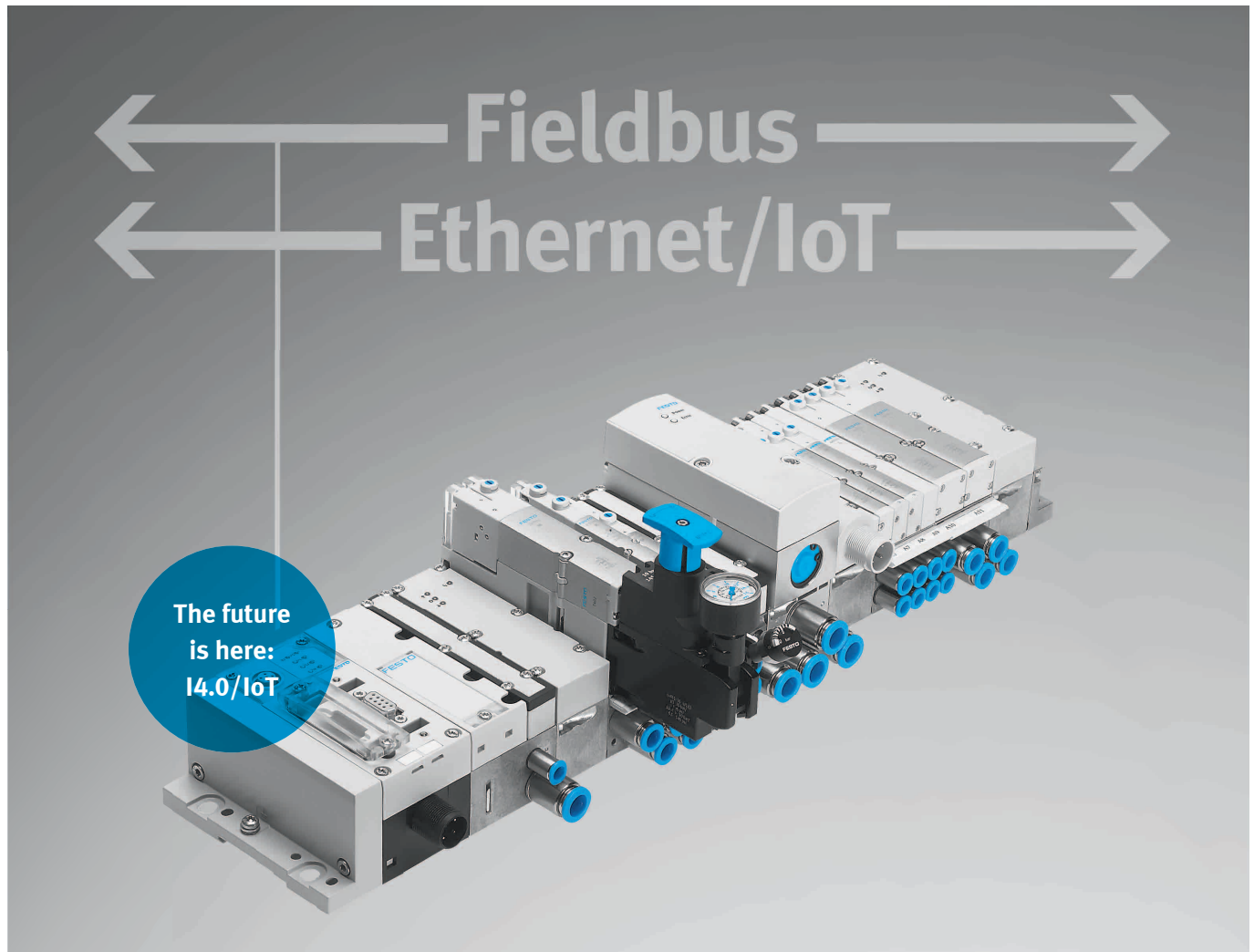# White paper
The future role of ethernet and the trend to decentralised control solutions

The driving force behind progress in Industrial automation in the last 20 years has without doubt been the networking of automation products via bus systems. The importance of industrial communication within machines and installations is increasing exponentially, especially in the context of recent Industry 4.0 (Internet of Things, IoT) discussions. Networking is decentralised from its starting point – communication at control system level – down to the connection of front-end devices, sensors and actuators, which perhaps already feature decentralised intelligence.

Here Jacqui Hanbury, Product Manager, Networks and Controls at Festo looks at how fieldbus and Ethernet solutions will develop in the future and the move away from centralised processing of signals and parameterisation to distributed control intelligence.

For more information on bus systems and control technology contact also Jacqui Hanbury (contact details page 7).

Trends in current product and market developments

While in the previous decade attitudes to the use of bus systems were still very critical, today fieldbus systems are regarded as a vital part of many applications. They are used in more and more areas. Installation-saving solutions with automation devices equipped with a bus connection are state of the art, while in front-end automation a new class of high-performance products is emerging as a next step to greater efficiency and higher availability. This applies in particular to automation with pneumatics and valve terminals. This development is reflected in new trends and increasing acceptance of automation in more critical applications and is leading to pronounced changes in the design of automation components and systems.

Industrial Ethernet versus field bus – competitors or partners?

In the field bus wars in the past decade between the many manufacturer-specific bus systems and the open systems, one thing soon became clear – it is the user who decides.

And the basis for this decision is performance, in particular, user benefit. The primary factor was not technology but the wide choice of field bus devices which were available with all kinds of technological functions, making it possible to achieve a seamless implementation in applications.

The clear winners were the open field bus systems. The installed base of field bus devices is enormous, with over 50 million nodes, and represents a commitment for users in terms of the need to protect the investment made in engineering and know-how.
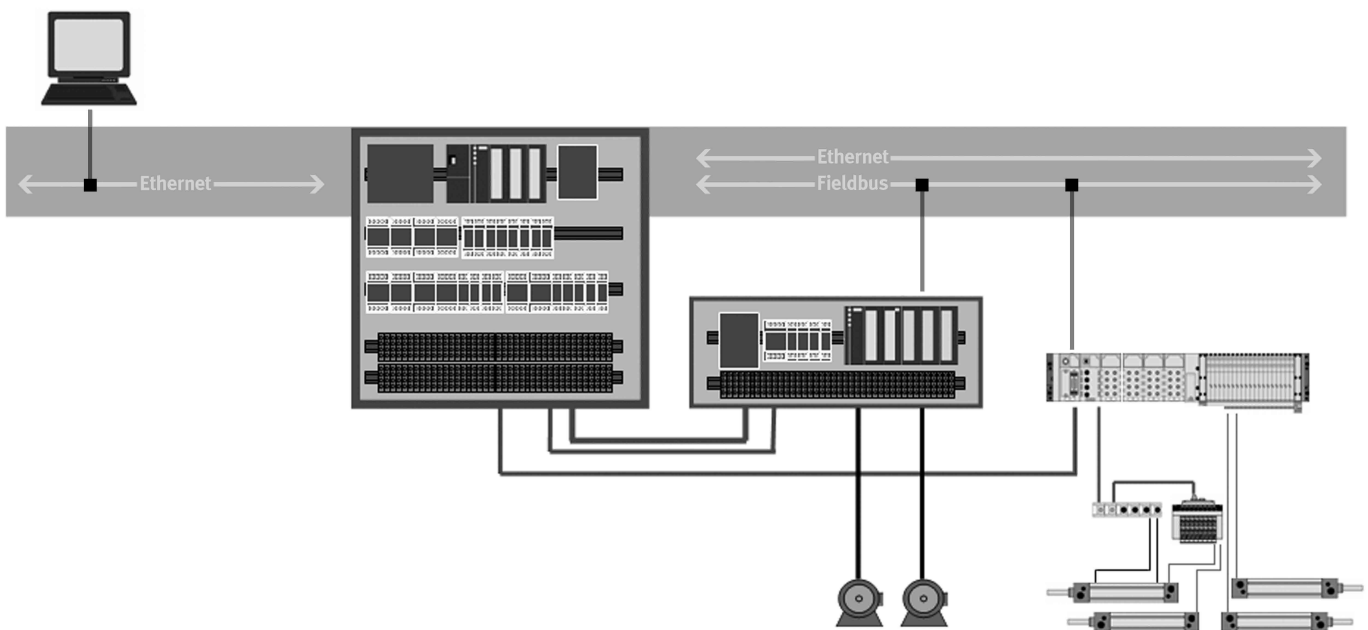

Fig. 1: The main factors with regard to bus systems: Less space in control cabinets, lower costs for wiring

A decade or more ago, industrial Ethernet was associated with the idea of further consolidating the bus landscape, while at the same time lowering interface costs and boosting performance – and making IT services available in the field. A tempting thought – achieving performance standardisation in industrial communication with one Ethernet system.

Target	Current situation
One industrial Ethernet protocol	≥ 5 relevant Industrial Ethernet protocols
Use of hardware from consumer and PC areas leads to uniform standardised products	Has not occurred: Individual hardware and designs required for each system, little usable electronics from the PC area
Lower interface costs per device through economies of scale and inexpensive hardware. Vision: Industrial Ethernet in individual sensors/actuators	Target missed: Higher prices per interface due to smaller quantities, high-performance electronics and individual design
Use of IT services in front-end automation devices creates a transparent link to higher-level systems and allows higher volumes of data communication	Not yet used: IT services are generally used at the control system level and higher, few projects with IT at field level
High-performance communication in terms of data volume, speed and synchronicity allows the integration of motion control applications into a network with other field devices	Target achieved: Variants with high-speed clock-synchronised data communication in co-existence with standard communication on one bus

Fig. 2: Current situation

The original objectives of standardising the communication landscape through the use of industrial Ethernet have not yet been achieved. The large installed base of field bus systems and the high cost of switching to industrial Ethernet is at present a barrier to the replacement of field buses by new system approaches.

However, new possibilities are emerging, and with these a very clear profile and target area for industrial Ethernet. As the result of the trend to ever-faster processes and machine cycle times, motion control applications and the necessary peripheral processes are moving ever closer together. This means potential for industrial

Ethernet. Applications of this kind can be based on ProfiNet IRT, EtherNet/IP, CIP Synch, EtherCat, Powerlink or even Sercos III. The discussion around Industry 4.0/IoT will only boost the potential of these networks.
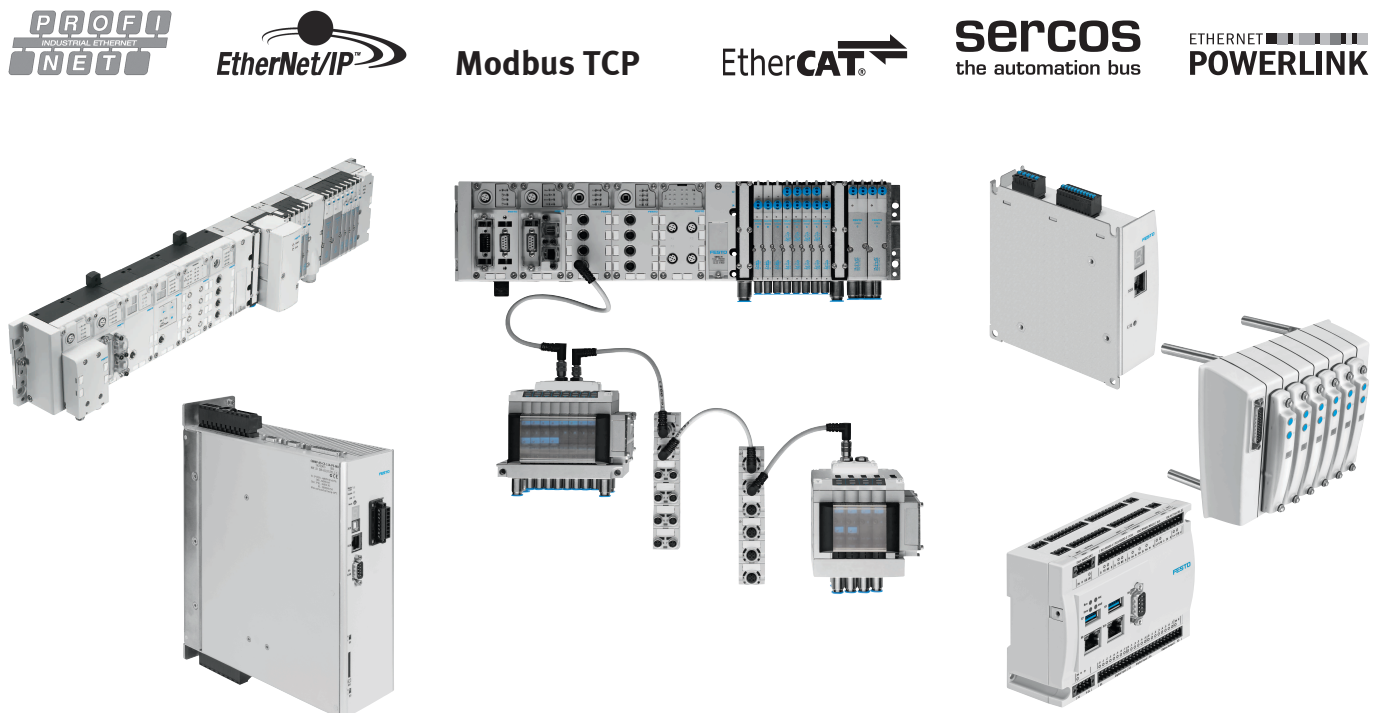

Fig. 3: Festo solutions for industrial Ethernet

Forecast for the future

Most simple applications (and most applications are simple) will continue in the future to be equipped with field bus systems. More complex applications – particularly those with high motion control content – will migrate to industrial EtherNet.

The principle once again applies that users will calculate the costs of migration and investment very carefully and then decide the proportion of industrial Ethernet and field bus on the basis of the benefit (price/performance ratio) for their application. Coexistence of the two systems to cover different applications and customer requirements would therefore seem to be the probable scenario.

Recent discussions about industry 4.0 and the need for even stronger horizontal and – even more important – vertical integration of devices, machines and control systems are interesting. Here OPC-UA is being discussed as the most appropriate data format to be implemented on existing Ethernet base networks. However the same arguments still apply; users will still have to take into account the benefits of this new technology with the cost of migration and investment.

Complexity of applications
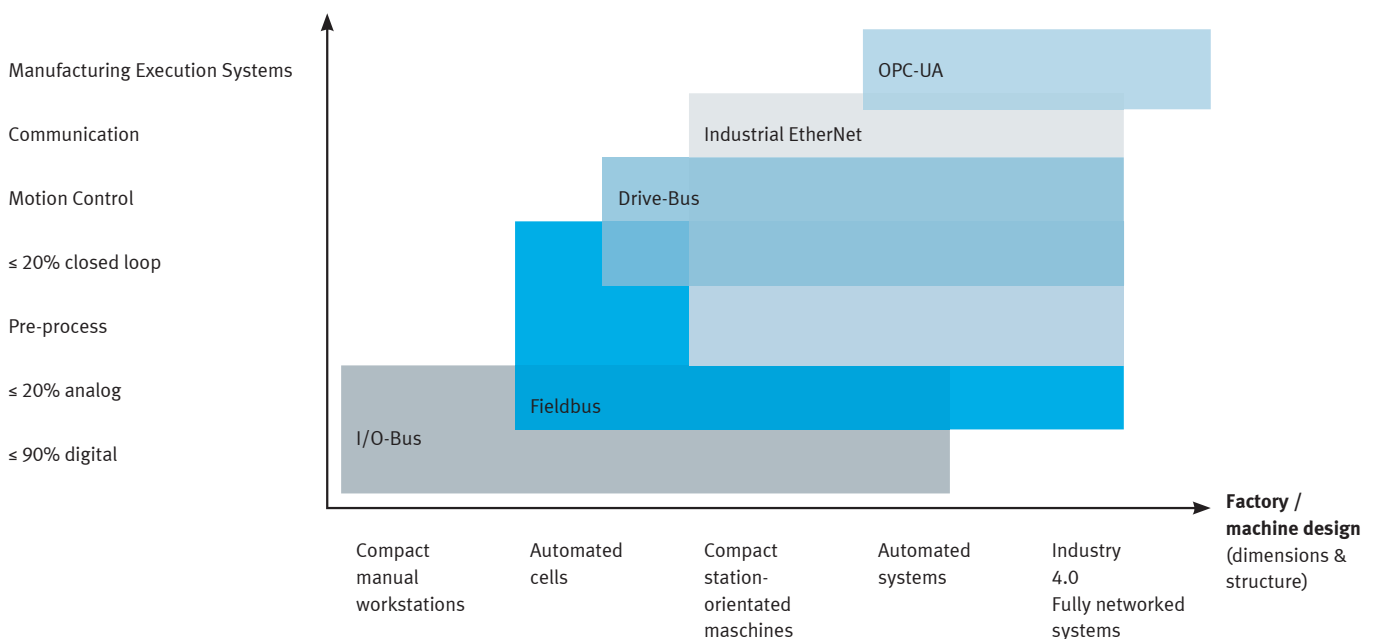(Sensors & actuators)

Fig. 4: Positioning and potential of the various communication systems

Distributed control intelligence in a network versus centralised processing of signals and parameterisation

The basic idea and the first move towards decentralisation by means of bus systems was the relocation of the I/O of the central controller in a control cabinet to de-central terminal boxes. Very soon, the principle was established of direct machine mounting of remote I/O units. A pioneering role was played by Festo valve terminals with their high degree of protection IP65/67. In a second step, more and more peripheral PLC functions were moved to the field level.

The logical consequence forecast as the third step was the distribution of control system/PLC functions to the field – "The network is the controller" was one of the slogans at the start of this decade.

This much-discussed trend has established itself in only a few applications. The barrier for most users was the increased hardware costs for de-central control logic and the increased engineering costs for the generation and maintenance and management of user programs.

One aspect of "de-central intelligence" has become established, however, namely the increased flexibility of de-central automation devices provided by integrated pre-processing functions. Examples include parameterisable fail-safe functions for outputs, valves and actuators in the case of an interruption of communication in the bus system, or also software-parameterisable limit-value monitoring for analogue sensors and actuators. Function integration has thus established itself as a facet of de-central intelligence.

In future it is expected to see an increasing demand for subsystems to be run autonomously as so called cyber-physical-systems (CPS) in industry 4.0 environments. This could lead to simple stopper modules that have a smart controller and IP address on board. Or larger devices/subsystems such as gantry or handlings systems featuring this CPS functionality.

Target	Current situation
Distributed networked control logic with central and intelligent programming tools – a neural network	Some integrated controllers in operator panels, motion controllers, remote I/Os and valve terminals
Replacement of central controller	Networking with central controller; conventional field bus communication, in certain cases download of user programs via field bus
High availability thanks to programmed fail-safe functions in the decentralised control logic	De-central periphery has parameterisable fail-safe functions and pre-processing function modules
Pre-commissioning of sub-functions and object-oriented user programming	Is used for discrete sub-functions and linked manual workstations, based on front-end controllers
Benefits to compensate for overhead costs of highly distributed control (see above)	Price/performance ratio for de-central control logic accepted only for certain applications

Fig. 5: Distributed control system structure versus centralised parameterisation

Setup and
service MMI

Front-end controllers and
modules with parameters

Valve terminals
with status monitoring
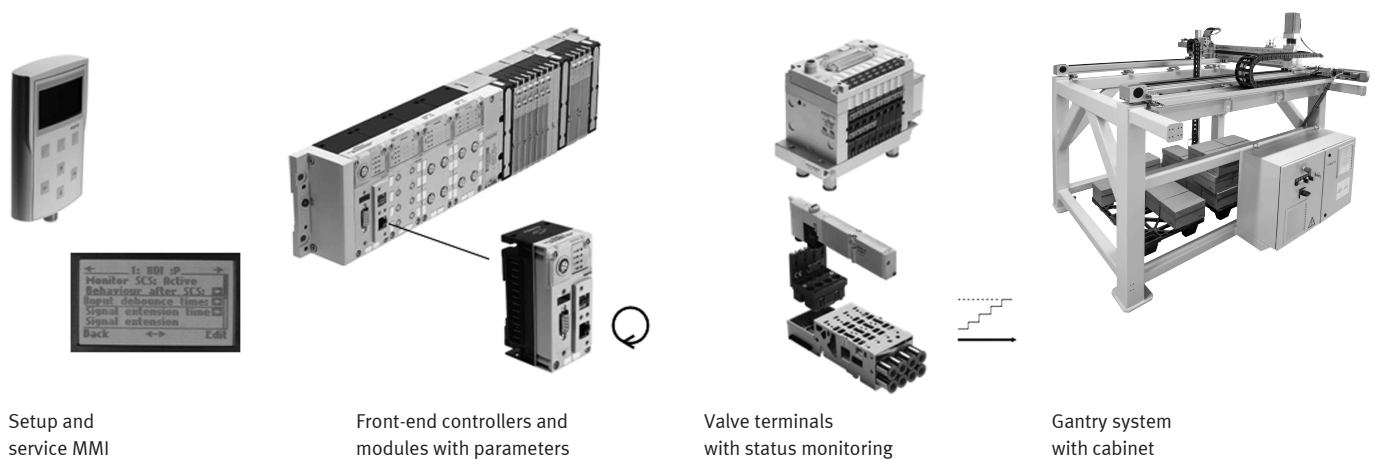
Gantry system
with cabinet

Fig. 6: Festo solutions – pre-processing via parameters and controllers

The changes in customer requirements and the rising demand for de-central installation systems
As the result of the decentralisation of control system components and their relocation directly next to sensors and actuators, direct machine mounting is becoming ever more important.

This development is due to a desire by users to cut wiring installation costs, use preassembled cables to further reduce wiring costs, and eliminate the need for a terminal box.

Particularly with regard to triggering a pneumatic control chain, direct machine mounting has clear benefits for users. The closer the triggering unit (the remote I/O or valve terminal) to the actuator, the more the environmental requirements of these front-end components also apply to the control components. Moreover, valve terminals in particular can be used for applications for which users would not previously have considered them.

Examples include the following:
• Increased use in automobile body-in-white production directly in very harsh conditions (welding area, vibration and shock load)
• Use in process automation (EX zones, zones subject to standards such as FDA)
• Use in the food industry in splash zones (contamination by food ingredients and subject to spraying with cleaning agents)
These requirements have led to noticeable changes in customers' demands, particularly in the last number of years.

Of special interest, however, is the development of mono-technological units to form multifunctional units. Most interesting of all to users are units which provide complete subfunctions within a machine, and also the technological functions. This is now being discussed as the basis of optimised engineering and installation flexibility in industry 4.0 environments.

A good example of this is the development of the valve terminal to become a hybrid technological terminal. Previously the emphasis was on the triggering of valves via a bus, but now a high level of signal mixture is required for everything from the simple sensing of end positions through to the acquisition of temperature data and the integration of pressure sensors, proportional valves and safety-critical electrical power supply concepts, including simple diagnostic functions for the connected periphery, special valve diagnostics and a preventive maintenance function. Valve terminals are not just a platform which provides pneumatic and electrical connections – or even 3D motion control with electric drives/axes – but are also able, through hybrid modular system concepts and de-central installation systems, to adapt to a machine design. The quotation from the architect Lois Sullivan applies precisely: Form follows function.
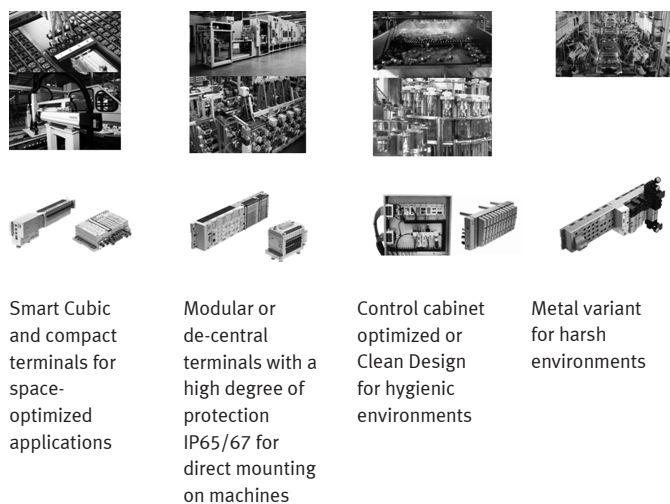

Smart Cubic and compact terminals for space-optimized applications

Modular or de-central terminals with a high degree of protection IP65/67 for direct mounting on machines

Control cabinet optimized or Clean Design for hygienic environments

Metal variant for harsh environments

Fig. 7: Festo solutions – with design adapted to front-end environment

Proportional valve

Pressure sensor

Additional energy supply

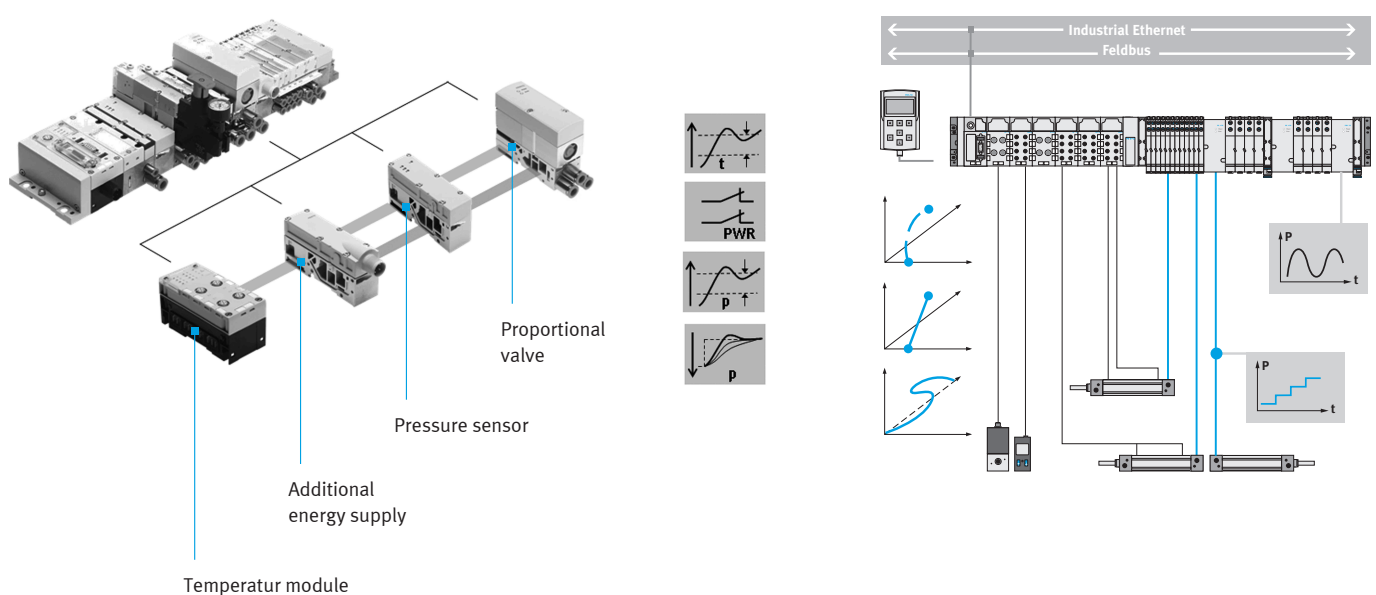Temperatur module

Industrial Ethernet
Feldbus

Fig. 8: Festo solutions – valve terminals with function integration (left) and decentralised PLC including 3D motion control (right)

Customer decisions on pneumatics, electrics and networking

The design of new machine generations and system concepts also makes it very important to select the right system supplier. Products that fit well into applications will be cost effective and result in overall solutions with higher performance.

Possible potentials

- Higher cycle rates through the use of decentralised and faster components
- Higher system availability through more detailed diagnostic functions or a more robust design
- More compact processes through optimised design for a given application
- Higher flexibility in industry 4.0 environments due to functional units and pre-defined interfaces like OPC-UA

The prerequisite for this is close cooperation between product manufacturers and key customers with all kinds of applications. Innovation is not an idea which comes from quiet contemplation but is usually a process in which a manufacturer and user work together to implement an idea in practice.

Conclusions

The subject of "Open Communication in Automation" – in other words, control devices with a bus interface – is a popular one in a time of very dynamic changes. A distinction must be made between its influence on the control system level and that on the field level. On the field level in particular, the potential for lower installation costs has virtually been fully exploited.

There is greater potential in the pneumatics environment through an evolutionary integration of functions and technologies. This, however, demands an adequate link to the control system level – and thus the use of industrial Ethernet protocols as a data backbone for machines and systems.

The established field bus protocols will continue in the next decade to play an important role in mass applications. Valve terminals are becoming multifunctional terminals able to provide complete sub functions of a machine or sub-processes within a system in a flexible form. And all Festo solutions, especially subsystems with valve terminals, will feature OPC-UA connectivity to fit industry 4.0 HOST environments.

Front-end motion control, pneumatics, signal processing, safety technology and networking are the key technologies here. This trend has been identified in joint projects with our customers, and already today the first results are available in the form of Festo products.

Festo, as the technological leader in the field of "Pneumatics, Electrics and Networking", will drive these trends forward in the coming years, working closely with its customers and taking into account the specific requirement in the front-end area of automation technology.

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