

FBM - Lateral thinkers are quick thinkers

Module intelligence and direct data exchange between fieldbus modules enhance the real-time capability of distributed control systems

When PLC programs are large, distributed control systems often do not achieve the response speed required for the technological process. Acceleration is obtained by using intelligent remote I/O modules, which perform complex functions of signal conditioning (e.g. filtering and limit monitoring) already in the I/O module. A further leap towards higher performance is achieved by distributed control systems if the I/O modules exchange individual data directly, without recurring to the PLC CPU. This communication technique, which is possible on the basis of the CANopen protocol, guarantees maximum response under tough real-time conditions.

Today distributed machine control systems consist of a central PLC with the CPU (Control Processing Unit) in the control cabinet and the input/output modules out in the field. The input/output modules communicate with the PLC CPU via the CAN bus. The PLC reads the data from the field, performs calculations and comparisons, decides what has to be done next, and returns data back to the field. In doing so, the PLC program also takes on tasks which could be done locally, for instance debouncing input signals, filtering analog values, or creating output pulses. With increasing size of the central PLC program, the cycle time of the Master CPU rises, and the response speed of the overall system is reduced. However, use of more and more powerful CPUs is usually limited because it becomes too expensive.

3-fold strategy for decentralized real time

The ECKELMANN intelligent input/output modules offer 3 solutions at the same time for improving the response time and the real-time behaviour of modern machine control systems:

- 1.) The input/output modules are capable of independently executing basic functions such as debouncing, filtering, controlling, locking, generating signals and even positioning.
- 2.) Due to certain characteristics of the CANopen protocol, the input and output modules can communicate with each other directly, i.e. without having to take the roundabout route via the PLC CPU.
- 3.) Due to their on-board intelligence, the input and output modules are able to execute logic operations on external and internal data within the module.

Thus built-in logic and direct communication yield the deciding advantage in terms of speed. The basis for direct data exchange according to the producer-consumer principle is given by the multimaster function of the CAN bus! In contrast to other fieldbuses, the CANopen protocol does not use addressing of a subscriber, but identification of the publisher. In this case, CAN bus stations that have to say something send their data via the bus (**Producer**), and these data are received by other stations who want to get information (**Consumer**). What is really new about this technology is the possibility of making the "information behaviour" of a consumer programmable.

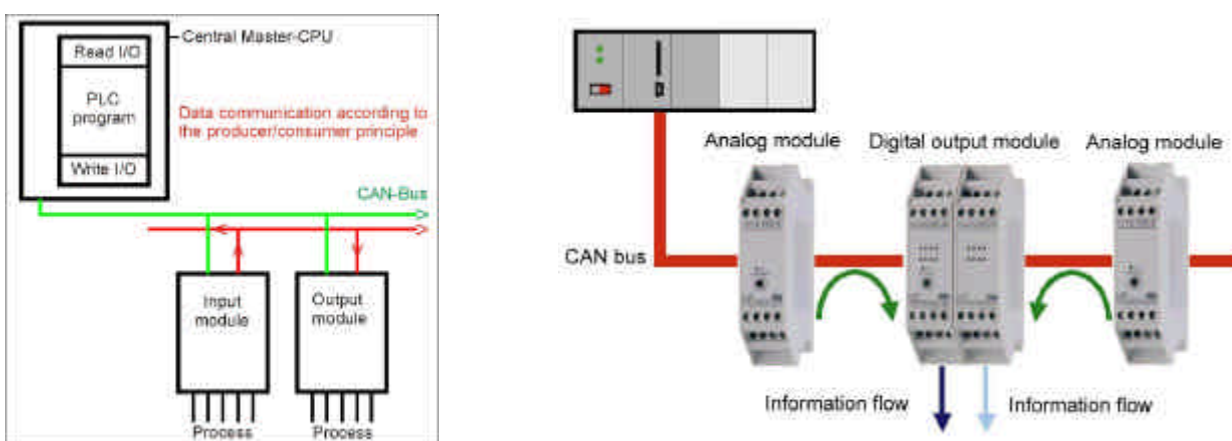


Fig. 1: Direct communication between the modules and with the PLC

With the new ECKELMANN Series E•FBM modules, the PLC CPU can enable the direct communication of the modules with each other by transferring the producer address of the source data, the function and other data to be processed to the consumer module.

The data, which have been made available publicly by the **producer** module, can now be read, combined and output by other consumer modules. After that the respective **consumer** module of course indicates its status change to the central PLC CPU.

The advantages of these techniques shall be illustrated here by means of a practical example.

Advantages of module intelligence in limit monitoring

Manufacturers of high-pressure sensors for hydraulic systems operate endurance test beds for checking burst strength, linearity, frequency and long-time behaviour of the employed pressure cells. The task of the test bed's control system consists in making the pressure in the hydraulic system increase and decrease linearly, whereby the sensor passes the whole of its measuring range and the overload range almost up to the burst limit. Depending on the sensor type, it has to be monitored in a parametrizable way whether the preset burst pressure is exceeded, and, in order to prevent this from happening, a switching valve has to open. In this way, the sensor is protected from destruction, the test bed from unnecessary loss of hydraulic fluid, and the check can be performed without interruption.

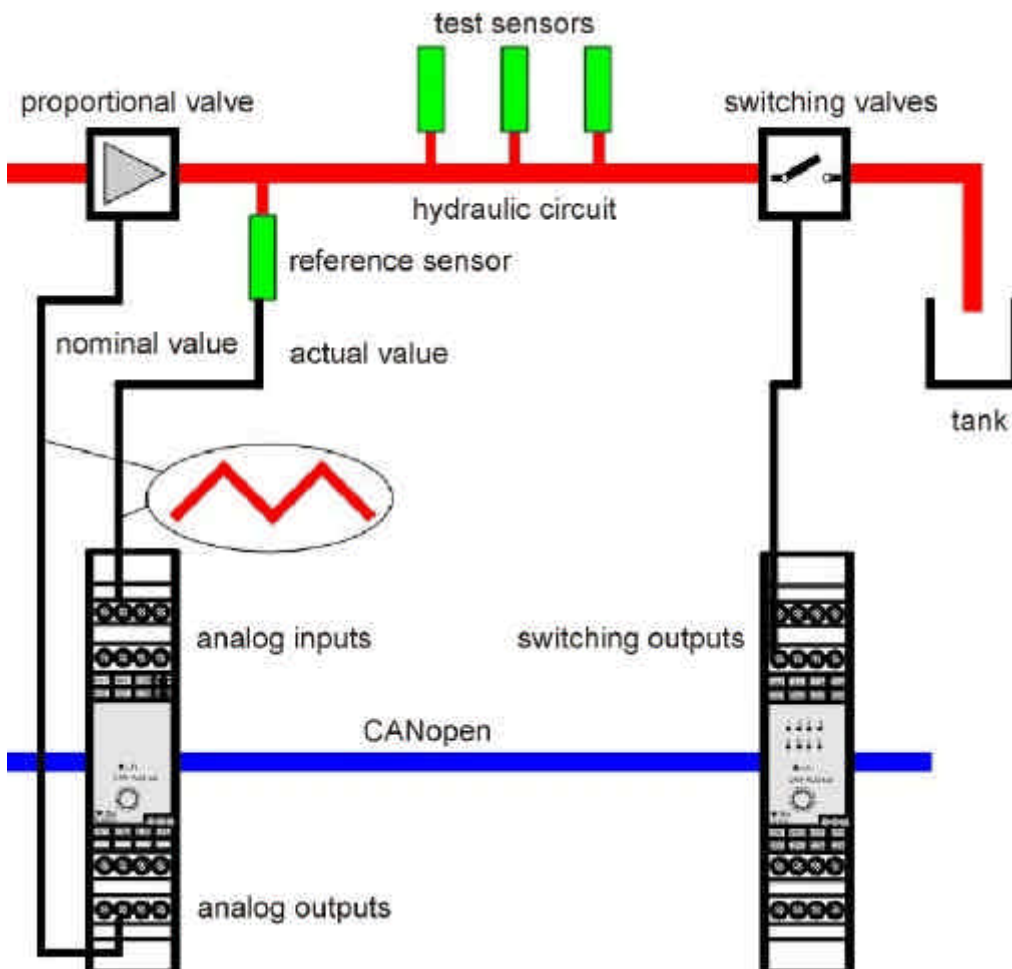


Fig. 2: diagram of circuits for signal generation and limit monitoring

In the application shown above, several functionalities are recognized that could not be implemented with simple fieldbus modules.

- 1.) Due to the bad deterministic characteristics of a multimaster bus, a delta signal (see Fig. 2: red delta signal for setpoint and actual value) cannot be generated via a field bus without jitter. In the ECKELMANN AIO22 analog input/output module, the self-contained function Signal Generator can be called, whereby the PLC specifies the shape, frequency and amplitude. Afterwards the output of the signal shape takes place in the module independently of the PLC CPU.

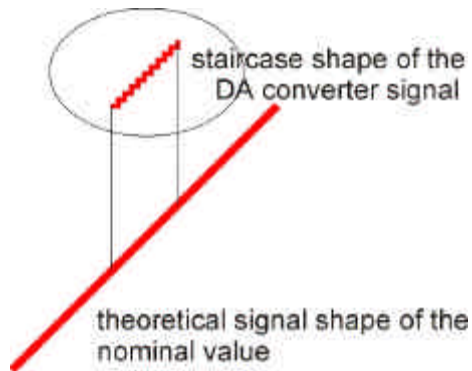


Fig. 3: the uniformity of the signal shape is extremely constant when the signal is generated internally in the module

In addition, the analog inputs of the same module can be assigned the parametrizable function Filtering for noiseless signal acquisition. This reduces the number of bus protocols, as not every bit change immediately results in a bus protocol.

2. In simple I/O modules, the processing time of the PLC governs the response time of the switching output for activating the switching valve when a programmed burst pressure is reached. The response time is the sum of the transfer time from the analog module to the PLC plus the cycle time of the PLC plus the transfer time from the PLC to the digital output module.

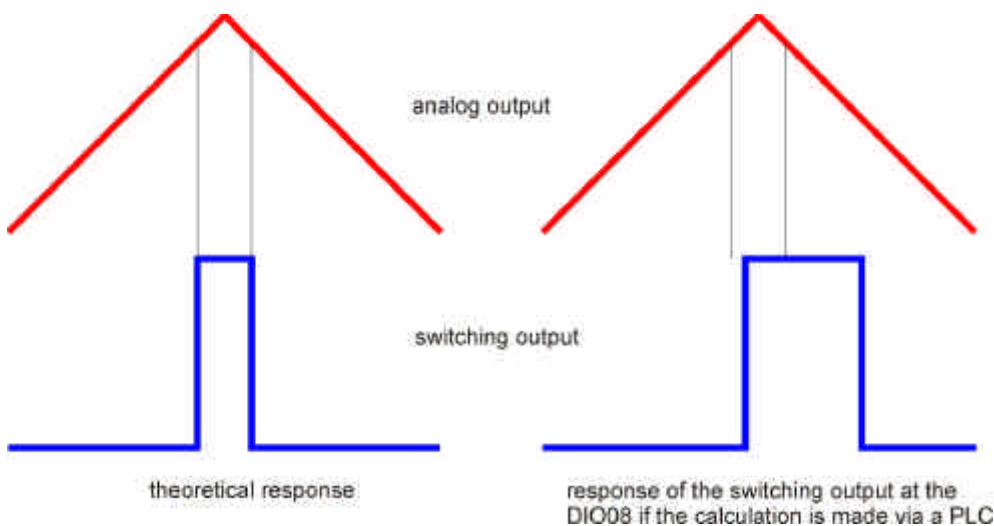


Fig. 5: the response speed does not meet the real-time requirements of the test bed

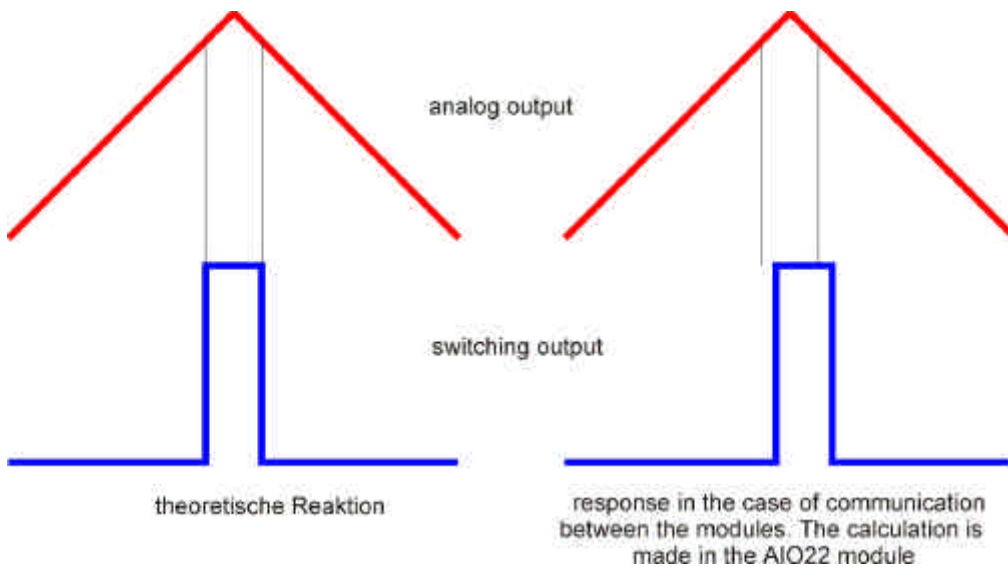


Fig. 6: The response speed is sufficient for the real-time requirements of the test bed

Here the new communication capabilities of the intelligent ECKELMANN I/O modules reduce the response times drastically, for the digital output module (**consumer**) listens to the data of the analog module (**producer**) from the bus. The digital output module is enabled by the central PLC CPU to process the data of the analog module internally. For this the PLC imparts the station address of the analog module to the digital output module.

3.) The PLC activates the function Limit Monitoring in the AIO22 and writes the desired limits into the compare register of the AIO22. If the analog value of the associated input exceeds a specified limit, the analog module sets a logic bit. This bit is communicated as a logical input via the CAN bus. The digital output module reads this logical input of the analog module and responds independently by setting or resetting its output. The response time is reduced by the cycle time of the PLC (20-200ms) and the transfer time from the PLC to the output module (2-5ms). In practise, it has been shown that these new module characteristics improve switching times by a factor of 4 – 20.

E•FBM: intelligence in control without a single line of PLC programming

The functions of the intelligent ECKELMANN input/output modules are an integral part of the built-in microcontroller. After the modules have been switched on, the function is preset as a decentralized input/output module. According to the requirements, the functions can be switched on and off, and the necessary parameters can be set and changed online via the CAN bus any time. For this a great number of registers in the module is available to the PLC programmer, enabling him to influence the behaviour of the module.

Register	Function
Input register real	8 or 16 bit read access to the physical inputs
Output register real	8 or 16 bit write access to the physical outputs
Enable register SF	8 or 16 Bit activates or deactivates special functions per channel
Function select register	Defines one of the selectable module functions
Parameter register SF	Temporary storage for sets of parameters of the selected function
Address register producer module	8 station addresses for external data
Operand register	Reference values for logic operations

The modules of the E•FBM series can be expanded by additional or customer-specific functions any time thus providing a new level of performance for distributed control systems.



Picture: AIO22 – mixed analog input/output module

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