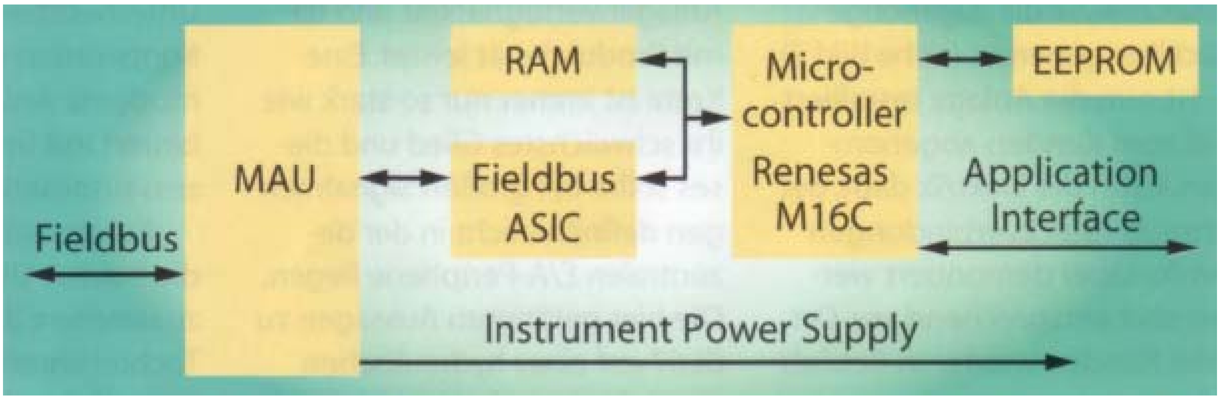
Intrinsically safe field devices for PROFIBUS PA and FOUNDATION™ fieldbus

Dr. Ing. Hans Endl, Softing AG

When it comes to fieldbuses for process automation, FOUNDATION fieldbus H1 and PROFIBUS PA are the two options available. Which one has the advantage depends on the region and the industry. The manufacturers of bus-enabled field devices feel compelled to support both standards. But because there are many similarities between the two fieldbuses as regards application model and bus physics, supporting both fieldbuses is fairly straightforward as long as certain conditions are met. While there are countless fieldbuses for manufacturing automation, the range for process automation is more manageable: FOUNDATION fieldbus H1 and PROFIBUS PA are the only alternatives when intrinsically safe, bus-powered field devices are required. Due to their history and goals, these two fieldbuses differ considerably as regards architecture and functionality, so they each have specific strengths and weaknesses. However, they also share certain architectural features. This makes it possible to develop field devices which can run on either fieldbus (by exchanging software components), or even on both fieldbuses (through automatic protocol detection). This is facilitated by the fact that FF H1 and PROFIBUS PA use the same bus physics and have very similar application models based on function blocks. The protocol software interfaces to the bus and to the application can therefore be identical. If the integration interfaces to the hardware (microcontroller, fieldbus ASIC), the non-volatile memory and the real-time operating system are constructed in the same way, then it's only a small step to migrate to a second protocol. However, there are certain requirements to be met, particularly as regards the hardware platform.

Hardware platform

Figur 1 shows the block diagram of a fieldbus circuit. The fieldbus is connected via a Medium Attachment Unit (MAU) which draws energy from the bus for the entire circuit and the sensor/actuator. The signal, which is still serial but has already been digitized, is forwarded to the microcontroller through a special serial interface component (SIO). The sensor/actuator (or a complete field device with a serial interface) is connected via one of the microcontroller's interfaces. The Medium Attachment Unit can be constructed from discrete components, but there are also integrated MAUs such as the µSAA22Q from Yokogawa or the SIM-1 from Siemens. Unfortunately, both of these were recently discontinued, but hopefully they will be replaced by successors. For PROFIBUS PA, Siemens offers the SPC4 and DPC31 ASICs with an integrated Data Link Layer and a synchronous interface for IEC MAUs. But if the bus connection is to be enabled for FOUNDATION fieldbus as well, then it is necessary to circumvent the integrated protocol support for PROFIBUS and directly access the synchronous serial interface, which is possible with SPC4-2. Both chips can also run on RS485 buses at rates of up to 12 Mbaud, making it possible to use devices with a PA profile on fast PROFIBUS networks. As an energy-saving alternative, a pure synchronous interface component can be used. This demands that the Layer 2 protocols be realized entirely in software for both PROFIBUS and FOUNDATION fieldbus. The options here are the FIND-1+ (YTZ440-F) from Yamaha and the Frontier 1+ from Fuji Electric. Both carry out Manchester encoding and decoding, and they also generate and check the CRC polynomial in accordance with IEC 61158-2. They also feature some useful protocol timers. The Frontier 1+ has even integrated the MAU so that no separate MAU chip is needed. It is also possible to use simple low-power microcontrollers as serial interface components, although additional software development is necessary for this. It is difficult to find a microcontroller with low energy consumption which still offers an acceptable level of computing power and an address space larger than 64 K. The ideal candidates at the moment appear to be the members of the M16C family from Renesas (a joint venture between Hitachi and Mitsubishi), which have up to 256 KBytes of reprogrammable memory on-chip. Since the integrated RAM of the microcontroller is not sufficient for a complex fieldbus protocol, it is necessary to use external RAM and a (serial) EEPROM for the non-volatile storage of the communication and function block parameters.



Figur 1: Hardware structure of the fieldbus circuit.

Software architecture

As mentioned earlier, FOUNDATION fieldbus and PROFIBUS PA field devices use very similar application models based on standardized function blocks. Simple function blocks include analog input and analog output. To make these function blocks device-independent, the device function is mapped to the function block via so-called transducer blocks. These are also largely standardized and contain device-specific parameters, such as those for parameterizing the measurement function of a measuring transducer.

A physical block (PROFIBUS PA) or a resource block (FOUNDATION fieldbus) is also needed for each device. The parameters for describing the physical device – such as the manufacturer ID, model ID, serial number, etc. – are stored in these blocks. The function blocks are coupled to the communication system and controlled by means of a function block shell, which can viewed as a type of operating system for function blocks.

From the viewpoint of integrating a fieldbus protocol in a field device, this architecture takes the following structure (Figur 2):

- The protocol software – together with the function block shell, the function blocks and parts of the transducer blocks – forms the reusable, protocol-specific part of the device software. This software almost always comes from specialized providers since too much development effort is involved for device manufacturers, even large ones.
- All the software components needed for providing the actual field device functions (such as recording and processing the measurement values from measuring transducers) or which realize hardware-dependent functions (such as controlling the non-volatile memory) are device-specific. These software components are usually developed by the device manufacturers themselves since this is where their core expertise lies.

For many years, Softing has offered portable protocol stacks for standardized fieldbuses, including optimized protocol stacks for field devices with identical interfaces for FOUNDATION fieldbus and PROFIBUS PA. This allows device manufacturers to support both protocols with a single hardware platform and application architecture.

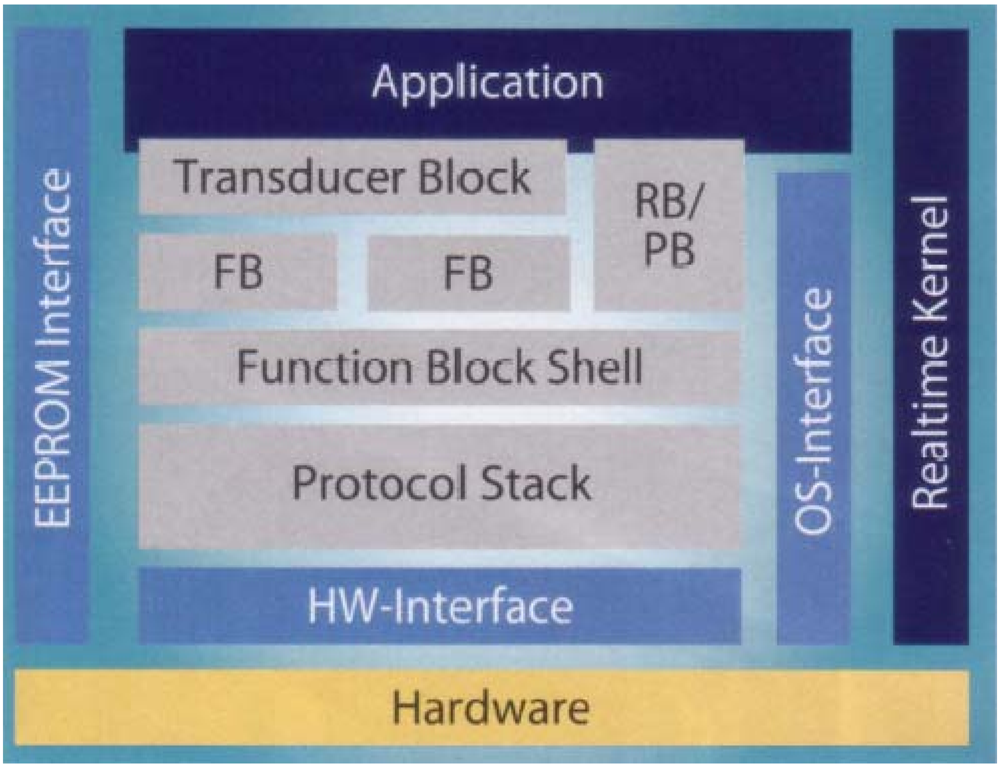
The integration interfaces comprise:

- A generic operating system interface which device manufacturers can use to integrate their preferred real-time operating system,
- an interface for integrating the device application in the transducer blocks,

- an interface for connecting and managing non-volatile memory for persistent data,
- and hardware-related functions for adapting the protocol software to the hardware platform.

In most cases, device manufacturers will use the object libraries of the protocol software; the source code only needs to be adapted to the integration interfaces mentioned.

The hardware and software architecture described here has proven successful in a large number of projects with numerous device manufacturers. This architecture makes it possible to realize intrinsically safe, bus-powered field devices with a total energy consumption of 10 to 20 mA which support PROFIBUS PA or FOUNDATION fieldbus (or both) depending on the library used.



Figur 2: Software architecture of the field device.