Bridging the gap between Modbus/TCP and Foundation Fieldbus

Integrating modern process peripherals in traditional automation architectures

Foundation Fieldbus is a powerful process automation system which offers numerous advantages over conventional technologies in terms of production quality and serviceability. But migrating to Foundation Fieldbus often entails changing the entire existing control technology - all the way to the managment level. The costs associated with this may make it difficult to take such a step. But appropriate network gateways can lower the barrier to entry and enable a gradual migration to the new technology.

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Fig. 1: Gateways between FF H1 and Modbus/TCP facilitate the migration to Foundation Fieldbus.

Foundation Fieldbus is becoming increasingly important in process technology, particularly in the petrochemical industry. The strengths of Foundation Fieldbus lie in its ability to network sensors and actuators and to distribute control tasks. Even though well over 80% of all newly installed devices are equipped with 4-20 mA interfaces, tremendous growth rates of around 30% are expected for Foundation Fieldbus (FF). On the one hand, this is due to the vast possibilities its bus system offers for device parameterization and diagnostics. This makes it possible to adjust a sensor's operating range to its environment from a central location, for example. This eliminates the need for a special parameterization interface at the sensor, as well as the long and – depending on where the sensor is installed – potentially difficult path to reach the sensor. Another advantage of FF is the ability to specify an exact time response for transmitting measured and manipulated variables. Control loops can be closed via the bus in this way, and distributed control loops can also be realized. Simpler control tasks can then be carried out directly in an intelligent field device (e.g., a valve) without the need for any centralized control.

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Foundations of the FF architecture

FF offers a two-level network architecture. Process peripherals are typically connected to what are known as H1 segments, which can also be intrinsically safe. The high-speed Ethernet (HSE) version of the FF protocol acts as the backbone which allows groups of peripherals to be connected to one another and to the control technology using conventional Ethernet infrastructure components. Field devices can also be operated directly on HSE. Many manufacturers offer a wide range of sensors and actuators for FF H1. As of yet, however, relatively few control technology manufacturers have adapted their systems to FF. For this reason, FF is usually integrated in a proprietary way, which has made it nearly impossible to use control technology components from different manufacturers on the HSE level, for example. In light of this, users are generally tied to the first provider they choose. In order to make it easier for users to implement FF and achieve investment security, manufacturers must improve the compatibility and interoperability of their components – particularly for control technology – and create gateways to established control architectures.

Gradual migration from 4-20 mA to FF

A gateway between FF H1 and Modbus/TCP (Modbus over Ethernet) can serve as an example of what is required of a gateway between FF components and a widely distributed automation solution. A large process control system is usually too expensive for simple control applications. Furthermore, when moving gradually from 4-20 mA point-to-point wiring to a fieldbus, it is reasonable to gain experience with smaller units first. In both cases, tasks can be carried out with inexpensive Modbus/TCP-enabled controllers. Even when new plants are planned with FF control technology in mind, it makes sense to include a gateway to Modbus/TCP so that third-party components for visualization, operation, servicing or additional data processing can be connected.

Divide and conquer

In order for a gateway solution to be accepted, user competence must be taken into account and complexity must be minimized. For this reason, the technologies in the FG-100 FF/M gateway were coupled as a pure process data interface. This means that no detailed knowledge of either side is needed to integrate the gateway either in the FF application or the Modbus application. On the FF H1 side, the gateway acts like series of I/O blocks which can be linked to the field devices using commercially available FF configuration tools. The measurement value of a sensor can be linked to one of the gateway's output blocks. The measurement value then becomes part of the process image held in the gateway, which can be read from the Modbus side. Conversely, a predetermined target value can also be written from a Modbus/TCP device to the gateway. This value, too, then becomes part of the internal process image and can be connected with an actuator in the field via one of the gateway's input blocks.
The FG-100 FF/M simulates several hundred I/Os at each of its four H1 connections and is therefore sufficiently equipped for maximally expanding the segments. The FG-100 FF/M can also handle the exact timing that is necessary for high control performance with FF. This function, which is known as an LAS (Link Active Scheduler), is usually handled by a control unit, but it can be implemented in each field device if desired. This ensures that even if the current LAS device fails, the process can continue, if only in limited form. The LAS function is taken over dynamically and individually for each H1 segment. On the Modbus side, the gateway implements the usual register interface. It acts as a server which gives several clients simultaneous access to the process data which is transmitted using the individual and combined read and write functions defined by Modbus. In order to optimize bandwidth and prevent Modbus/TCP devices from having to repeatedly poll the gateway, the FG-100 FF/M itself can also act as a Modbus client. To this end, it is possible to define which device should receive which data at which time. This enables event-driven behavior, which means that selected data is only reported to an "interested" Modbus device in the event of a change.

Configuration

Like any field device, the FG-100 FF/M provides a "device description" file for FF configuration which is read by the configurator. It does not matter whether the configurator is part of a control system or whether it is a stand-alone application on a notebook. The gateway is always accessed for configuration via the corresponding H1 connection (Image 2). The gateway's Modbus server requires absolutely no configuration, since the mapping of the local FF function blocks to the Modbus register is fixed. Besides this fixed mapping, which will reveal gaps in the Modbus address space if not all FF function blocks are linked to real devices, the gateway also provides a compact process image in which only those elements which are actually occupied are included. This can spare valuable bandwidth on the Ethernet side. The compact process image is documented by an automatically generated data sheet.

Integrated Web server

This data sheet can be accessed on the Web page of the gateway. Users can expand it by adding application-specific information such as function descriptions, the installation location, and much more. This valuable information assists service technicians when on-site

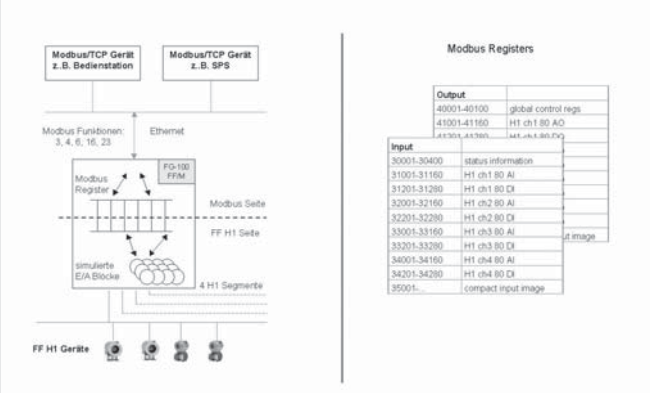

Fig. 2: Structure of the gateway between FF H1 and Modbus/TCP

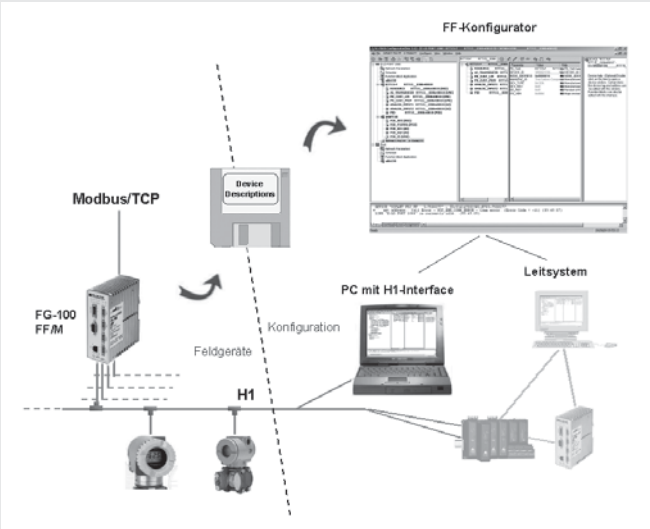

Fig. 3: The gateway is configured like any other FF device.

maintenance is required. The Modbus client function is also configured using the Web interface. Source data, data triggers (value changes or time constraints) and target devices can be individually specified here. The Web interface can additionally be used for network administration, as well as to carry out extensive diagnostic and commissioning functions. It is possible to access a comprehensive self-test, status and version information, and process data and status information from the connected devices. All of the configuration data in the gateway can be downloaded and uploaded again as a file via the Web interface, so no reconfiguration is necessary if devices are exchanged.

The FG-100 FF/M is well-equipped for the future since it also makes process data available via Web services in accordance with the OPC XML DA specification. This open standard is increasingly found in commercially available SCADA systems.

Summary

The primary conditions have been established for using Foundation Fieldbus in process automation. A number of sensors and actuators are available for FF H1. The network gateways between H1 and HSE which have been standardized as "linking devices" are also available from various providers. But there are still weaknesses among control systems as regards openness to HSE. Gateways to traditional automation architectures can help by allowing systems to be expanded to include third-party components, such as those for handling process data or for visualization. Such gateways also make it possible to realize smaller systems more inexpensively without the need for a dedicated control system and to integrate these systems in standard software environments. Conventional systems can therefore migrate gradually to comprehensive Foundation Fieldbus control technology. This limits the risks of investing in and realizing such systems and paves the way for third-party providers.