Industry 4.0

From vision to reality – Status 2020

FESTO

What does Industry 4.0 mean for Festo?

Festo is adopting an integrated approach to the change in the world of production which incorporates the interaction between people and technology, training and education as well as technology. Festo is conducting research into new solutions and technologies for future production together with partners from business and science; it is also offering coordinated concepts for basic and further training.

What are the characteristics of the production of the future?
Production systems will become digitally networked throughout.
- Intelligent, self-regulating and self-controlling components for plug and produce
- The system has a virtual image for virtual commissioning and reconfiguration
- Highly flexible production plants: economical manufacturing of batch sizes of 1, fast balancing of the workload in a production network, prompt adjustment to the orders in hand
- Comprehensive condition monitoring helps to avoid downtime and optimises maintenance procedures as well as mobile maintenance

Active in political decision making and standardisation

Festo plays an active role in all relevant standardisation bodies for Industry 4.0 and advises the German federal government on the "Industry 4.0 platform" initiative. Universal, open standard architectures provide significantly more benefits than closed concepts for small and medium-sized machine and system manufacturers, as well as for end users.

Examples:
• OPC UA communication standard
• RAMI reference architecture
• Asset Administration shell model
• AML (Automation Markup Language)*

Research

A crucial factor in Festo's success is its cooperation with its partners in science and business; this accelerates the innovation process and resolves complex technical issues. For example, in the early stages Festo was involved in Smart Factory KL – the model for an adjustable production system – and OPAK, an open engineering platform for autonomous mechatronic automation components.

Currently the focus is, amongst others, on the AutomationML initiative for designing automation components in a uniform engineering file format. As part of the ENTOC research project, Festo is working with partners from the automotive industry and the scientific community on the topic of "virtual commissioning".

You can find an up-to-date list at
➔ **www.festo.com/research**

Products and services

Industry 4.0 relies on fully networked, adaptive production through intelligent products with "embedded functions" – the cyber-physical systems. Many Festo components already meet the hardware and software requirements. Festo's newest production plants, such as the Scharnhausen Technology Plant, both produce and use these products, thus paving the way for Industry 4.0.

These products can be incorporated into the following IoT or cloud environments as part of pilot projects:
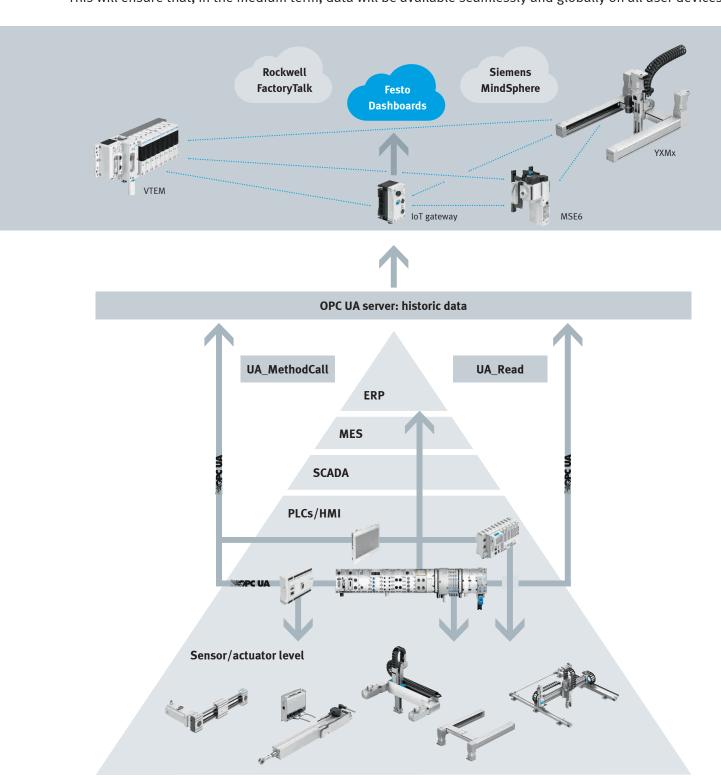• Festo Cloud
• Siemens MindSphere
• Rockwell FactoryTalk/TeamONE
• Others available on request

Industry 4.0 begins here and now – just turn the page to find out more.
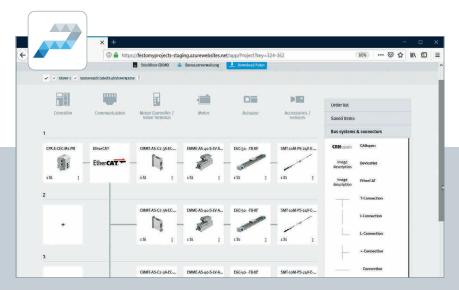
Industry 4.0 – always a finger on the pulse thanks to complete networking and partnerships
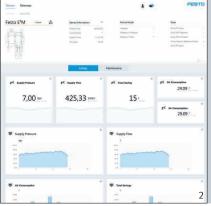
Many concepts from the past have been overtaken by the fourth industrial revolution: business models, partnerships, customer interfaces, value chains, and even the traditional automation pyramid – all are undergoing huge change. As an innovator and trendsetter in fieldbus technology, Festo will make a major contribution to reshaping the future with new concepts for Industry 4.0. This includes new products, cloud services, apps, as well as a new online shop with comprehensive, integrated engineering concepts. This will ensure that, in the medium term, data will be available seamlessly and globally on all user devices.

Festo Cloud Services – added focus. Added transparency. Added value!

Festo Dashboards for CPX/MPA[1], MSE6-E2M and YXMx show all the key characteristics and metrics for the products and subsystems fully predefined in the Festo Cloud – without the need for any programming. As a result, the data is available anywhere in the world and anytime, including on mobile devices.

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Industry 4.0: things communicate with one another

More communication from controller to controller or subsystem to subsystem, and horizontal as well as vertical connectivity with a single, uniform information model, including the cloud: these are the hallmarks of a fourth industrial revolution – Industry 4.0. The traditional, inflexible automation pyramid will cease to exist in the foreseeable future. Festo CPX and the Motion Terminal VTEM are making an important contribution to this transformation.

Hardware for unlimited communication: Festo's IoT gateway CPX-IOT

The industrial Internet of Things gateway is based on the CPX module format. CPX-IOT collects information about Festo devices and their statuses via an Ethernet connection and a standardised communication protocol such as OPC UA, for example. It then sends that information to the cloud via the second Ethernet connection using IoT protocols such as AMQP or MQTT. Suitable IT security mechanisms ensure data security.
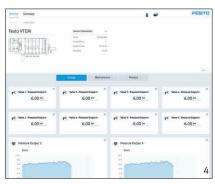
Integration as a subsystem or as a non-hierarchical system

Festo products, such as electric and pneumatic drives, valves/valve terminals, I/O terminals, compressed air supply or sensors, can thus be integrated as subsystems from the traditional pyramid if needed, e.g. via decentralised controllers such as CPX or CECC.

Or alternatively they can be integrated directly, with no hierarchy. For example:
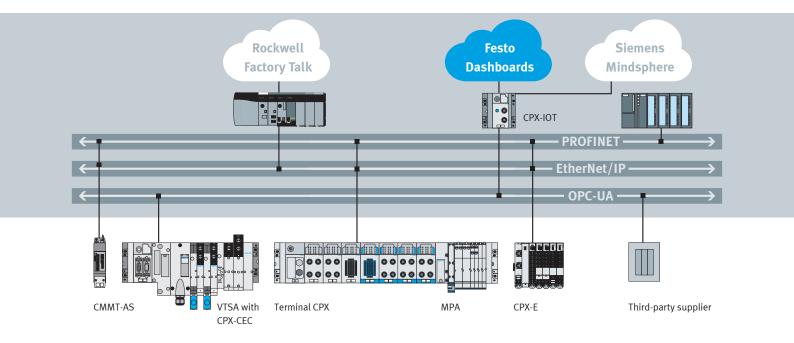- The handling system YXMx*
- The energy efficiency module MSE6*
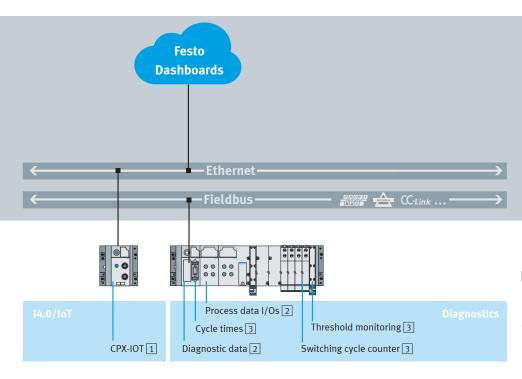- Or the modular electrical terminal CPX and thus also the valve terminals MPA*

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* These Festo products are thus cyber-physical systems in the sense of Industry 4.0. They take in data from the application and from the device itself, precompress it by compiling the data into diagnostic modules in CoDeSys V3 in accordance with VDMA 24582, and then forward that information to the cloud – Festo Dashboards shown as examples.

Industry 4.0 – networked components and their options in detail

Rockwell Factory Talk

Festo Dashboards

Siemens Mindsphere

CPX-IOT

PROFINET

EtherNet/IP

OPC-UA

CMMT-AS   VTSA with CPX-CEC   Terminal CPX   MPA   CPX-E   Third-party supplier

How the Festo CPX-IOT-Gateway works in detail

1. Connect the Festo product with OPC UA communication interface (or third-party devices) to the CPX-IOT-Gateway via switches.

2. Connect the IOT gateway to the Internet via intranet/NAT.

3. Set the switches to "Boarding": this enables physical access to the CPX-IOT-Gateway; guided interaction and confirmation steer users through the process.

4. The CPX-IOT-Gateway independently connects to the Festo Cloud. A defined login process happens the first time the gateway connects/starts up.

5. Read or Read/Write switch position: the gateway searches for the connected OPC UA stations/servers itself by port scanning and multicast access.

6. The gateway then fetches data from the connected servers via the OPC UA Publish/Subscriber Communication Model (PSCM) and sends this data to the cloud, encrypted in line with the chosen concept and over secure connections.

7. Administration of the gateway can also be carried out remotely via the cloud.

Festo Dashboards

Ethernet

Fieldbus — PROFIBUS · InterBus · CC-Link ...

I4.0/IoT

CPX-IOT 1

Diagnostics

Process data I/Os 2
Cycle times 3
Diagnostic data 2
Threshold monitoring 3
Switching cycle counter 3

The Festo Dashboards in detail

1. Festo products for which apps with cloud connection/dashboards are available report their diagnostic and condition monitoring data in accordance with the industry standards VDMA 24582.

2. Such predefined dashboards are planned for all key products from Festo.

3. Core elements like energy monitoring, preventive maintenance and OEE metrics are taken into consideration where appropriate.

4. Historical data is stored for one year.

The Festo Dashboards thus enable
- greater OEE and thus increased productivity thanks to suitable metrics
- lower costs through improved energy efficiency
- accelerated maintenance thanks to better condition data and services

The available information and data in the Festo terminal CPX in detail

1. The Festo terminal CPX and the valve terminals MPA and VTSA connected to it have been providing comprehensive data for analysis for years. This can be read out via all fieldbus connections.

2. New: It can be displayed in a cloud without any programming (see example of Festo Dashboards on page 5).

1 **MMI connection**
The CPX-IOT-Gateway can be connected to every installed or new CPX using the CPX-MMI cable. Thus all data is accessible and can be transferred to a cloud. This can be retrofitted on all CPX fieldbus nodes installed in the field.

I4.0/IoT/Cloud protocols:
AMQP, MQTT, OPC UA

2 **Data categories**
- Asset data
- Diagnostic data
- Process data (I/Os)
- Parameter data
- Smart data like switching cycle counter, timer, UTC (universal time), travel profiles/cam disks

3 **Optional information:**
- Cycle times
- Life cycle information
- Switching cycle counter per valve with threshold monitoring
- B10 value comparison
- Early warning system in case of deviations
- Automatic reordering of spare parts

Industry 4.0 – integration options in IoT environments

Integration into the IoT environments of Siemens MindSphere and Rockwell FactoryTalk
The MindSphere is a cloud-based, open IoT operating system from Siemens with which your machines and physical infrastructure can be connected to the digital world. This enables you to use huge data volumes from countless smart devices. And gain groundbreaking insights into your entire company.

Display of the Festo energy efficiency module in the MindSphere as "E2M-Asset"

Festo was the first partner in a pilot project to integrate a smart field device, the energy efficiency module MSE6-E2M, into the MindSphere via its own IoT gateway CPX-IOT. The pilot project demonstrated the following four key aspects:

1. A secure, encrypted connection to the cloud (HTTPS)
2. A connection to the field level for gathering data via OPC UA
3. Siemens MindSphere connection via the MindConnect LIB
4. Easy start-up by the customer via the cloud. Such Industry 4.0 scenarios provide an opportunity to analyse and above all combine various data in the MindSphere. Examples:
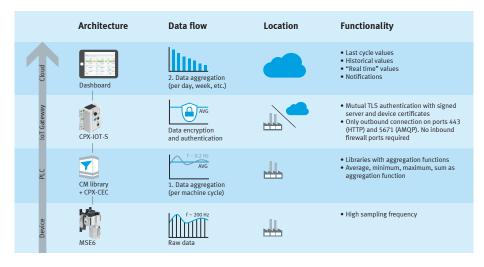
Basic data and insights
- Actual air consumption and pressure indication in real time
- Pattern recognition for consumption profiles, leakage
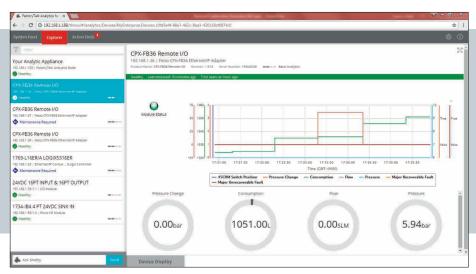- Selectable tolerance windows for error messages

Advanced analyses
1. Position monitoring
- Time-based and using pQ sensors
- Comparison with the digital twin
2. Determining cylinder leakage
- Indirectly, by comparing the leakage with the determined position and the actual or reference position.
- Using the pQ sensors to determine the cylinder position indirectly during leakage-free operation
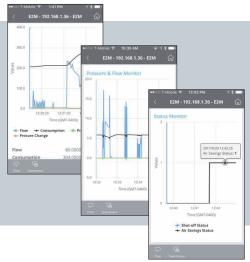- Separation into internal and external leakage

Schematic representation of the basic setup, the data compression and the data flow from the Festo product to the Siemens MindSphere

Architecture	Data flow	Location	Functionality
Cloud Dashboard	2. Data aggregation (per day, week, etc.)		• Last cycle values • Historical values • "Real time" values • Notifications
IoT Gateway CPX-IOT-S	Data encryption and authentication		• Mutual TLS authentication with signed server and device certificates • Only outbound connection on ports 443 (HTTP) and 5671 (AMQP). No inbound firewall ports required
PLC CM library + CPX-CEC	1. Data aggregation (per machine cycle)		• Libraries with aggregation functions • Average, minimum, maximum, sum as aggregation function
Device MSE6	Raw data		• High sampling frequency

This is how the condition of Festo pneumatic products is displayed within Shelby/Device Analytics

Integration of Festo products as a module for the mobile application TeamONE

Integration into the IoT environment from Rockwell

Rockwell offers several approaches for networking the Internet of Things for industrial devices, machinery and systems and for making effective use of the resulting data: Device Analytics and TeamONE. Festo supports both approaches in this early phase with pilot projects.

Device analytics and "Shelby Appliance"

Shelby works as a kind of black box and does not require configuration. Like the Festo IoT gateway, it automatically scans all devices that are connected and prepared for communication. It then sends their data as telegrams to higher-level units like edge devices or cloud services. Shelby calls the devices cyclically approx. once per minute, offers dashboards and also advanced diagnostic functions.

TeamONE

With TeamONE preventive maintenance tasks can be organised into teams, and all the necessary data from the devices in a system/machine can be displayed. This speeds up troubleshooting. TeamONE is made available as a free app. As with all other third-party providers, the Festo devices are integrated via an embedded module within this app. All the relevant values of the Festo devices can be displayed, as the small mobile phone screenshots in the picture indicate. You can purchase the Festo module via the Festo App World.

Festo App World – for greater flexibility and productivity

Purchase apps or view your order history in the Festo App World. It is the perfect place to discover apps, cloud products and software libraries for your PC, mobile devices and Festo products. Purchase, download and get started right away!

Apps for products
Are you looking for apps for your Festo products? Discover the possibilities and purchase Motion Apps for the Festo Motion Terminal VTEM, software libraries for the handling system YXMx or add-ons for the servo press kit YJKP.

Apps by functions
Not sure exactly what you are looking for? You can browse our apps by function: motion, condition monitoring, design tools or maintenance management. This is where you will find Smartenance, the digital maintenance management, where you can create electric and pneumatic circuit diagrams on your PC using the FluidDraw app, get preconfigured dashboards for the Festo CPX, CMMT and other Festo products or the Schematic Solution for complete creation of EPLAN projects at the push of a button.

It couldn't be easier!
Log in with your Festo account, select the digital product you want and add it to your basket.

If you aren't authorised to make purchases, just forward the basket to the right colleagues.
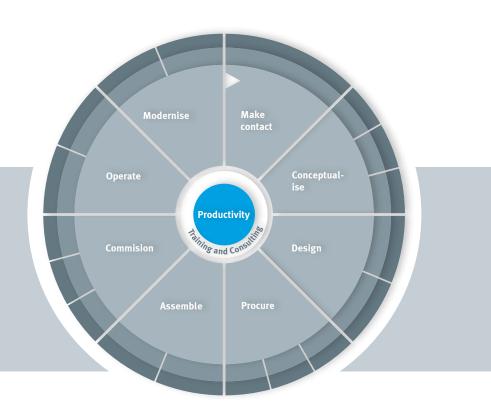
App World

Find out more:
→ **www.festo.com/appworld**

Industry 4.0 – engineering in the virtual and the real world

Engineering and productivity

Our goal is to increase your productivity. State-of-the-art engineering plays an important role in achieving that goal – the kind of engineering which will be central to Industry 4.0 and which will form a cornerstone of your success. That is why we are continuously further developing engineering methods and enhancing our software tools and apps.
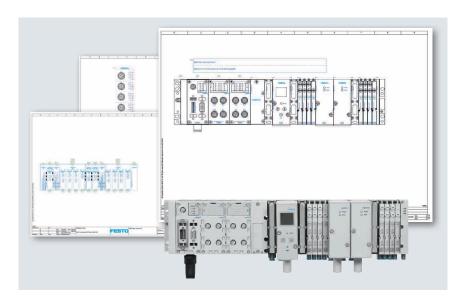
Engineering and value creation

We help you tap into unimagined productivity reserves and generate additional productivity along the entire value chain. In every phase of your project, from the initial contact to the modernisation of your machine, you will come across a number of different tools which will be of use to you.*

Engineering and life cycle

To meet your needs even more effectively, we have analysed project workflows and defined eight phases. We then allocated our software tools and apps to the appropriate phases. You benefit by being able to find the right support quickly and easily.

Schematic Solution for EPLAN projects, for example, documents your configured solutions comprehensively and in next to no time. Simply enter the order code and receive the complete plan in just a few minutes – error-free and trouble-free. Instead of tediously having to search for, download and piece together individual components, all the hard work is done for you, cutting the amount of time required from several hours to just a few minutes.

* This document shows just a small selection of the tools we have on offer. Discover our world of software tools:

→ **www.festo.com/support**

Comprehensive networking: the virtual and the real world

Computer-aided engineering and virtual images are future scenarios that will accelerate development. For example, virtual images will allow the autonomous and continuous improvement and correction of designs. The factory itself will also be redefined. The concept of the future unites the virtual and the real world. The objects produced will be able to communicate amongst themselves in the same way as the tools and machines that produce them, and the processes will virtually run themselves. They will also become more flexible down to a batch size of 1.

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For maximum process efficiency: the Handling Guide Online

From project engineering and ordering right up to delivery, the Handling Guide Online* optimises and shortens work flows by combining the virtual with the real world. You can get to the right standard handling system in just three quick and easy steps:
- Select the type of handling system
- Enter your application data (X-Y-Z measurements and load)
- Order as 1 unit in the Festo Online Shop.

Including the finished CAD model for the complete handling system. This will be presented in AML data packets in the future.

The perfect control cabinet for water technology in just a few minutes.

The Cabinet Guide Online revolutionises the engineering process for individual control cabinet solutions in water technology; from now on, configuring and ordering will be smart and intuitive. The Cabinet Guide Online guides you through the configuration process step by step by asking simple questions about the application, so you do not even need in-depth knowledge of automation technology. It suggests a solution straight
away along with the price and delivery time. The control cabinet is delivered fully assembly and tested, with CAD data and EPLAN circuit diagram – this saves time and costs in areas other than just engineering. Everything fits perfectly!

Scan, look, discover with the Product Key as an Auto ID function

All the information for a modular valve terminal with terminal CPX is contained in the Product Key incorporated in the data matrix code – putting Festo unmistakably on the road to Industry 4.0.

These auto ID functions are small but important building blocks for the transparent, smart and intuitive factory of the future with Industry 4.0. This is underpinned by Festo products with their Product Key and logistics code, providing centralised access to a "digital twin".

Smartenance – keeps maintenance simple!

Smartenance lets you schedule autonomous maintenance tasks, report faults on the move and document your measures. Use the Smartenance app on your smartphone and tablet to perform maintenance tasks on the system, and the Smartenance web app to manage the tasks on a PC.

Smartenance Basic	Smartenance Advanced	Smartenance Premium
Autonomous maintenance	Autonomous maintenance **+ fault management** **+ system logbook**	Autonomous maintenance Fault management System logbook **+ data interface**
• Create maintenance tasks including images, PDFs and videos • Mobile app with maintenance schedule and access to all documents • Feedback from the app including images • Overview of the maintenance status	• Report faults via the app • Process and close fault tickets • Documentation of measures and completion reports • Intelligent search for existing knowledge • Complete system logbook	• Full read and write access via REST API • Comprehensive documentation on working with the API • Option to link to MES/ERP systems • Activate maintenance tasks based on events

Available for Android and iOS
- Register at
  www.festo.com/smartenance-trial
- Download the Smartenance app in the Google Play or Apple App Store

- Create a new device access in your Smartenance web application.
- Scan the QR code using the Smartenance app to connect to your account.

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The mobile app gives you access to maintenance plans and attachments wherever you are.

The web application gives you an overview of all maintenance activities and lets you manage fault tickets.

For machine operators

On the shop floor, the Smartenance app offers access to the maintenance plan. It provides you with the maintenance tasks in digital format. You have access to images, PDFs and videos at your fingertips and can add feedback about maintenance tasks. In the event of a fault, you can create a ticket directly on the spot.

For production managers

You can use the web application conveniently in the office. This is where you create and manage the autonomous maintenance tasks, check the maintenance status of your systems and view feedback from your colleagues. You can link Smartenance to other systems or initiate automated maintenance tasks via the interface. With the system logbook you are perfectly prepared for audits.

For maintenance personnel

With the web application you can work on a PC or on the move on a tablet. You can view, assign and respond to current fault messages. The intelligent logbook allows you to search efficiently for similar faults, so that you can build on existing knowledge and rectify specific problems efficiently. Images, PDFs and videos make it much faster to share knowledge.

The benefits to you:
- The maintenance task is sent to you as the user
- You waste no time looking for tasks and documents
- Intuitive and easy-to-use app

The benefits to you:
- Overview of maintenance from your office
- No need to print out, distribute or collect lists and documents
- System logbook for audits

The benefits to you:
- Fast access to fault messages
- Learn from existing knowledge
- Well prepared to deal with the system

→ **www.festo.com/smartenance**

App-controlled flexibility: digital pneumatics for Industry 4.0

Intelligent apps and appropriate software are a central component of Industry 4.0. They allow the "things" in the Internet of Things to communicate with one another and to initiate or execute processes autonomously. At the same time, software modules, analysis and combinational logic are making functional integration possible as never before. With the app-based Motion Terminal, Festo has catapulted pneumatics into the age of Industry 4.0.

The access to new information and being able to process it boosts knowledge, adds value and puts you a step ahead technologically. It also provides you with huge benefits in engineering, design and programming, and ultimately increases your competitiveness and productivity. With 4.0 products such as the Festo Motion Terminal, you are buying much more than a mere product – you are buying a comprehensive added-value package.

The future of pneumatics – functions assigned at the press of a button
Digitisation will profoundly alter the world of production as digital simplicity is moving into the world of pneumatics.

With the Festo Motion Terminal, we are offering our first standardised solution that intelligently combines mechanics, electronics and software in the form of a "cyber-physical system". It will enable you to build intelligent machines now for the world of tomorrow, and ensure your systems are truly ready for Industry 4.0, even in terms of pneumatics.

Available variants of the Festo Motion Terminal
Festo Motion Terminal VTEM is available as a platform with 2 valves, with 4 valves and with 8 valves, as well as with supplementary input and output modules.

Disconnected: functions and hardware
With the Festo Motion Terminal pneumatic functions are, for the first time, no longer automatically connected to the mechanical hardware, and can be assigned simply using apps. You now require just a single valve type for an extremely wide range of pneumatic movements and functions. The Festo Motion Terminal makes it possible for the first time ever to have the same hardware for a multitude of functions. No modification, no additional parts, no arduous installation: none of that is needed any more. With the matching motion app, you can change functions at the press of a button, whether for a simple change in the directional control valve functions, Soft Stop, energy saving mode (gentle travel in the end positions, energy-efficient movements), proportional characteristics or a format change. The Festo Motion Terminal thus combines the advantages of electric and pneumatic systems.

Motion apps – for almost limitless functional integration
- Directional control valve functions
- Proportional directional control valve
- Soft Stop
- Proportional pressure regulation
- Model-based proportional pressure control
- ECO drive
- Selectable pressure level
- Leakage diagnostics
- Supply and exhaust air flow control
- Presetting of travel time
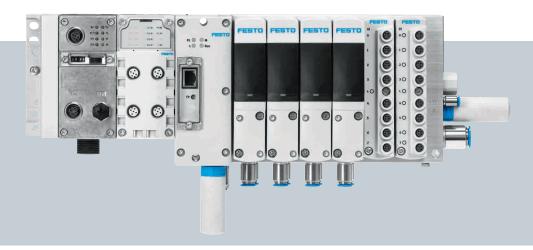- Positioning
- Flow control

Further apps for even more functions are already being planned.

For detailed information:
→ **www.festo.com/motionapps**

Pneumatics 4.0 – Festo Motion Terminal VTEM, a world first

The Festo Motion Terminal VTEM is opening up radical new dimensions in the world of automation, as it is the world's first valve to be controlled by apps. It is the first product to truly earn the label "digital pneumatics". For a multitude of functions which currently require you to order and install more than 50 separate products/positions.

Central component of the Festo Motion Terminal

CPX terminal – electric systems at its most flexible
With CPX, you have the option of using many different control systems and end user specifications, as well as all the usual digital and analogue I/O modules or decentralised "simple" valve terminals.

CPX is available on request with an integrated CODESYS controller and OPC UA for Industry 4.0.

Find out more at
→ **www.festo.com/motionterminal**

Controller with motion app – software at its most flexible
The core of your Motion Terminal. It enables you to conveniently control numerous functions and to assign them to the individual valves via the Ethernet WebConfig interface.

With the Internet of Things, you can adjust parameters efficiently through the intuitive WebConfig user interface, which you access via a web browser on a computer – no additional configuration software is required. Or you can set parameters in the usual way, easily and directly via the PLC machine controller.

VTEM – pneumatics at its most flexible
The individual control and freely programmable functions of the individual VTEM valves offer a high degree of flexibility.

The integrated stroke and pressure sensors provide optimal control and transparent condition monitoring.

Each VTEM valve contains:
- Valve electronics with sensors
- 4 innovative piezo pilot valves for minimum energy consumption and maximum service life
- 4 diaphragm poppet valves for reliable functional diversity

Highlights
- Many functions in a single component – thanks to apps
- Combines the advantages of electric and pneumatic technologies
- Very high level of standardisation and reduced complexity
- Reduced time to market
- Greater profitability
- Reduced installation effort
- Increased energy efficiency

Highlights 2 – products and solution packages for Industry 4.0

Detecting states, condition monitoring

All fieldbus/Ethernet, AS-Interface and IO-Link® products are suitable for use as "contributors" in terms of Industry 4.0. Festo offers you a comprehensive IO-Link® portfolio, for example:

• Various sensor ranges
• Actuators such as proportional pressure regulators VPPM
• Vacuum generator OVEM
• Valve terminals
• Electric drives with stepper motor/servo controllers CMMP, CMMO, amongst others

Further areas of research include:
• OPC UA TSN – time-sensitive networks
• IO-Link® wireless

Vision systems

Identify and control intelligent workpieces and workpiece carriers. Several sensor technologies are used in an Industry 4.0 environment, such as RFID as well as vision systems. This includes our code reader SBSI-B, object sensor SBSI-Q and the compact camera systems SBOx-Q.

Industry 4.0 energy management

Reduce energy consumption and control central operating parameters automatically. The energy efficiency module MSE6 prevents compressed air wastage during system downtime (auto-stop function), detects leakages independently, and offers online process monitoring. Suitable for new and existing systems.
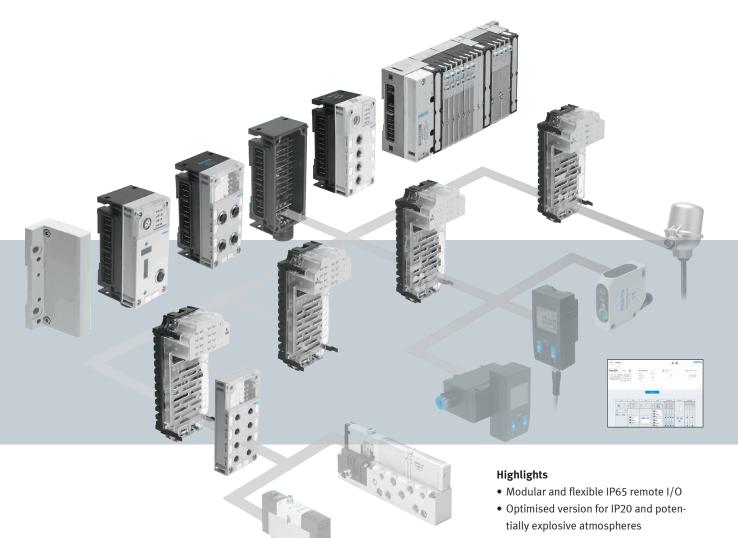
Leakage measurement*

When the compressed air supply is shut down, the MSE6 checks the system for leaks. Rapidly dropping pressure indicates excessive leakage. A notification is then sent to the system operator. This allows maintenance which, for the first time, is based on actual requirements.

• Zero compressed air consumption in standby mode
• Checks the system for leaks
• Ensures maintenance in the event of leaks
• Monitors relevant process data
• Communication via PROFIBUS, PROFINET, Ethernet/IP. CODESYS with OPC UA on request

Data can be quickly integrated using the following platforms:
• Festo Cloud
• Siemens MindSphere
• Rockwell FactoryTalk/TeamONE
• Others available on request

* This function is also available on the Festo Motion Terminal. Thanks to the cloud connection (see page 4/5), both components are fully fledged cyber-physical systems for Industry 4.0.

Automation platform 4.0!

Ideal as an automation platform, valve terminal partner or remote I/O – electric, open and direct. CPX – the perfect platform for electrical peripherals. With CPX, you can integrate pneumatic and electrical control chains easily, quickly, flexibly and seamlessly into all automation concepts and company-specific standards – and into Industry 4.0 as well!

CPX – the new benchmark for perfect networking thanks to:

- Universal communication via fieldbus/ Ethernet
- A choice of pneumatic platforms (valve terminals MPA or VTSA, Festo Motion Terminal VTEM)
- Subordinate, decentralised installation systems CPI, IO-Link® or I-Port
- Unrivalled module and application variety

CPX – greater economic efficiency and operational reliability through function integration, such as:

- Front-end control
- A choice of scalable installation concepts
- Comprehensive diagnostics and condition monitoring
- Motion control for electric and servo-pneumatic drives
- Measurement and control

Highlights

- Modular and flexible IP65 remote I/O
- Optimised version for IP20 and potentially explosive atmospheres
- Maximum function integration for complete applications
- Falling installation costs and rising productivity
- Decentralised and compact handling systems
- Networked intelligence with embedded CODESYS controller
- Industry 4.0 thanks to OPC UA and CODESYS control V3 and IoT gateway for cloud connection

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- Rockwell FactoryTalk/TeamONE
- Others available on request

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Highlights 3 – products and solution packages for Industry 4.0

Cyber-physical systems as solution packages

Industry 4.0 and the Internet of Things (IoT) fascinate original equipment manufacturers (OEM) and end users alike. No wonder, as this is where production and the digital world come into direct contact with each other, making factory automation more flexible, increasing energy efficiency, linking logistics processes more closely, and optimising the value chain in both factory and process automation.

The Internet of Things (IoT), smart factories, cyber-physical systems and big data are getting the project "A more productive future" off the ground. Solutions must therefore be ever faster and more diverse, more flexible and more intelligent – down to a batch size of 1. Calls for greater availability, energy efficiency and just-in-time production are on the increase and are likely to be answered.

Intelligent sub-systems/solution packages

From the solution package YXMx to the automation platform CPX, Festo provides comprehensive expertise.

Handling systems in the form of linear, planar surface or three-dimensional gantries are available through the Handling Guide Online with the option of individual configuration – or they can be supplied as a predefined, specialised solution package by consulting our experts.
- Planar surface gantry EXCH
- Linear gantry EXCT
- High-speed parallel kinematic system EXPT (tripod)
- Industry 4.0 research project: parallel kinematic system
- CPX/EMCA as robotics without a control cabinet
- Servo press
- Handling systems YXMx

You will find the most up-to-date overview of all our products, solutions and services on the Internet at
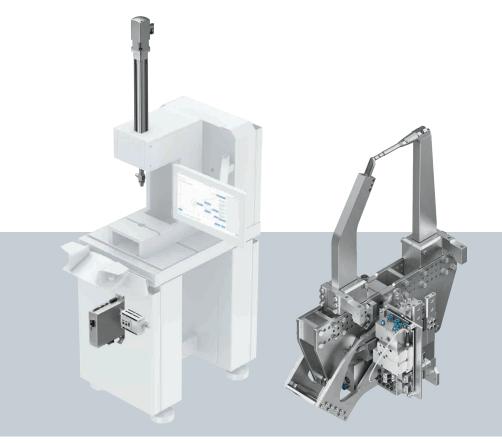➔ **www.festo.com/iot**

Compact handling system YXMx for desktop applications

The flexible basic platform for a wide variety of desktop applications. Everything from a single source: the coordinated, ready-to-use system kit consists of software, controller and kinematics – and forms the basis for a wide variety of desktop applications such as screwdriving, dispensing, testing, soldering, gripping, opening and closing containers and much more.

- Ready-to-use system kit comprising kinematics,
- controller and software
- Industry-4.0-capable cyber-physical system thanks to motion apps and cloud connection (see page 4/5)

Servo press kit YJKP for electrical press-fitting applications

The modular servo press kit YJKP gives you just the software functions you need for your application. You get an extremely precise press-fitting system with a high level of repetition accuracy and an excellent price/performance ratio. Simple, cost-effective and quick to install.

- Software and hardware from a single source
- Less expensive than conventional press systems
- The controller CECC-X with OPC UA interface makes the system ready for Industry 4.0.
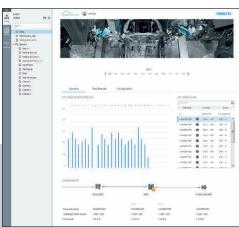
Servo-pneumatic drive solution for welding guns

Car body welding requires a high level of precision and robustness. The components from Festo for servo-pneumatically driven welding guns are specially designed to meet this requirement. You decide which is best for you – the X gun or the C gun. Our range of types and designs makes pneumatics for spot welding extremely efficient.

- Very short cycle times
- High quality and outstanding reproducibility of the spot welds
- Excellent value for money
- Individual components fit for Industry 4.0

Diagnostic capabilities in demand for optimisation

The new generation of welding guns will be connected to a cloud. By analysing the status data and changes in it, it is possible to make predictions about the future failure of system components and as a result of equipment or production facilities. Maintenance thus becomes predictive and no longer preventive as in the past.
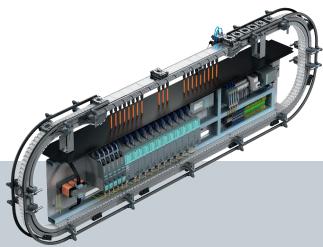
Analysing the data provides in-depth insights into the behaviour of components in a production environment. This results in system optimisations that increase availability and quality.
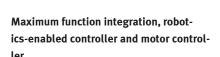
Universal structure

The welding guns are therefore equipped with firmware from Festo. PC or tablets with software from Festo collect the data from every cell and compress it. Test cycles are triggered under certain circumstances; otherwise the data is transferred via an IoT gateway to the appropriate cloud. It is then available for further evaluation, for example for big data analytics, machine learning or for dashboards.

Highlights 3 – products and solution packages for Industry 4.0

Maximum function integration, robotics-enabled controller and motor controller
in IP65 integrated on site
Robotics is getting ready for Industry 4.0 with the high-speed handling system EXPT with CPX/EMCA.

CPX control technology from Festo for an IP65/67 environment and the numerous functions included in the new "integrated drive" EMCA facilitate robotic functionality which is close to revolutionary, with no need for a control cabinet.

- Robot controller without control cabinet – in IP65/67 thanks to CPX
- All-in-one integrated electric drive EMCA
- Very fast, light and compact
- Maximum economic efficiency
- Virtual commissioning with CIROS by Festo Didactic
- Pioneering: OPC UA interfaces for Industry 4.0, CODESYS V3 SoftMotion transformation models with calibration option.

Expanding the limits: inter-system cooperation
Multi-Carrier-System: as a transport and logistics system with maximum flexibility, the Multi-Carrier-System offers several highlights in line with Industry 4.0:
- Maximum electromechanical flexibility with Festo linear motors
- Compatible with all intralogistics systems, simple and seamless inward and outward transfer of the carriers, and thus a fully flexible overall concept
- Control concept including virtual commissioning
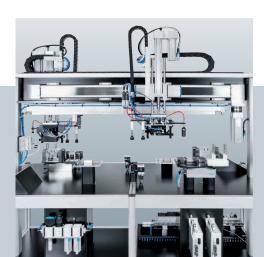
Simple implementation, optimum combination
- Existing intralogistics are retained
- Seamless integration
- Efficient engineering
- Proven control platform
- Complete synchronisation of transport and motion control for continuous production processes

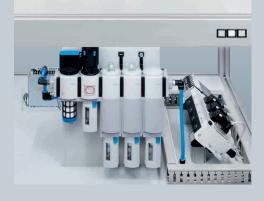**Multi-Carrier-System in a closed loop**
- The closed-loop circulation of carriers is now also an addition to the existing intralogistics solution, making the MCS ideal for long processes and machines or for compact module solutions. The alternative: complete integration or connection.
- Inexpensive servo-controlled toothed-belt solution for the return transport of MCS carriers in a closed loop.
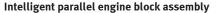
Industry 4.0 functionality
Virtual commissioning (simulation), modular servo controllers, motion controller with optional OPC UA interface and carriers equipped with RFID permit open integration into Industry 4.0 host environments.

Intelligent parallel engine block assembly

Flexible and efficient: engine block, seal, pistons, cylinder head and screws are gripped in parallel and mounted in two steps. This type of parallel engine block assembly is faster and less expensive than sequential production. Furthermore, it can be implemented with either servo-pneumatic or electric axes.

Thanks to decentralised intelligence on the valve terminal CPX/VTSA, the reliable and space-saving grippers are flexible, adaptive and versatile when carrying out different gripping processes. A compact CODESYS controller CPX-CEC with IP65/67 protection controls the gripper unit on-site, and without a control cabinet. The available interfaces include all fieldbuses/Industrial Ethernet as well as Industry 4.0 standard OPC UA.

Flexible loading with end line packaging

We provide you with flexible automation solutions for your loading requirements, whether electric, pneumatic or a combination of both. With all components from a single source, from suction grippers and electric axis systems right up to CODESYS controllers. That allows you to implement dynamic loading processes with fast format changeovers, for example. And we provide you with additional support, from engineering to commissioning and operation.

The application is controlled by a CODESYS controller CPX-CEC with IP65/67 for compact on-site installation – without a control cabinet. The available interfaces include all fieldbuses or Industrial Ethernet as well as Industry 4.0 standard OPC UA.

Optimum food production

Festo provides you with support for optimum food production – with hygienic products and solutions, from valve terminals right up to electric or pneumatic actuators. Also included in our product range: robust, clean-design tubing and fittings. It is the ideal choice for form-fill-seal applications and much more besides.

Industry 4.0 and "big data" using the example of the energy efficiency module MSE6-E2M: evaluate pressure and flow sensors in real time for quick, on-site decisions. Communication via PROFIBUS, PROFINET, EtherNet/IP or Modbus/TCP. OPC UA is available on request.

The application is controlled by a CODESYS controller CPX-CEC. The available interfaces include all fieldbuses or Industrial Ethernet as well as Industry 4.0 standard OPC UA.

On the way to Industry 4.0 – Festo's Scharnhausen Technology Plant

Scharnhausen: the production plant of the future for valves, valve terminals and electronics

- Automated and adaptable
- Flexible and continuous production
- Optimised energy consumption
- Learning is a matter of course
- Highly flexible, energy-efficient assembly lines
- An optimised flow of processes, information and materials
- Energy networking of the building and the production processes
- A "training factory" as a practical, integral part of the actual factory

Designing an adaptable future in the Scharnhausen Technology Plant
The Scharnhausen Technology Plant is Festo's main factory for the production of valves, valve terminals and electronics. It will also be a model plant for customers. Designed as a future-ready and adaptable factory, its production systems already embody the first elements of Industry 4.0. In addition, knowledge gained from our research into Industry 4.0 is incorporated into the further development of the Technology Plant.

According to the definitions included in the recommendations made to the German government, there are several action and research areas that constitute a "smart factory" in line with Industry 4.0. These were defined by Acatech within the framework of the working committee on Industry 4.0. A central goal of the smart factory is to have a fully networked factory.
Festo is steadily working towards this goal in the Technology Plant. This is an evolutionary process.

Highly flexible, energy-efficient assembly lines

Millions of units every year, but with flexible batch sizes from 10 to 10,000. These are just a few of the features of our latest assembly lines, which are based on findings from the Industry 4.0 research project "SmartFactoryKL".

This machine, with standardised mechanical, electrical and software interfaces, points the way forward.
It is based on up to 400 decentralised cyber-physical systems (CPS).

Big data analytics

After two years, an initial analysis of comprehensive data from the production process of this assembly system made it possible to identify bottlenecks and optimisation potential. Concrete measures could then be introduced and the productivity of the line was increased by approx. 15%. Employees with knowledge of the specific production facility and data science also have an important part to play.

Energy networking of buildings and production processes – retrofit projects for existing machines

How can you hook your existing machines up to Industry 4.0?

This is a question that many customers/users ask themselves – and we faced the same challenges in our own production.

Festo retrofitted a variety of machines with a small secondary controller and additional sensors in order to uniformly record key metrics like energy consumption and operating data via OPC UA. Then a number of efficiency optimisations were analysed, their cost effectiveness reviewed and initial measures implemented.

All the measures for machines and buildings taken together reduce the energy used for manufacturing at the new site by a few GWh; the retrofit projects therefore have an estimated ROI of 2 to 3 years.

Mobile maintenance for greater efficiency and higher availability

As part of a pilot project, all the data for a machine, such as plans and diagrams, bills of materials, spare parts and repair instructions, were ported to mobile devices and linked up to a central computer system – which in our case is SAP.

This allows on-site maintenance technicians to view, analyse and prioritise all the alarms, and to work their way efficiently from one machine to the next. They can also consult experts online, exchange images and photos, view stocks of spare parts, and directly pick or order stock.

The rollout to all other Festo plants is currently underway. Incredibly, the return on investment is less than six months.

Festo Didactic offers consultancy services for optimising production, assessing production plants and processes in accordance with "fit for Industry 4.0", and the latest service and maintenance concepts. Ask your Festo sales engineer.

Training for Industry 4.0

Industry 4.0 will permanently change how production work is done and thus the demands on skilled workers. Festo is not only focused on technological developments, but also offers an integrated approach and a special training programme to develop the skills required to use and work with the latest digital industry technologies.

With turnkey training factories, laboratory facilities, innovative learning systems, e-learning and training programmes, Festo Didactic has the training solutions required for forward-looking and practical training in mechatronics and automation technology.

MPS 203 I4.0: Basic principles of Industry 4.0 specifically for mechatronics engineers

The learning system ranges from comprehensive training in the fundamentals of automation technology to the flexible production of customised workpieces. Training content like MES, augmented reality and RFID make MPS 203 I4.0 an ideal learning system for everyone looking for a future-oriented training course with a solid foundation in practical skills.

CP Lab: Modular entry into the world of Industry 4.0

The Cyber-Physical Lab is a professional and compact Industry 4.0 learning system. It includes all the technologies and components needed for the practical and in-depth transfer of Industry 4.0 knowledge. Its modular and flexible structure allows the range of training content to be expanded step-by-step.

CP Factory: The universal Industry 4.0 learning platform

The cyber-physical learning platform CP Factory models the stations of a real production system, allowing trainees to learn system programming, networking and many other topics such as energy efficiency and data management.

The CP Factory is also used for developing and testing flexible software solutions.

Skills development for Industry 4.0

Employees can be steered successfully through the Industry 4.0 change process with targeted skills development. With customer-specific training programmes, customised content and an integrated approach to consulting, Festo Didactic supports companies in equipping their staff with the skills required for digital production. Students benefit from our CP Factory-based course concepts on Industry 4.0 technologies.

Human-machine interaction and inspiration from nature

The collaborative behaviour of ants, the collective flight behaviour of butterflies, or an extremely versatile gripper modelled on the tongue of a chameleon are revealing new directions for visionary automation technology, exclusively at Festo. Festo's Bionic Learning Network also studies human learning behaviour and new ways for human-machine interaction, thereby furthering groundbreaking research for Industry 4.0 and the future of production.

BionicMobileAssistant

The BionicMobileAssistant is a mobile robot system with a pneumatic gripping hand. It moves autonomously in space and can independently recognise objects, grasp them adaptively and work on them together with humans.

In the future, operators and robots will work ever more closely together. This is why Festo has been working intensively on systems which, for example, can relieve people of monotonous or hazardous activities while at the same time posing no risk. Artificial intelligence plays a central role here.

The BionicMobileAssistant was developed in cooperation with ETH Zurich. It consists of three subsystems: a mobile robot, an electric robot arm and the BionicSoftHand 2.0. The pneumatic gripper is inspired by the human hand and is a further development of the BionicSoftHand from 2019.

LearningGripper

Gripping and positioning through autonomous learning

The LearningGripper looks like an abstract form of the human hand. The four fingers of the gripper are driven by twelve pneumatic bellows actuators with low-level pressurisation. Thanks to machine learning, the gripper is able to teach itself to carry out complex actions such as the targeted gripping and positioning of an object. Machine learning reduces the amount of programming required.

The prototype shows how it takes less than an hour for it to learn a mechanical motion strategy, from its first attempt to the reliable execution of the required task. Yet the gripper is only told what it needs to be able to do, not how to do it. The complex strategy required for this is developed independently by the gripper's learning algorithms – without any further programming.

BionicCobot

The way the joints of the BionicCobot are arranged resembles a human arm. With its seven-axis robotic kinematics with pneumatic rotary drives it grips and transports payloads of up to 2 kg quickly and easily, powerfully and precisely. Closed-loop control together with flexibility and adaptability recreate the stretching and bending abilities of human muscles. This inherently safe system that is used for human-robot collaboration, doesn't require any holding forces.

The modular design allows a variety of gripper systems to be fitted for transporting different loads. The BionicCobot is operated intuitively using a tablet, and can be precisely corrected and adjusted via an infrared tracking system.

The application is controlled by the Festo Motion Terminal with 7x2 chambers and a CODESYS controller CPX-CEC with IP65/67 protection for compact on-site installation – without a control cabinet. The available interfaces include all fieldbuses, Industrial Ethernet and Industry 4.0 standard OPC UA.

→ www.festo.com/bionik

You want to make your applications more productive.
You are looking for efficient solutions.
We are entering the digital future with you.

→ WE ARE THE ENGINEERS
OF PRODUCTIVITY.

As a trendsetter in automation technology, Festo is actively involved in a broad range of areas: our experts advise the German federal government, contribute to the standardisation of communications and software interfaces, and offer basic and further technical training opportunities across the globe. Festo is the only company to offer flexible, decentralised installation concepts and integrated mechatronic solution packages. From the mechanical system to the Industry 4.0-compatible cloud – everything comes from a single source.

Maximum productivity is a question of ambition – both now and for Industry 4.0

Sometimes there is only a small step between a very good result and market leadership. But that step is the crucial one. Outstanding productivity is part of that step. If that is your goal, we have the right solutions for you – such as the automation platform CPX together with the highly innovative Festo Motion Terminal VTEM. Whether you are looking for a technically sophisticated system solution or a very economical alternative for components, we are here to support you on the road to success. Ambitious and goal-oriented, with vision and awareness of our responsibilities – everything you expect from Festo and everything we are.