up to 512 safety nodes. Since Safetynet p uses CANopen as application layer it is easy to integrate in existing CANopen devices and CANopen users can reuse their know how. A drive integrated safety system that shall be used in applications with a safety integrity level of SIL 2 and higher, has to be designed in a redundant way with a dual channel hard- and software. That means two processors, which are monitoring each other. The safe software stack of Safetynet p can be integrated in the same processor where the safety functions of the drive are also implemented.

There are several ways of building up a distributed safety control system with safe drives. It is possible to trigger drive integrated safety functions with distributed sensors like E-stops or safety light curtains connected to a remote I/O system. The processing of the safety logic can be done inside a safety PLC and the safe motion control function in the drive is triggered by a command of the safety PLC. The other way is to integrate the safety PLC function inside the drive. Then the drive has the ability to react directly on published commands of the remote I/O system.

www.safety-network.de