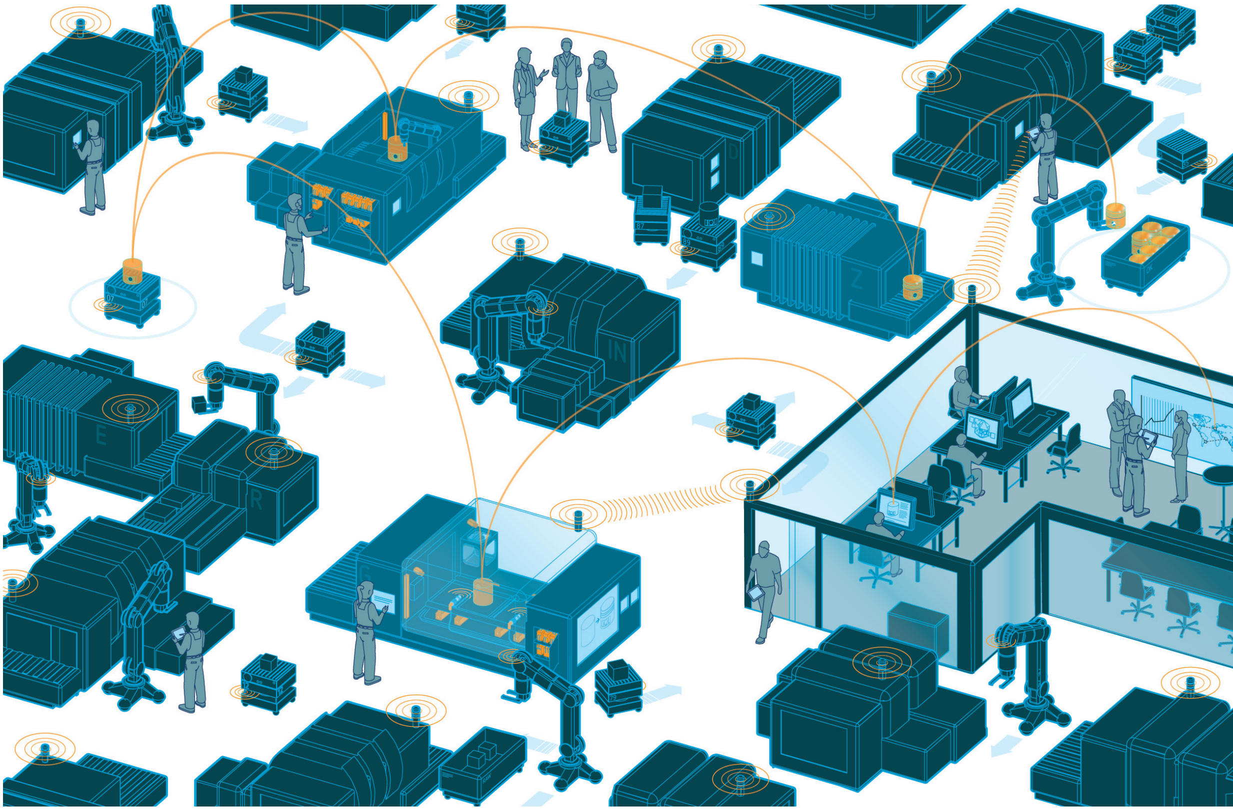
ZVEI: Die Elektroindustrie

Electrical connectivity for Industrie 4.0?

Challenges for electrical connectivity as a result of emerging "Industrie 4.0" concepts



White Paper – Part 2

Automation Division

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Electrical Connectivity for Industrie 4.0?

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This publication is part of a series of white papers:

Part 1 – Industrial Software 4.0?

Part 2 – Electrical Connectivity Industrie 4.0?

…other parts will follow.

A White Paper from the working group System Aspects in the Automation Division

The Automation Division works on topics and challenges within the German Electrical and Electronic Manufacturers Association (ZVEI) from the perspective of manufacturers and users of automation equipment. By far the most discussed topic in this context is Industrie 4.0 and the associated potential, architectures, standards and technologies.

The working group System Aspects is conscious of the significant importance of this topic area and has set itself the goal of examining and identifying the specific potential impact on basic technologies in our domains. This is being pursued as part of a small series of White Papers, and this document on the subject of electrical connectivity is the second part in this series. As the basic work on Industrie 4.0 topics is still in its early stages, the members of the working group do not see the White Paper as additional solution proposals, but rather as a (to some extent) critical examination of the anticipated implementation and application scenarios.

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Content

1 Introduction

Industrie 4.0 is a subject that cuts across a number of automation topics. The task ZVEI's working group System Aspects has set itself in this White Paper is to identify the possible effects of Industrie 4.0 on electrical connectivity – in other words, electromechanical elements, plug connectors, terminal connection methods and terminal strips – as well as to develop opportunities and to describe these. This also includes the identification of technical challenges and risks and proposals for avoiding them. ZVEI periodically publishes these findings in this series of White Papers.

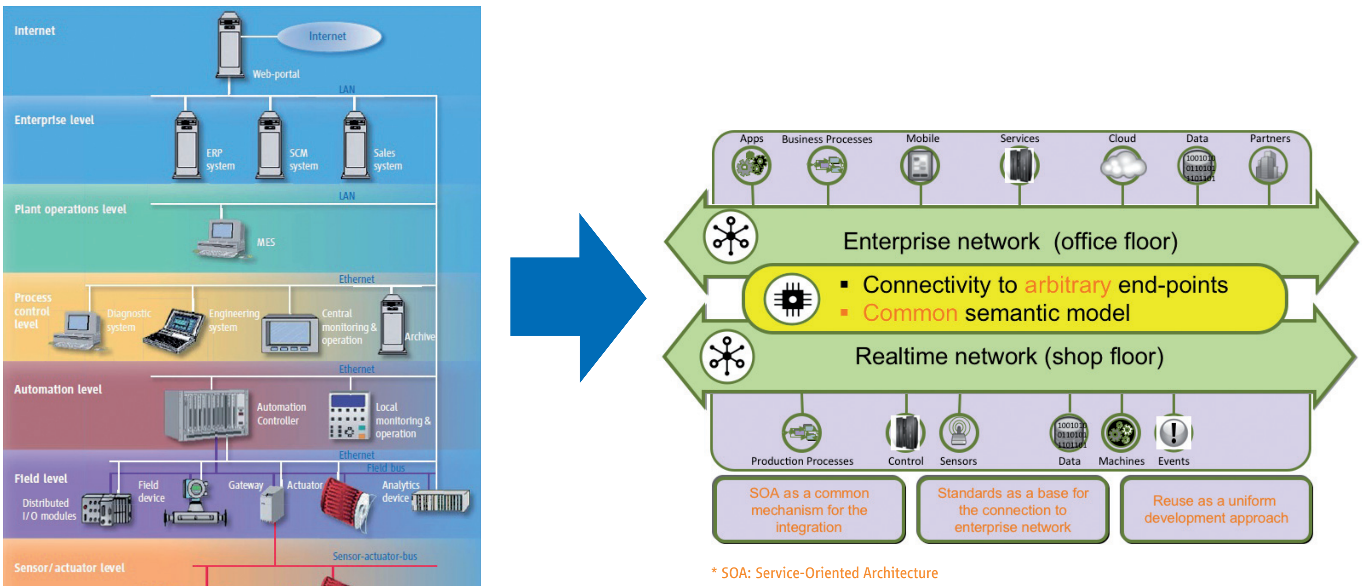
The debate about Industrie 4.0 (Figure 1) generally focuses on machines, systems and automation technology – in other words, active devices in the field of industrial electronics that are becoming increasingly intelligent. However, apart from these intelligent components it is also necessary to consider the passive components which must also be integrated and communicate in the value-added chains and systems. This is inevitable for electrical connectivity: these provide the infrastructure for automation systems and form the prerequisite for safe and reliable transmission of data, signals and energy. They will also remain the vital lines of communication in future machines and systems. Furthermore, even today electrical connectivity, plus its planning and installation, accounts for a significant proportion of the overall outlay for automation.

What does electrical connectivity involve?

Electrical connectivity involves all kinds of connection methods – whether electrical, wireless, optical or contactless – which are used in an industrial context in order to transfer data, signals and energy.

At the present time, connection technology primarily focuses on plug-and-connector systems and wiring. Consequently, it is classified as "conservatively passive". Figure 2 provides an overview of the relevant applications. Section 4 contains a concise description of state-of-the-art technology.

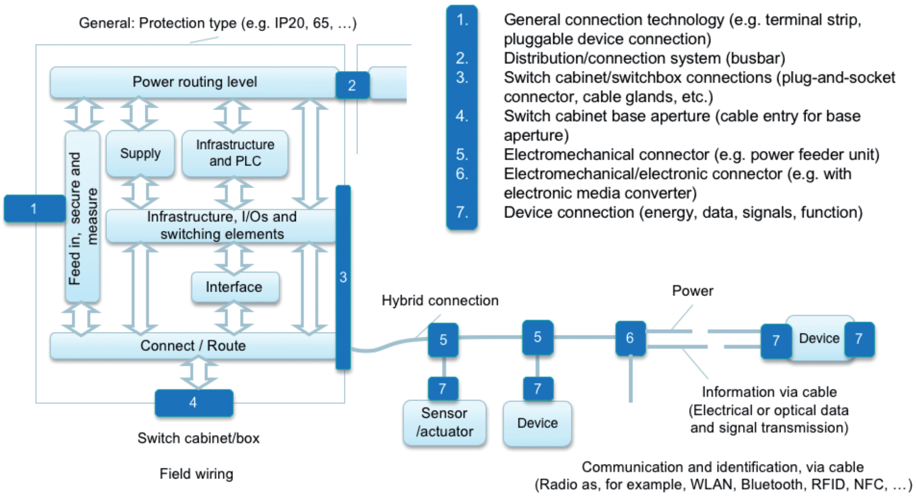
Figure 1: From the automation pyramid to Industrie 4.0



Source: Prof. Wollschlaeger, TU Dresden

Source: ZVEI-Führungskreis Industrie 4.0, January 2014

Figure 2: Connection technology inside and outside switch cabinets, switchboxes and devices



Source: Johannes Kalhoff, Phoenix Contact / ZVEI-AK Systemaspekte

Electrical connectivity in an Industrie 4.0 environment

The demands made on electrical connectivity are changing on the way to Industrie 4.0. To date, they primarily contain passive components. As developments continue on the way to Industrie 4.0, these will become more intelligent and play a greater role directly in the value-added chains.

Future connection elements will therefore actually be "intelligent" themselves in order, for instance, to allow monitoring and diagnostics to take place on site and to bring additional benefits throughout the value-creation chain. In many cases, it will not involve fundamentally new functions but it will entail a relocation of functions (decentralization). However, there will also be new applications such as a unique identification and link to product and life cycle information. This information can be found and accessed both in the connector itself (e.g. RFID transponder) and also in external databases (e.g. cloud-based solutions).

The same requirements for horizontal integration [4] along the value-added chain as well as vertical integration [4] and migration to decentralized systems, networks and services apply to electrical connectivity as to all systems and components for Industrie 4.0. Consequently, apart from a purely physical presence, a digital presence is also absolutely essential. (See section 6.) All active and passive components pertaining to electrical connectivity will always feature as Industrie 4.0 components [9] in different variations. This White Paper will describe the practical application of the principles of operation and benefits of this development by citing examples (use cases), and identify the challenges for electrical connectivity posed by the implementation of Industrie 4.0 concepts and technology.

2 Anticipated user benefits relating to Industrie 4.0

Acceptance of Industrie 4.0 solutions depends to a large extent on how successful the manufacturers of smart products are in achieving real, tangible application benefits. This is anticipated due to more efficient production of goods by increasing the flexibility, adaptability, scalability and availability of production while reducing expenditure.

The easy operation, app technologies, and continuous mobile communications possibilities familiar in the consumer sector inspire these expectations for industrial applications, too. This can be illustrated using the example of predictive maintenance of production systems:

In an Industrie 4.0 production network, the installed components ensure that the status data of all production means are constantly available, monitored and can be compared with online historical data. This means that maintenance tasks (servicing or exchange) can be scheduled and performed at exactly the right time. In particular, the maintenance personnel have access to the right information when carrying out an exchange, including product information and installation instructions in the right version, variant or configuration as well as the right language, and additional information with appropriate granularity. The expert knowledge that will still be required is now accessible to a wider group of users and on a larger scale.

Less effort is also required for the selection, planning, project planning and set-up of production facilities and their automation solutions. In particular, some causes for this are described in more detail in the section on "Challenges for electrical connectivity".

The anticipated increase in the consistency and availability of data that depends on the product and installation across the entire engineering period also results in faster system set-up and commissioning. When the system is in operation, availability of the system is improved due to the enhanced data quality that can be accessed during maintenance and servicing work.

New requirements for manufacturing companies, such as the wish to scale the output of a system, can be realized more easily in the Industrie 4.0 environment. This use case, which is discussed under the title "Module-based production in process industry" [8] benefits above all from the open and combinable integration concepts using exchangeable system modules with standardized interfaces. This allows reduced capital commitment and the possibility to adapt to local markets, as well as a prompt reaction to fluctuating requirements.

The easiest way to see the potential of Industrie 4.0 for industrial connectivity is through the following use cases from practical industrial situations, which are just examples:

Use Case:
"Simplified engineering process with electrical connectivity"

The purpose of installation systems is to connect electrical and electronic devices to each other and to supply them with energy and communications as well as to connect sensors and actuators. As part of the engineering process, the systems are designed in accordance with the technical requirements and documented in the planning documents and work instructions. In order to reveal faults that occur during installation and acceptance, the installed systems are checked and, in some cases, also formally approved (e.g. functional safety engineering). This requires end-to-end documentation of the mounted components, starting with the requirement and continuing through the design of the installation systems and their components right through to installation.

When compared to the current solutions and procedures, the advantage of Industrie 4.0 concepts is that it is very easy to access engineering data during the entire life cycle. The fact that the tools used in engineering and for live operation are coupled via standardized interfaces prevents multiple entries and transmission errors and also cuts down the amount of processing work required. In this engineering scenario, the technical function and connecting technology are defined using electrical planning (ECAD), the material is selected using classification systems (e.g. eCl@ss), clearly marked (material identification, labelling) and the products to be procured are correctly configured from a technical point of view. The result is full documentation for the purchasing process, installation, inspection and approval, and the use during operation of the systems. Changes are possible via data links at any time and can be accessed directly via very different systems and users. This facilitates both parallel and collaborative working between the stakeholders.

Use Case: **"Intelligent cable and socket system for flexible installation"**

In future applications installation systems can offer added value compared to the current solutions by making them smarter and mapping additional functions. For example, color or mechanical coding is used at present to protect cable and socket systems from being plugged into the wrong socket or to prevent incorrect use by the user. In future Industrie 4.0 solutions, the use of cable and socket systems specified by Engineering can be shown to the user either by activating optical displays, marked directly at the connector with the associated socket, or in system-wide digital form via virtual reality. In this case, communications are not accessed directly on, say, the passive components such as connectors or cables but on their digital representation which is made available on a management server, for example. This does not only provide potential to make processes in engineering and during commissioning more efficient but also enhances efficiency during the time the system is operating. The example of the patch cable for an industrial Ethernet infrastructure illustrates this clearly. For instance, if the patch cable has to be plugged into another port during the operating period, the current and future insertion position of the patch cable on site can be visualized via a mobile device or via virtual reality. The corresponding services request the data from the engineering system and the data is then made available to workers on their devices. The worker acknowledges that the connector position has been changed and Engineering stores the rewiring as a new version of the wiring plan. This ensures that documentation of the connection technology is always up-to-date. Smart connection systems are also able to identify independently plugging processes and to forward these to higher-order systems. Automated feedback means that the connection technology documents itself.

Use Case: **"Wiring – Electrical connectivity as a manageable resource"**

The primary role of electrical connection technology is to connect components and provide an infrastructure for power engineering, communications and signals. They also create additional resources so that machines and systems can be expanded in ways that could not be envisaged at the time these were created or to meet needs for specific system conditions, e.g. higher power demand required during system start-up. If installation systems today were designed for the rated values of the power or communication endpoints, Industrie 4.0 systems would use the infrastructure more intelligently in future. For example, in energy supply systems in future short-term requirements for higher current, e.g. when starting up motors, could be accommodated by warming the wiring briefly which, even though the specification has been exceeded, is not damaged or put at risk, and by means of data analysis (big data analysis) and, for instance, derating information (knowledge management).This is achieved by linking the management of machines and systems to production management (Manufacturing Execution system) and the management of energy in production and buildings.

As the systems are running, higher-order systems can use the same resources for status and condition information such as the current load, the temperature or the comparison with requirements for the cables and wiring (e.g. the suitability for certain transmission technologies/CAT6 or similar) in order to assist the user to diagnose malfunctions and the threat of outages as well as to identify faults at an early stage. This diagnosis functionality can affect the actual connection technology as well as the application. In both cases, engineering data, run-time systems of all involved and the user's information can be accessed via services or data can be transmitted to these.

3 Influence of Industrie 4.0 on applications

The systematic application of the Industrie 4.0 concept and the underlying technologies will open up opportunities and potential for mechanical and plant engineers as well as manufacturing companies:

- Flexibility: The flexibility of machines and systems, which means to be able to manufacture a much larger spectrum of different types of individual parts, assemblies and end products, is being developed significantly. The term flexibility does not only refer to the actual diversity of the goods produced: it also refers to the time sequence of the individual production orders and the ability to respond quickly and simply to new manufacturing orders and capacity requirements.

- Adaptivity: Machines and systems will be adaptive, which means they are put in a position to respond to changes in their environment automatically, to adapt the way they operate to this and to optimize their operation dynamically according to different objectives.

- Modularity: In future, machines will increasingly be divided into independent functional units, which take on individual sub-tasks of the overall manufacturing process. Modularization affects all elements of the machine, in other words, mechanics, electrics, electronics and software as well, possibly, as other parts. These machine modules are implemented independently of each other – even transcending the boundaries between manufacturers – and can be combined freely with each other for a specific manufacturing order. Furthermore, these machine modules can be distributed throughout different areas – such as different places in a factory – but also in different factories that are linked together via appropriate transport systems. Comprehensively standardized interfaces are required for systematic modularization. In addition, modulation supports object-oriented approaches during planning and engineering including the necessary tools.

- Plug and Produce: Manufacturing modules will, in future, be able to commission themselves, i.e. without manual effort for parameterization and configuration, by making available models and methods for self-description. This does not only relate to the initial installation in a production system: it also refers to possible changes in the course of the life cycle of a machine or system, e.g. the exchange of a device for the service life of the system. Plug and Produce also covers the interoperability of devices, which means its ability to cooperate via standardized interfaces and protocols, although it is more extensive. Self-description and configuration are required for this so that it can adapt to changes in automation technology and its status independently and without the influence of users.

- Decentralization: The subdivision into individual, independent modules and function units also relates to the distribution of the overall control function, which is increasingly distributed to different smart devices in the course of the introduction of Industrie 4.0. These devices do not necessarily have to be controls or control computers in the true sense of the word but can also be further automation devices such as drive devices, I/O modules, Ethernet switches or even smart connection technology that can take on parts of the overall control function.

- Transparency of condition and life cycle information: Here the machines provide their own condition and configuration data as well as the process data system wide, which means throughout all phases of its life cycle, in a manner which is transparent and complete in the network. Services can then access this data to implement new applications. Simple and cheap sensors provide the basis for this. By increasing the accuracy and availability of these signals and data in the entire network, the data volume and thus the need for data transmission and storage increase significantly. The term big data [5] expresses this.

- Diagnosis of processes and conditions: The important application for the use of this data, which can even be identified today, is comprehensive and systematic recording of the condition of production processes, machines and processes and automation engineering, which drive these processes. This makes it possible to diagnose processes and thus identify and flag up deviations during ongoing operation. Furthermore, the basis is created to optimize manufacturing processes systematically on the basis of this detailed data that is available online.

- IT security: Digitization and networking, which naturally also form the prerequisite for the implementation of the aspects listed above, are important concepts of Industrie 4.0. The other side of this coin is the need to protect these networks, which are as a principle open, against access by third parties – not only in order to protect the intellectual property of a business but also to safeguard the functional security and integrity. For this reason, it is absolutely essential to take measures for IT security for future Industrie 4.0 solutions. However, to describe these would go beyond the core of this White Paper.

4 Technologies / “Physical layer”

Electrical connectivity, called the “physical layer”, is divided into solutions for data, signals, energy and – in combinations of these – the hybrid connection technology. Different physical transmission types and connection technology components, such as plug connectors and terminal strips, have been established for specific applications for the different use cases and these will also continue to be relevant in Industrie 4.0.

Electrical transmission of data, signals and energy

Different types of plug connectors and terminal strips are used for transmission of data, signals and energy via cable, depending on the application. Where the wiring for energy and signals are fixed, terminal strips are generally used. Plug connectors are used for connections that frequently have to be separated as well as connection technology for data. Furthermore, the installation location and the type of protection required for this also decide the type of components. Consequently, terminal strips are fitted in switch cabinets or housings associated with the type of protection IP20. Plug connectors are deployed over a wider spectrum, which in terms of protection type ranges from IP20 to IP67. Consequently, the places of deployment are very varied and range from the office environment, the switch cabinet, rough industrial environments to outside applications. Terminal connection methods using screw technology or spring connections have become established for terminal strips. Because of the different demands made on plug connections, the diversity of this component is considerably greater and a distinction is made between square and round connections. In order to maintain connection compatibility, there are a number of norms and standards for plug connectors. As a rule, copper or tinned copper are used as contact material for transmitting energy. In the case of data and signals, gold is used as a contact material in addition to copper contacts as the quality needed for data and signals increases.

Optical transmission of data

Optical transmission is used when there is a requirement to transmit data via cable for long distances with minimal losses, to transmit data over the widest possible bandwidth or to carry out transmission securely against the influences of electromagnetic interference fields. Optical fibers made of glass fiber, quartz fiber or plastic optical fiber (POF) are available. Light signals generated using light or laser diodes are used for optical transmission and they are received by photo-optical elements at the end of the transmission line. Electrical signals are converted to optical signals and vice versa before and after optical transmission.

Contactless transmission of data, signals and energy in the near field

Contactless transmission systems offer considerable advantages when it comes to transmitting data, signals and energy in rough industrial environments with high environmental requirements in respect of sealing, vibration, corrosion and explosion protection, if the plug has to be frequently connected and disconnected or where rotation is required. Contactless connection technology primarily involves transparent point-to-point connections for transmitting data, signals and energy. In the case of contactless connection technology, the transmitter and receiver units do not touch each other physically and therefore permit hermetic protection against dirt and fluids and are not at all affected by wear, vibration, rotation and the angle at which the sender and receiver units are in relation to each other. The distance between the transmitter and receiver is usually several millimeters to centimeters and, apart from through the air, transmission is also possible via any non-conducting substances (fluids). Whereas energy transmission is a conversion from electrical to magnetic energy and vice versa, RF chips in combination with near-field aerials can, for instance, be used for contactless data transmission.

Remote-field radio transmission

A further type of contactless transmission is the radio transmission of data. In contrast to the term near-field transmission, the term radio transmission stands for transmission over longer distances. In technical terms, remote-field radio transmission such as WLAN is only different because of the higher transmitting and receiving power and other radio frequencies.

5 Forecast for the future

The Industrie 4.0 vision always looks towards more efficient and flexible production systems, which involve increasing modularization and distribution of machines and systems.

The volume and scope of the information and data used will increase tremendously because of decentralized intelligence, the required data transparency, data consistency of systems and the availability of information – the buzzword is big data.

The efficient use of energy requires flexible energy management and active distribution of energy flows in the machine and system environment. Because of the decentralization of machines and systems, the number of connection points, generators, consumers and memories is increasing substantially. Energy storage, energy recovery and "energy harvesting" [6] are becoming increasingly significant in decentralized machine and system networks and are also increasing the need for information.

These requirements in respect of energy and data inevitably result in modular pluggable energy distribution systems and a significant increase in automation communication.

Flexible wireless solutions are sure to play an important role here. Networking by cable will continue to be a major focus of future production systems because of the cost-benefit effects, the data security to be guaranteed and the available bandwidths.

It can be ascertained from this that the significance of connection technology for energy and data distribution will continue to increase significantly across the board. A basic prerequisite for efficient network infrastructure management in future widely distributed networks is information about the network topology and its physical characteristics. These include simple planning and automatic recording of network topology and the provision of network infrastructure performance in respect of the energy and data to be transmitted. This may be information on the documentation, diagnosis, functional capability, aging condition, wear or exchange of connection technology.

Adaptations and changes to today's network infrastructures require not inconsiderable planning and documentation outlay. In order to deal effectively with such widely distributed network infrastructures in the future, it will be necessary to have information about the type and use of all components of the network infrastructure – ideally from the connection element itself.

Apart from the machine-readable description of the components in the network infrastructures, information closely associated with the network infrastructure and functions such as equipment identification codes, place of deployment, technical performance data, electronic coding and higher-value functions including the measurement of energy data, diagnosis of the condition and wear and the recording of further sensor-based information such as temperature, pressure and moisture are relocated to the network infrastructures. As network infrastructures and the functions of components and connector systems become increasingly complex, the "form relevance" to date, i.e. connector profile and coding, no longer cover the wide range of options and must be expanded to include electronic coding and functions for self-description and configuration, in other words, specific semantic and syntax. Apart from simple handling during prefabrication, electronic coding is one of the important basic prerequisites for plug-and-produce capability during installation and operation.

In order to increase the availability and robustness of network infrastructures for Plug and Produce as well, greater demands on durability – such as frequency of actuation and plugging cycles – or inserting and disconnecting under load and their data-related analysis must be taken into account.

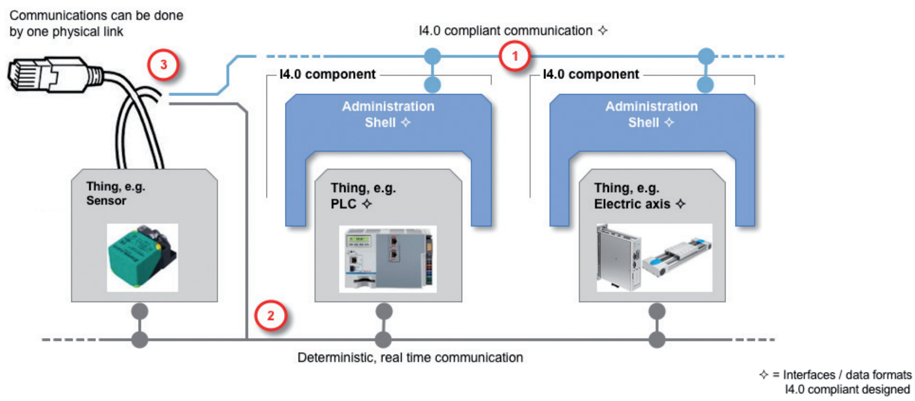
6 Challenges for electrical connectivity

In the previous sections the potential benefits and consequences of Industrie 4.0 and its implementation for mechanical and plant engineering has been described and a forecast for the future of electrical connectivity highlighted. It can be seen from this that the current position of electrical connectivity already satisfies a significant proportion of the requirements. However, it can be seen that further challenges exist for systematic implementation of Industrie 4.0 concepts and technologies. In essence, they can be found in the following fields:

- **Digital representation:** Horizontal and vertical integration, the consistency of the engineering processes and the availability of data and information of all components involved throughout their life cycle form the basis of Industrie 4.0. This requirement also applies to electrical connectivity components so that a digital representation to present Industrie 4.0 components as an entity is absolutely necessary. What this essentially means is that, apart from the physical components, a digital model will also exist in which all relevant data is mapped and made available for future Industrie 4.0 services. The term Industrie 4.0 components [9] is also used to express this relationship. This relates to the data describing a product that is identical for all types of a component and is primarily required during the engineering process.

  Nevertheless, this also relates to the data and process status information produced over the life cycle of a specific component – an instance – and must therefore also map the digital model. Information on the specific use of an instance is noticeable, for example the place where it is used, the special function or the specific configuration. However, it also relates to diagnostic information which comes from the intelligence of connection technology described above and the decentralization of automation functions. For this purpose, suitable standardized data models and description languages must be defined, architectures defined for unambiguous filing of this information and the accessing of this, as well as implementing both in the relevant systems. Furthermore, it must be ensured that this information can be accessed continuously and at all times so that the services that are being created in the Industrie 4.0 environment can also be implemented systematically. For this, the information does not necessarily need

Figure 3: Encapsulation capability and networking of an Industrie 4.0 component [9]



Source: Plattform Industrie 4.0

to be stored "on" or "in" the connection technology components themselves. They can just as easily be stored in a parallel database which contains an unequivocal identifier on the component. Consequently, the components do not necessarily need to be capable of communicating independently but it must be possible at all times to access the administration shell from the outside.

- **Standardization:** Industrie 4.0 is a concept for future production scenarios that operates worldwide with different suppliers (technical equipment of production systems, services and finished products) and is primarily characterized by a plug-and-product capability. These require worldwide standardization of interfaces via its life cycle, which are needed for the interoperability of the components and systems. Global standards (e.g. IEC or ETSI standards) must be established here in consensus and free of rights and they are only allowed to des-cribe the system-relevant characteristics in Industrie 4.0 architecture. System-relevant features describe those parts of Industrie 4.0 interfaces [9] or patterns of behavior that describe Industrie 4.0 functionality generically or secure interaction between these. The technical execution should be left to the manufacturers and future technological advances. In the case of plug-and-socket systems, these are, for example, the connector profiles for the plug-and-socket systems (fully standardized interfaces) and the generic nature of their digital description, incl. the technical data required for operation (geometry, log, further physical characteristics, if required). Versioned standards therefore ensure the availability of systems, international use and the life cycle of products and solutions.

- **Integration of electronics:** With progressive miniaturization of electronics, the computing power this provides and the possibility of a simplified communications connection means functions which have, to date, been carried out centrally are increasingly being decentralized. This allows components, which until now have almost exclusively been passive, such as electromechanical components including cables, connectors and contactors, to be developed further with electronics in components that perform functions. On the one hand, these are functions which have a direct effect on components. Component diagnosis, settings and telecontrol user interfaces are a few other examples. Additional functions, which to date have been mounted separately to the installation system such as temperature or energy measurement, create additional benefits in connection technology and supplement the existing use of components at their fitting position. With Industrie 4.0 it will be possible to design the installation in such a way that it can respond adaptively to dynamic events. An example of this is the resource-efficient use of materials and energy. The conflict that the cross-section of a power cable must always be designed for the maximum output, although this condition only occurs in certain situations, can be resolved by a smart installation technique. Using Industrie 4.0 resources, functions such as temperature and current monitoring can be incorporated in the automation sequences and thus prevent an overload or, in the case of additional current consumption for a limited time in an installation system that physically has a somewhat delayed response (conscious toleration of heating) whilst still ensuring the safety and availability of the system through temperature monitoring. Communications capability is an important aspect that inevitably appears in connection with Industrie 4.0 concepts. On the one hand, this affects the data and information that is produced in the connector technology during operation, e.g. as a result of sensors, but it is also within the scope of the information contained in the digital representation. Both must be available continuously and at all times, and this is why appropriate communications technologies and interfaces are to be made available on the basis of standards.

- **Ease of use (usability):** Ease of use, particularly as regards handling and prefabrication, is becoming increasingly important within the context of Industrie 4.0. On the one hand, prefabrication on site (field prefabrication capability) is required in principle on account of increasing decentralization and automation and network structures that change dynamically. Here it is important to provide the simplest and robust terminal connection methods and connection technologies that can be used free of faults, even in difficult field conditions. Connection technology will also have to deal with the rapid increase in data throughput (communication capability and big data), the more complex and sensitive wiring structures in relation to bandwidth, transmission quality and EMC shielding that will arise from this. This will inevitably make innovative connection methods that are largely independent of the user necessary. On the other hand, because of Plug and Produce connection technology will have to be considerably easier to use, because globally it must be assumed that the users are untrained or only have minimal training. This trend will inevitably support and drive the development of easy-to-use, robust and contactless transmission technologies and radio transmission.

- **Transfer technologies:** The implementation of Industrie 4.0 is a continuous process where it will not be possible to exchange electrical connectivity for completely new systems overnight. The process of changing over will be continuous and it means that existing and new technologies will have to co-exist and therefore compatibility must be maintained from the users' point of view.

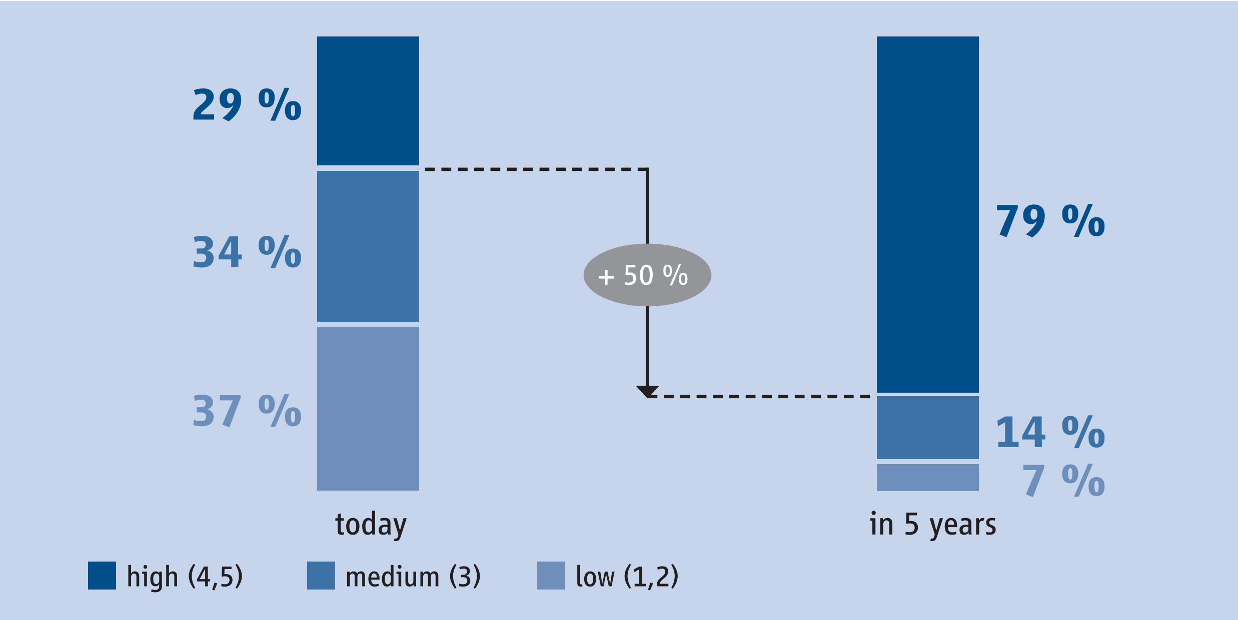
Furthermore, the continuously increasing demands in respect of data transmission rate are a driving force. The Ethernet is a good example of the developing process and the challenges it poses.

As for IT, Fast Ethernet (transmission rate of 100 MBit/s) will in future be superseded by Gigabit Ethernet in industry too. These higher transmission rates pose considerable demands on shielding against electromagnetic interference and contact quality. This must be taken into account in respect of the development of electrical connectivity such as plug connectors for Industrie 4.0, considering suitability for industry (the robustness of the mechanical elements, high plugging cycles). Furthermore, aspects such as the field prefabrication capability, and simple and clear handling are further requirements that are also relevant for Industrie 4.0. In connection with the growing demands for data transmission rates, the technological limits of the physics of copper-based data transmission, in particular for Ethernet, will be reached in the future and the technology will have to move to the next level with optical transmission. Transmission technology will increasingly have to move towards contactless or wireless transmission to achieve even simpler universal handling. The new transmission technologies will be required for data transmission but also for signal and energy transmission. Hybrid plug connectors that combine energy, signals and data, are becoming increasingly relevant. Here contactless near-field transmission technologies such as optical, inductive, capacitive methods are complementing and superseding conventional contacting.

7 Summary

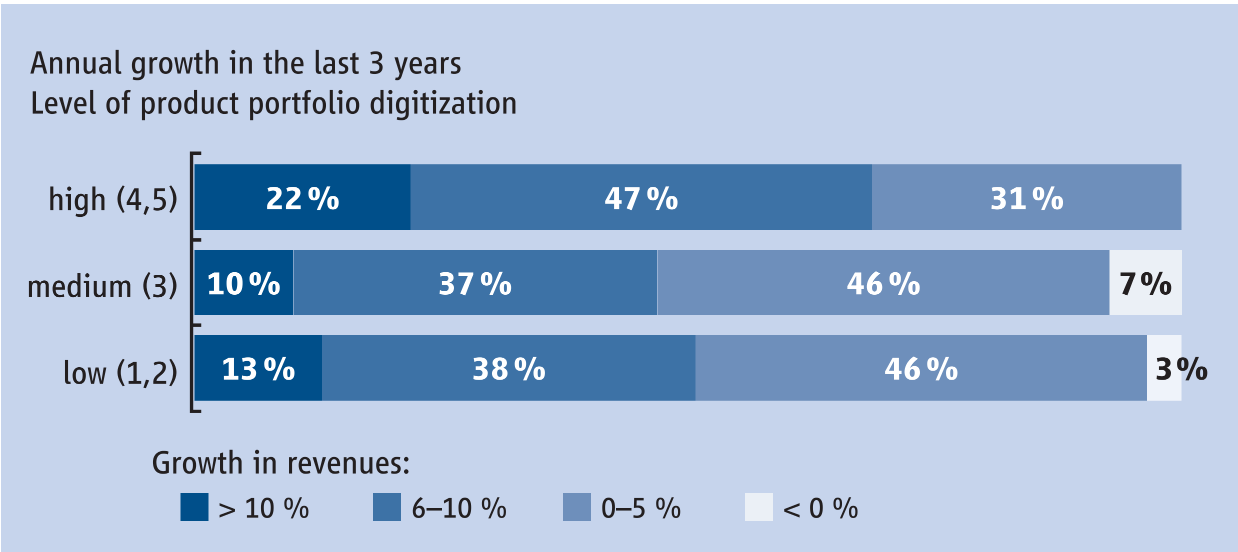
In order to develop the considerable additional sales potential (see Figure 5) that Industrie 4.0 offers to industrial companies, the product portfolio needs to be digitized throughout. (See Figure 4.) This also particularly affects the electrical connectivity, which plays a central role in connectivity. Digitization or the use of all components and also Industrie 4.0 components with an administration shell is the basic prerequisite for a functioning Industrie 4.0 infrastructure in order to achieve the planned potential. Only the end-to-end digitization of the information flow in the engineering chain and installation allows, in connection with the integration of intelligence into the electrical connectivity, the full documentation of connection technology and its development and performance status or performance and monitoring over the complete life cycle. In order to permit digitization or digital representation, international standardization of connectivity is absolutely essential. Furthermore, manufacturing companies must put the electrical connectivity on a path to significant transformation and change, moving from electromechanical to electronic and software expertise. The ability to master this transformation will primarily be decided in the form of market share and thus the decision will be made through success in the market. This development will take a few years and develop on an evolutionary basis – it cannot be assumed that the change will take place quickly, as the term revolution implies. During this process, connection technology in its current form will also have a role to play in the future. However, it is clear that the utility and business models that are facilitated by connection technology in the industry 4.0 environment and the data gained will bring about revolutionary results and further possibilities will be developed.

Figure 4: Level of product portfolio digitization



Source: following PwC, October 2013

Figure 5: Growth in revenue depending on the level of digitization



Source: following PwC, October 2013

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