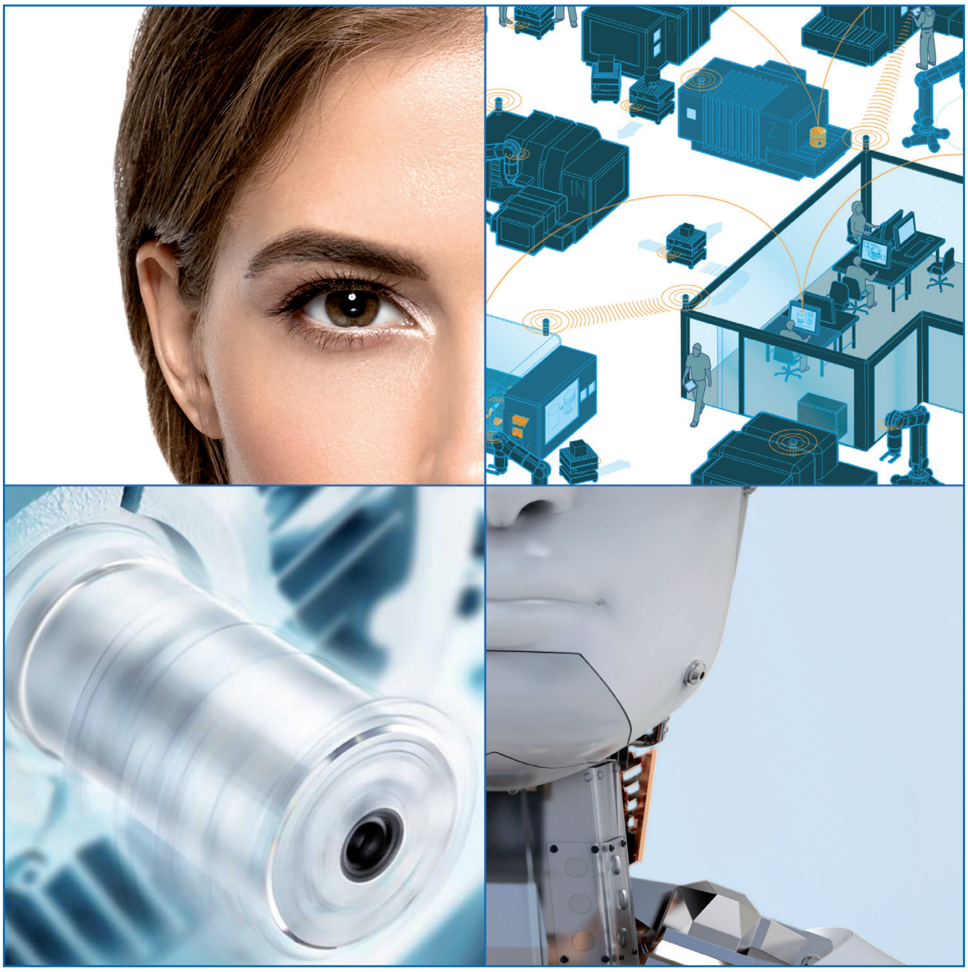
Die Elektroindustrie

Drive 4.0 – Vision Becomes Reality

Properties, data and functions of electrical drive systems in Industrie 4.0 for drive manufacturers, machine builders and plant operators



German Electrical and Electronic Manufacturers' Association

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Drive 4.0 – Vision Becomes Reality

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Content

Management Summary

In a ZVEI ad-hoc working group, various manufacturers of drive technology met with representatives from machine builders and those working in the fields of classification and standards to push forward the implementation of "Drive 4.0" with the aid of university research. This information brochure reports on the initial results and explains the implementation of the electrical drive as an Industrie 4.0 component (I4.0 component). Standardised, manufacturer-independent data provision plays a particularly important role here. The classification system eCl@ss, which is based on international standards, was chosen to create a uniform data structure with I4.0 semantics. Numerous properties of various drive technology fields are already defined in this system. The standardised data resulting from this then also serves as the basis for establishing data models, for example for OPC-UA. In a further step, initial functions have also been described in a manufacturer-independent way. As a specific example, the oscilloscope function was presented. All in all, the working group developed overarching properties, data and functions of electrical drives for drive manufacturers, machine builders and plant operators, thus bringing closer to reality the physical implementation of the drive of tomorrow.

1 Introduction: Networked Mindset for Electrical Drives

The drive as a core component goes through a range of very different value creation processes, from planning and manufacturing, to integration into machines and commissioning, and finally use in the production process. In combination with sensors and IT solutions, electrical drives make it possible to rethink actuators. They can therefore be considered as the initiators of Industrie 4.0 (I4.0). As a result, drive technology considers it has an active role in driving forward the design of the future Drive 4.0 industrial product. For this purpose, the ad-hoc working group "Industrie 4.0 in der Antriebstechnik" for electrical drive systems set up by the German Electrical and Electronic Manufacturers' Association (ZVEI) is currently developing a concept that deals with terminology and classifications relating to the drives, places properties and functions in an I4.0 context and, ultimately, forms the basis for standardised digitisation of the drive.

As a result of digitisation, drive manufacturers, machine builders and plant operators will obtain extensive knowledge of the production process and also increased transparency regarding the technical processes. This digital transformation is establishing and driving forward modularisation in the value creation chain of production plants and products similar to those found in software products. Each individual module serves as an information and knowledge carrier with defined properties and communication interfaces. In particular, due to the increasingly shorter life cycles of machine elements, the goal must be to establish generally applicable standards for the implementation of interfaces and data communication. Suitable horizontal and vertical integration of such modules and their networked information will result in new, intelligent products and thus, in drive technology, also in Drive 4.0.

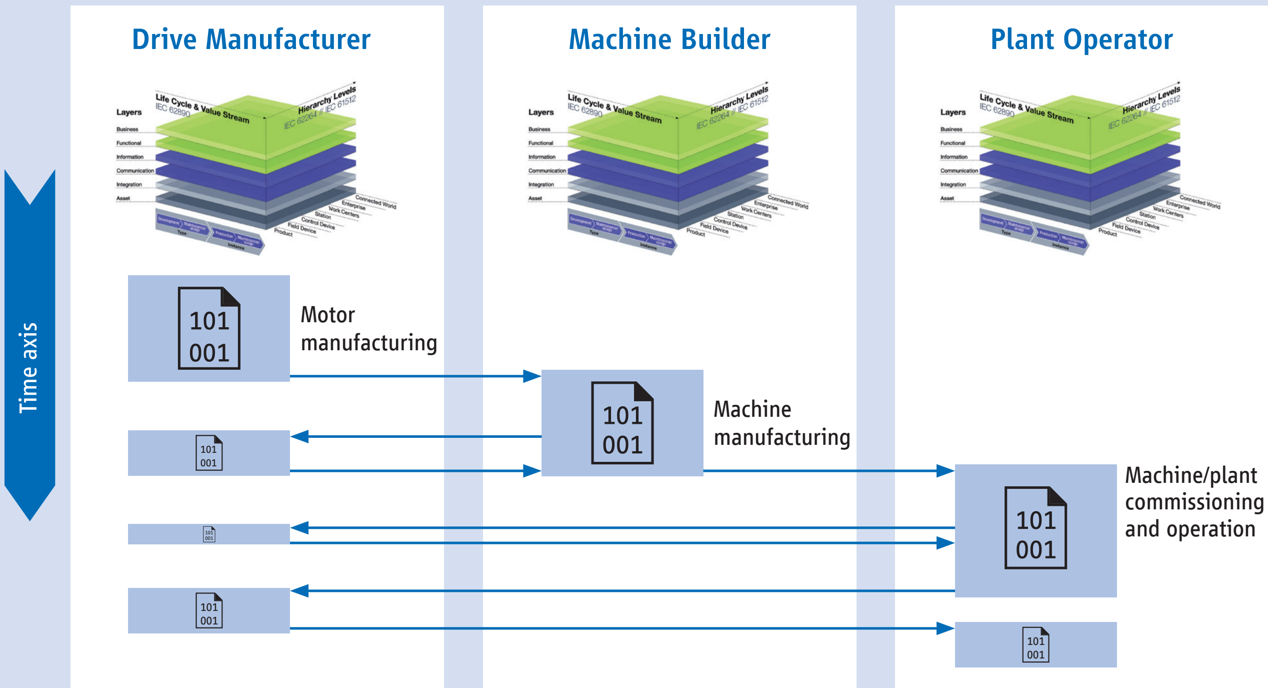
"Industrie 4.0" stands for full digitisation and integration of the industrial value creation chain. Connecting information and communication technology with automation technology to the Internet of Things and services enables an increasing degree of networking within and between production plants – from the supplier right through to the customer. This also includes digitisation of the product and service offering, which allows new business models. Ultimately, Industrie 4.0 is the realisation of the smart factory within the digital value creation network.

Gunther Koschnick

In order to achieve this ambitious goal, in the working group's view it is necessary to provide data from electrical drives in a standardised, manufacturer-independent form. These cross-manufacturer, standardised interfaces and data structures should make it possible to freely combine components and system parts with ease and to use the relevant data and functions easily and efficiently. Based on potential application cases, the working group identifies and analyses information that can be allocated to the following roles in the value creation process in the scope of I4.0 (see Fig. 1):

- **Drive manufacturer**
  The manufacturer produces the drive from various parts and individual components, tests and delivers it. The manufacturer brings the drive to market.
- **Machine builder**
  The machine builder develops a machine by combining and networking drives and other components and brings this machine to market. Frequently, the machine builder also takes care of installation and commissioning. This definition can also be used in the same way for plant engineers or similar roles.
- **Plant operator**
  The plant operator integrates the machine produced by the machine builder and operates it following installation and commissioning. Usually several machines and/or machine modules are coupled and networked to establish a production plant or process engineering plant.

Fig. 1: Roles and Data in the Value Creation Process



Source: ZVEI

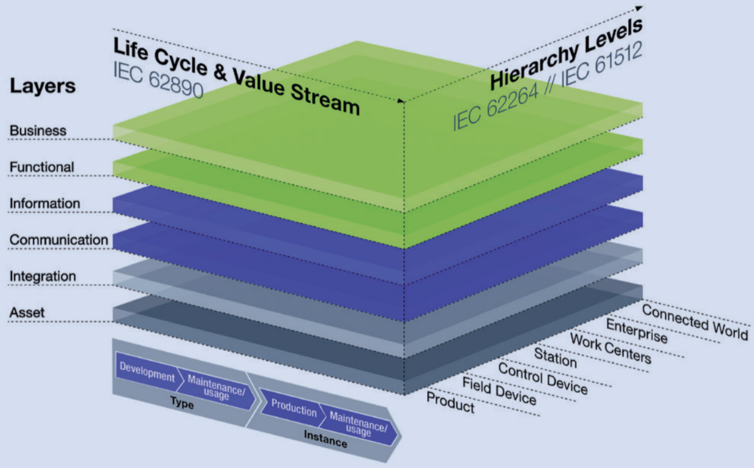
2 Foundations for Industrie 4.0 in Drive Technology

RAMI 4.0 is the first time the key characteristics of objects in I4.0 solutions have been compiled in a three-dimensional layer model. Based on this structure, the content of I4.0 technology can be systematically assigned and further developed.

2.1 Reference architecture model for Industrie 4.0 (RAMI 4.0)

The reference architecture model for Industrie 4.0, RAMI 4.0[1] for short, consists of a three-dimensional-coordinate system containing the key aspects of an observed object in I4.0 (see Fig. 2). This object is termed an object of value, or asset, for I4.0 purposes. An asset can be an electronic component such as a drive, a system such as the drive chain, the plant, or even the entire factory made up of different elements.

Fig. 2: Presentation of RAMI 4.0



Source: ZVEI

- **"Hierarchy Levels"**
  The right-hand horizontal axis represents the integration of company IT and control systems in accordance with IEC 62264. This area maps functionalities within a factory or plant from the product to its connected world in the Internet of Things.
- **"Life Cycle & Value Stream"**
  The left-hand horizontal axis maps the life cycle of products and plants in accordance with IEC 62890, divided into type and instance. It describes the development from prototype to operation of the finished product.
- **"Layers"**
  Six layers on the vertical axis of the model describe the IT representation, i.e. the digital reflection of, for example, a machine or a drive, in a structured manner – layer by layer. Here, special attention should be paid to the information layer on which all the I4.0 data is stored and the functional layer with its I4.0 functions.

These three dimensions of RAMI 4.0 can be used to present the aspects described above of an object that is relevant for I4.0, such as an electrical drive.[2]

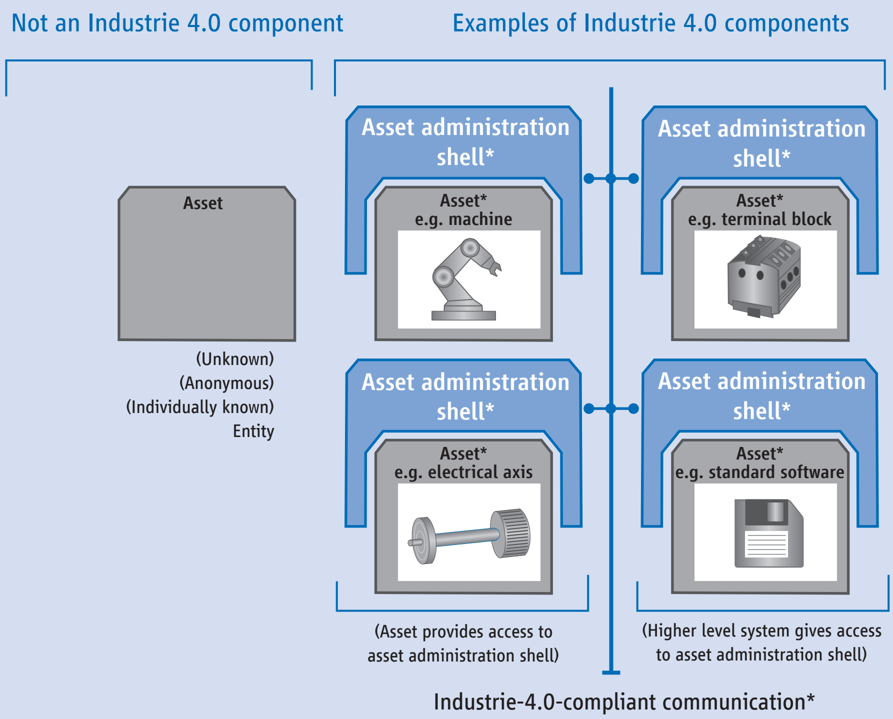
[1] cf. Heidel, Hoffmeister, Hankel, Döbrich; Industrie 4.0 – The reference Architecture Model RAMI 4.0 and the Industrie 4.0 component; Beuth Verlag

[2] cf. https://www.zvei.org/en/press-media/publications/the-reference-architectural-model-industrie-40-rami-40/

2.2 The Industrie 4.0 component

The Industrie 4.0 component[3] uses the asset administration shell to map all the relevant properties and information of a physical object in the IT world of RAMI 4.0. The term "asset administration shell" thus covers one or several physical objects, known as assets, and the shells that surround them with all the relevant information and functions of the asset in the information world. These data can be generated, modified or saved, and allows communication and networking capabilities in the scope of I4.0. A key requirement for this is that I4.0 components maintain data and functions in the asset administration shell in an electronic, secured "container" (be this a storage location created specifically for this purpose or on the asset itself) throughout their entire life cycle. This results in a high level of transparency for drive manufacturers, machine builders and plant operators and enables horizontal and vertical integration in accordance with RAMI 4.0. For I4.0 to be a success, it is vital that not only entire machines but information on key machine parts and components are maintained in the asset administration shell. For example, the properties of the power drive system (PDS) significantly affect the quality of the machine function. In the future, it should be possible for this property information also to be recorded directly by the central maintenance system. The same applies in automation technology to production components that do not have their own data interface, for instance cable properties such as cross-section and shielding. In this way, every part becomes a smart component of networked production in I4.0.

Fig. 3: Object as an Industrie 4.0 Component



Source: ZVEI

*Interfaces/data formats implemented in Industrie 4.0-compliant form

[3] cf. https://www.zvei.org/en/press-media/publications/examples-of-the-asset-administration-shell-for-industrie-40-components-basic-part/

2.3. Communication and semantics I4.0

I4.0 follows a service-oriented architecture. It must be possible to carry out services and exchange data in a standardised manner if communication is to work. For this purpose, requirements are being formulated for message transmission between I4.0 components. These requirements can be summarised under the term "I4.0 communication". The specifications of I4.0 communication are currently being defined. I4.0 communication does not need to be developed entirely from scratch, but preferential standards that are best suited for I4.0 communication should be filtered out of the standards that already exist and are currently under development.

In RAMI 4.0, this is reflected in the communication layer. In addition, communication by components, machines, plants and IT systems requires a cross-manufacturer, shared language, i.e. shared vocabularies in the form of data, as well as a shared syntax that ensures the structure and context of the properties and data. Cross-manufacturer functions that use I4.0 data are mapped in the higher-level layer, the functional layer. The objective is to obtain general functions that can be used with data and devices from different drive manufacturers. All other properties, data and functions that are not standardised in accordance with I4.0 are stored in the integration layer. The ZVEI and Industrie 4.0 platform[4] standardisation committees are discussing potential candidates for the creation of standardised communication with I4.0 semantics. Alongside a classification system such as eCl@ss and standards like IEC 61360 with the IEC Common Data Dictionary (IEC CDD), independent methods for standardised data exchange, such as AutomationML[5], are being considered. Initial standardised data and functions as well as the communication itself are described in the criteria for Industrie 4.0 products[6] as necessary product properties.[7]

2.4 Existing standards

To make the drive I4.0-compatible, certain specifications are required that are implemented in an I4.0 drive component. For this purpose, the drive must be described using terms that are stored as properties in the I4.0 drive component asset administration shell. The asset and asset administration shell must therefore be uniquely identified with identifiers (ID). To migrate a current drive to an Industrie 4.0 environment, description properties in accordance with I4.0 semantics are required; in other words, the properties must be specified in accordance with the rules of IEC 61360[8,9] or ISO 13584-42[10].

[4] cf. https://www.zvei.org/en/press-media/publications/implementation-strategy-industrie-40-report-on-the-results-of-industrie-40-platform/

[5] cf. https://www.automationml.org/

[6] cf. https://www.zvei.org/en/press-media/publications/industrie-40-product-criteria-for-industrie-40-technologies/

[7] cf. https://www.zvei.org/en/press-media/publications/what-criteria-do-industrie-40-products-need-to-fulfil/

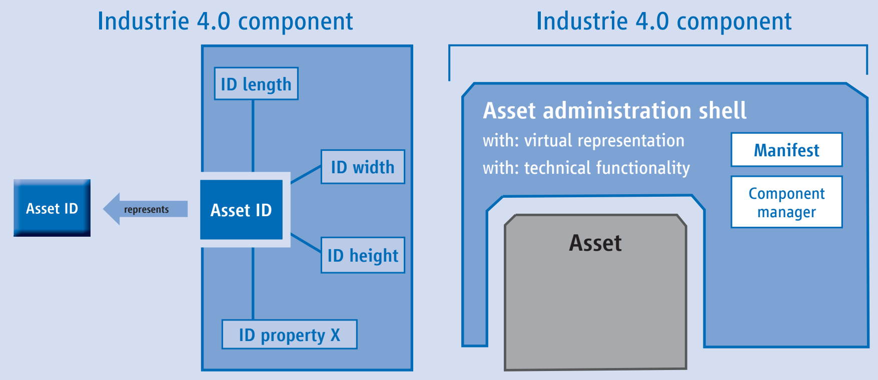
[8] cf. IEC 61360-1:2009, Standard data elements types with associated classification scheme for electric items – Part 1: Definitions – Principles and methods

[9] cf. IEC 61360-2:2012, Standard data element types with associated classification scheme for electric components – Part 2: EXPRESS dictionary schema

[10] cf. ISO 13584-42:2010, Industrial automation systems and integration – Parts library – Part 42: Description methodology: Methodology for structuring parts families

Specification of asset's properties

Fig. 4: Industrie 4.0 Component



Source: ZVEI

There are already various standards that can be consulted for the conversion of a drive to a drive component 4.0. We therefore expect that the transition to I4.0 will not cause too much disruption.

Cooperation capability of I4.0 components

When standardised communication protocols were being developed, "cooperation capability" or "cooperability" was still known under the term "interchangeability". This describes important criteria going beyond pure data exchange. The perspective of pure data exchange is enhanced to the benefit of an application-related viewpoint based on cooperation at application level. As this enhancement is characterised by standardised "(application) functions" and "compliant dynamic behaviour", standardised semantics play a key role.

The structure of the Drive 4.0 can be illustrated with the device model from IEC 61804-2 (see Fig. 5).

Fig. 5: Cooperation Capability

Compatibility level

Needed feature	Incompatible	Coexistent	Interconnectable	Interworkable	Interoperable	Interchangeable
Dynamic performance						•
Application functionality					•	•
Parameter semantics					•	•
Data types date access				•	•	•
Communication interface			•	•	•	•
Communication protocol		•	•	•	•	•

Interchangeability = Cooperation capability

Cooperation between any assets of value (Dynamic performance, Application functionality, Parameter semantics)

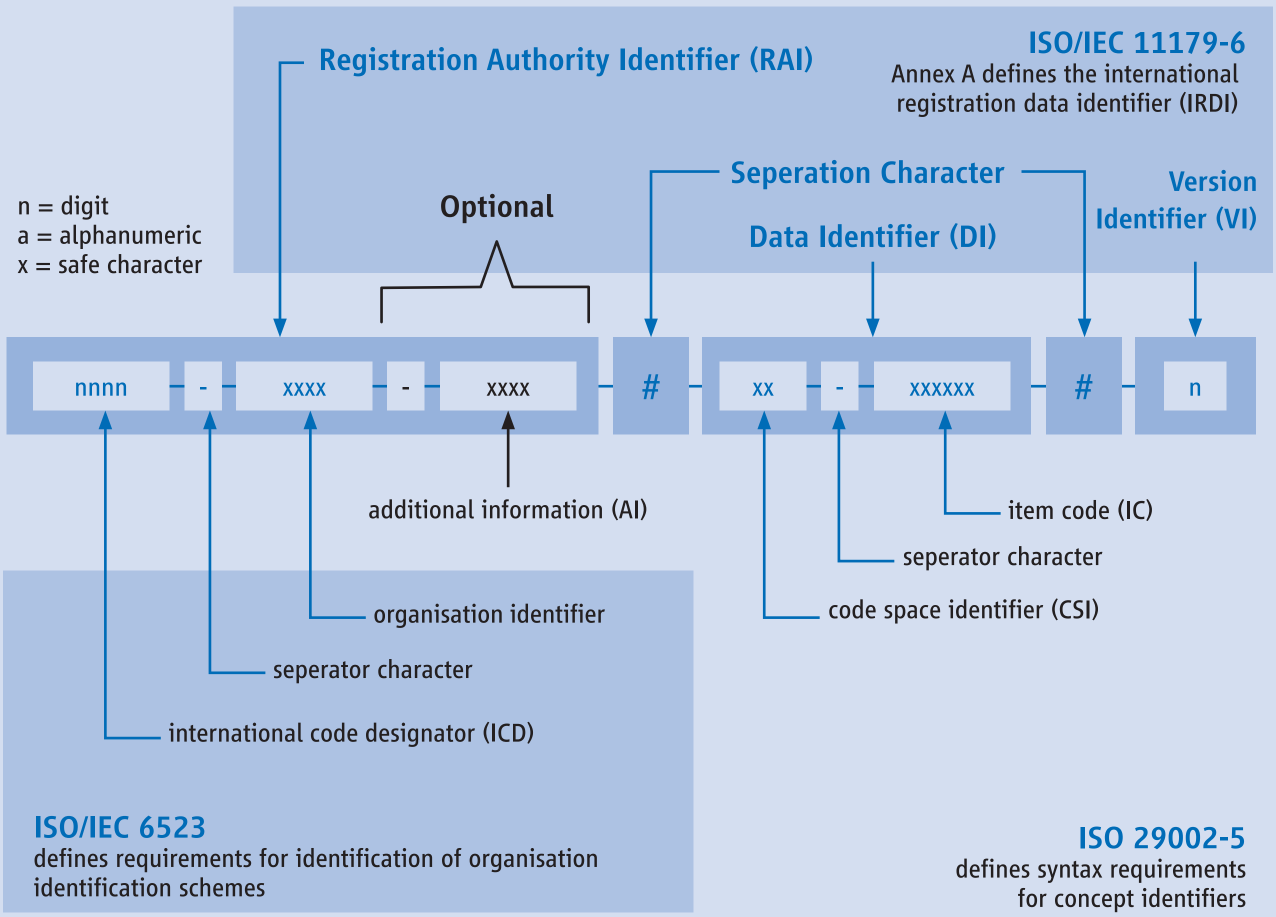
Communication (Data types date access, Communication interface, Communication protocol)

Source: Heidelcom/IEC 61804-2

Identification of assets

The goal of providing standardised information models that can be used across drive manufacturers requires the use of digital and uniquely generated properties with reusable value ranges. The IRDI (International Registration Data Identifier) forms the basis for applying a unique identifier to data.

Fig. 6: ISO 29002-5:2009



Source: ZVEI

Among other things, the repositories from eCl@ss e. V. provide the option to create and maintain properties in a form that is standardised according to I4.0 in accordance with ISO/IEC 6523 as well as ISP/IEC 11179-6 (see Fig. 6). A property in eCl@ss essentially consists of a unique identifier (access path) for the issuing organisation and the item code that characterises the property in question. This is composed of three letters and three numbers. For example, the identifier for the organisation eCl@ss is 0173 and the item code for the property "Power" is "BAF846". Every motor must be uniquely labelled regarding this characteristic using this item code for the property.

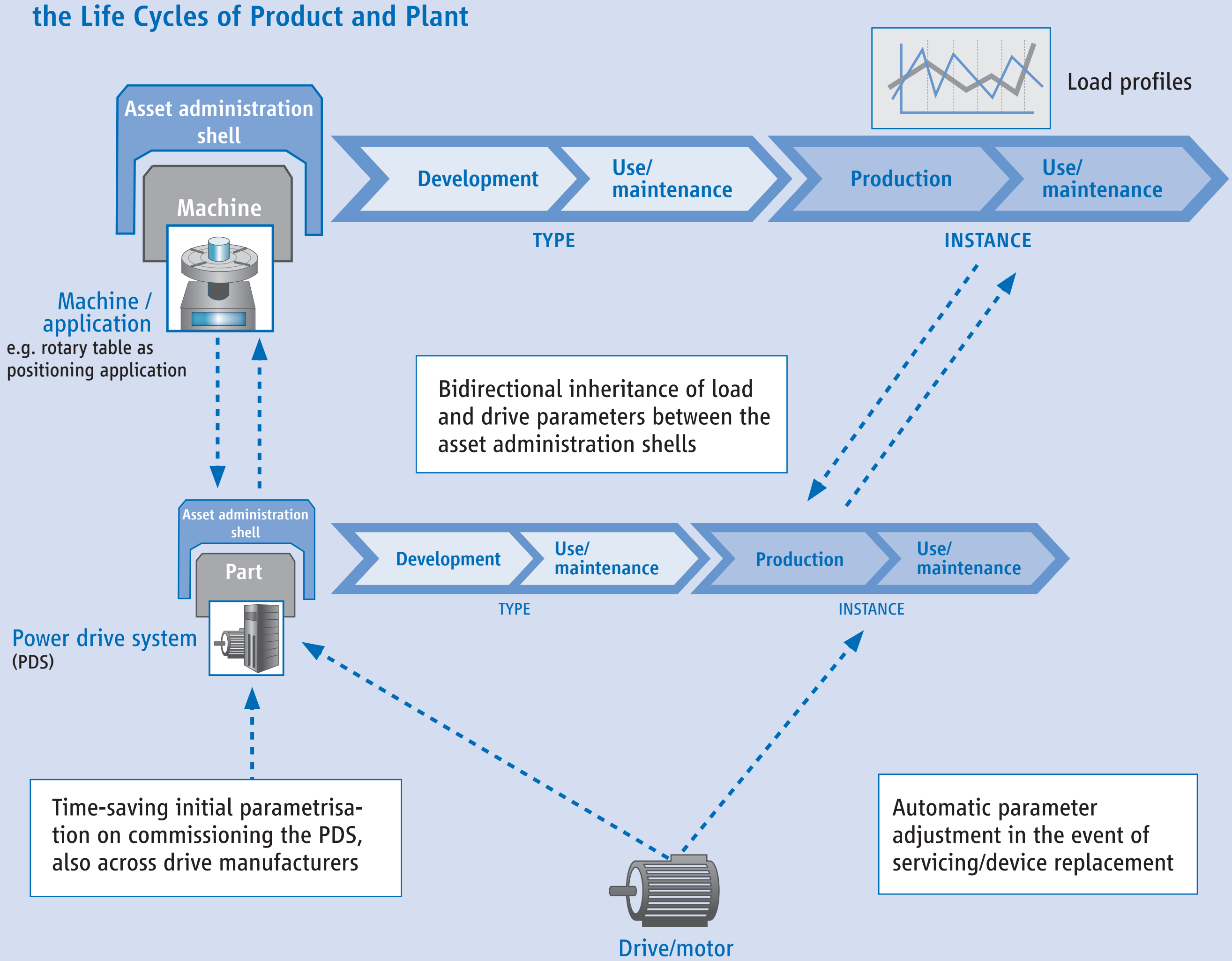
3 Implementing Industrie 4.0 in Drive Technology

To present the electrical drive as a physical component in accordance with I4.0 in the form of information, the properties, data and functions of this asset are described. Possible users are the drive manufacturer, the machine builder and the operator of the production plant.

3.1 Properties of the Drive 4.0

The properties may have different values across the value creation chain, for example in development or production phases (see Fig. 7). As RAMI 4.0 intended, this corresponds to consideration of the "type" (with typical values for certain properties) and "instance" (with values that can be clearly assigned to the individual asset for certain properties that are the same).

Fig. 7: Provision of Information for Electrical Drives Across the Life Cycles of Product and Plant



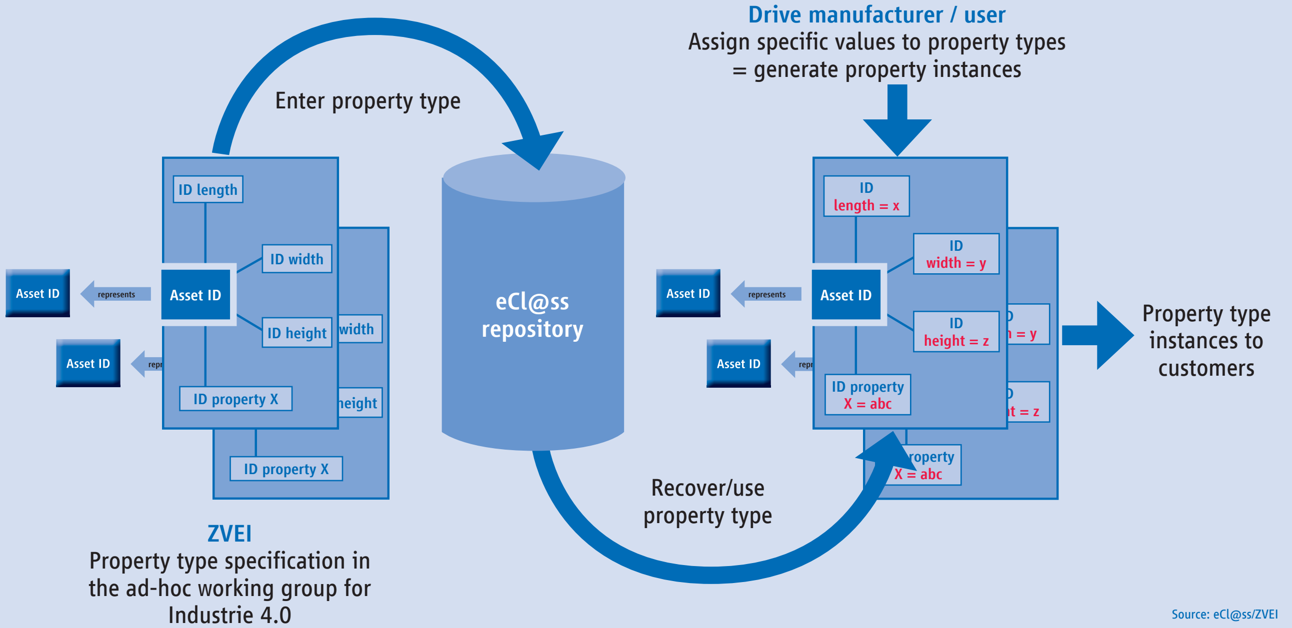
Source: ZVEI

The grouping of the properties and the description of suppliers and users of the data make it possible to quickly identify which data may be relevant in which phase. For much of the collected data, there are guidelines and regional or global standards (VDE, VDI, ISO, EN, IEC, etc.), which define and describe the characteristics. However, despite the efforts of various boards and committees, the details differ. In addition to potential deviations in the physical units (e.g. [H] for Henry or [mH] for millihenry), there are differences in the data formats used, which are generally not standardised (integer, floating point number, number of decimal places, etc.). The working group chose the eCl@ss classification system, which already defines properties across various areas of drive technology, as a basis for initial standardisation. A catalogue of properties is currently being developed and will later be available for drive manufacturers, machine builder and plant operators for use and maintenance.

"The intelligent manufacturing networks of the digital factory can only become a reality with automatically standardised information exchange formats. They must enable secure, reliable and error-free data flow across the various systems (ERP, PLM, MES, logistics, production automation, etc.) and, in the ideal case, it should also be possible to deploy them across companies and (even) industries."[11]

The ZVEI working group is currently specifying properties that are still missing or need to be revised and integrating them into eCl@ss. The objective is to make these properties available to every manufacturer so that they can create a specific instance description by adding the KPIs and characteristics of their drive product. In addition, at the end of the process, information on the products is available to the users or operators in a standardised data structure (see Fig. 9).[12]

Fig. 8: Generating a Property



Source: eCl@ss/ZVEI

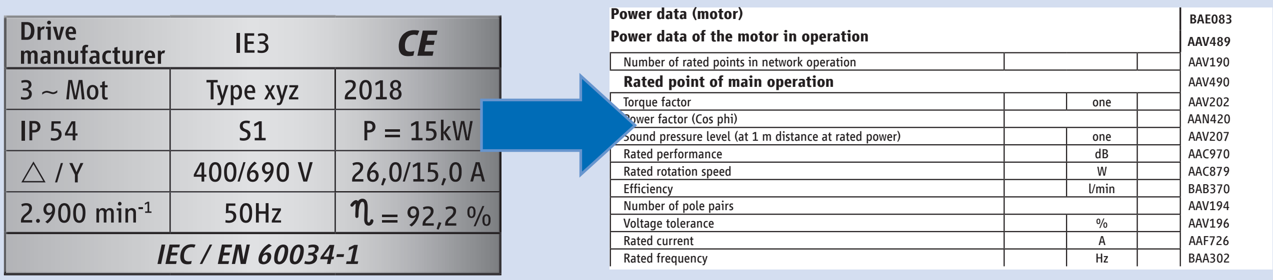
[11] cf. https://www.eclass.eu/fileadmin/downloads/ecl-Whitepaper-Industry40_EN_klein.pdf
[12] cf. http://wiki.eclass.eu/

Example of an electronic nameplate

One of the first implementation examples of Drive 4.0 is the electronic nameplate that must be present on all drives, mapped digitally by means of eCl@ss.

The realisation of the "electronic nameplate with I4.0 functionality" is to be simulated on a virtual drive train, among other things, with unique identification of the motor including instance information such as the serial number and wiring of the motor. Here, subject group 27-02-21 "IEC low-voltage motor" serves as a template for the data modelling of properties and property blocks in eCl@ss, which is being supplemented with specific characteristics of other motor types; for example, currently subject group 27-02-26 servo motors.[13]

Fig. 9: Transferring a Nameplate to eCl@ss



Source: ZVEI

The nameplate data is described in properties and mapped using structural elements, which can, for example, be summarised in a property block with corresponding cardinality to show the power data (switching mode, voltage, frequency, power factor, etc.) (see Fig. 9). The value ranges are assigned individually.

For the future of Drive 4.0, this will apply not only to static information that is already specified when the drive is manufactured, but to all properties, data and functions across the entire life cycle of the drive right up to operation in real time.

3.2 Data of Drive 4.0

To map the characteristics of electrical drives at information level, the properties that are relevant for the entire life cycle need to be identified and specified. To make them available independently of manufacturers, the identifier, description, type, data format, unit and access method must be defined for every property. For this, the working group is specifically looking at the "Power Drive System" (PDS). The basic definition in European Standard EN 50598 or international standard IEC 61800-9 specifies that a PDS is made up of the entire electrical drive train from the control electronics and motor up to the motor shaft.[14]

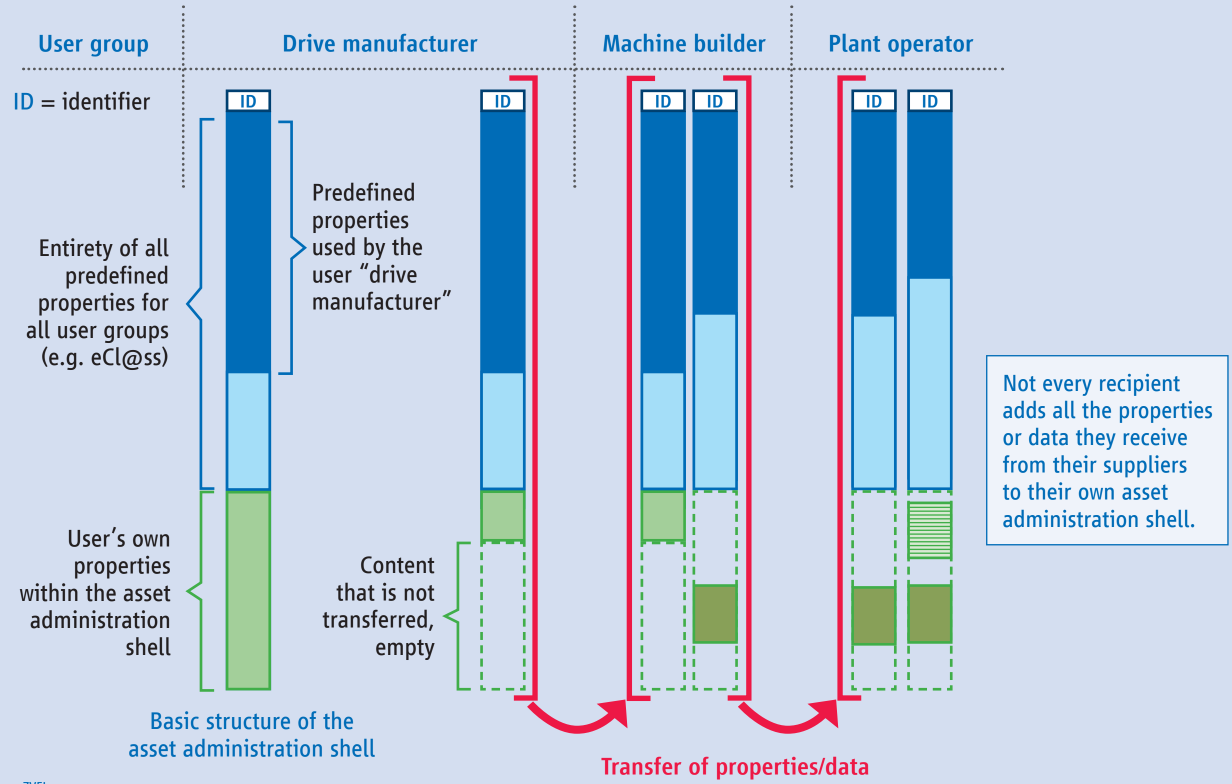
The data that the various users generate relating to the PDS is stored in the asset administration shell. First, the predefined applicable properties must be completed. Only the use of agreed, generally valid properties enables subsequent automatic exchange.

[13] cf. http://www.eclasscontent.com/?id=27022101&language=en

[14] cf. https://www.zvei.org/en/association/divisions/automation-division/electric-drive-systems/

In addition, data can be stored that is intended for internal use only, for instance sensor data from a test run or internal design drawings. Thus, certain data is passed on through the value-creation process. For this, every user passes on the data that he or she must and would like to publish as a data supplier. Each recipient then decides what to add to its asset administration shell. The drive manufacturer only shares part of the dataset to the machine builder. If necessary, the data can be continuously tracked using a unique identifier (ID). The machine builder or the plant operator can then adjust and supplement some of the data in their asset administration shell (see Fig. 10).

Fig. 10: Transfer of Properties/Data from the Asset Administration Shell



Source: ZVEI

It is also possible for the machine builder to distribute a product under its own name – following prior agreement with the original manufacturer. In this case, the machine builder would assign an own unique ID and thus take on the role of a manufacturer for this product. During operation, other data is generated that may be of interest to the various participants in the value creation chain. This data is generated by both the machine builder and the plant operator and is also stored in the asset administration shell. The fact that so many users change them underlines how dynamic the asset administration shells are and that there can be differently filled asset administration shells for different users of a certain device. The data can be traced between users by means of the unique ID.

The Industrie 4.0 electrical drives ad-hoc working group has grouped properties and data that relate to the PDS based on different application cases:

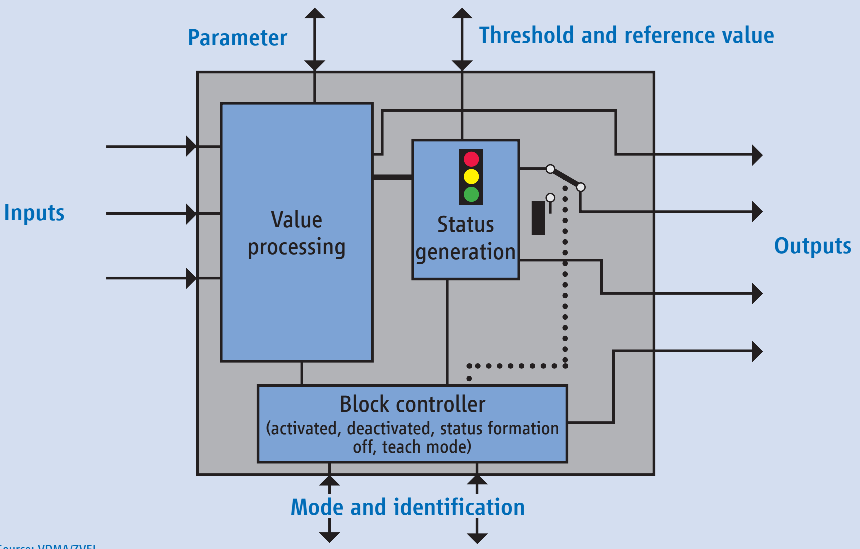
- Functionality
- Technical data, mechanics/electrics
- Documentation
- Certificates/approvals
- Purchase order data
- Logistics
- Interfaces
- Service/maintenance/support
- Other

The results are directly incorporated into eCl@ss data models for the various motor types. The properties and data developed by the ZVEI working group will be added to the international standard at IEC to increase global acceptance.

4 Functions of Drive 4.0

The ZVEI working group has developed I4.0 functions based on the properties and data handling. To describe the cross-manufacturer functions, the working group proposes representation in the form of function blocks in a similar way to the VDMA standard sheet[15] for condition monitoring. This ensures a unique assignment of the data relevant to the function (e.g. input, output or reference values), which are independent of the purpose of the function in question.

Fig. 11: General Block Diagram for I4.0 Functions



Source: VDMA/ZVEI

[15] cf. https://www.vdma.org/documents/105628/2244593/Inhalt+VDMA+24582_en.pdf/

Generally speaking, the I4.0 functions of an asset can be assigned to the functional layer of the same name in RAMI 4.0. The functions located there are made available using a standardised method. This method includes the access, the semantics (= information content or meaning of the information) as well as the internal logic of the function, i.e. how the information is formed. The I4.0 functions are mapped independently from the asset, independently from the drive manufacturer and independently from the communication infrastructure used.

A good example of such a function is a standardised oscilloscope. Access to real-time data is to be enabled for every electrical drive. Users will then be able to visualise the data for different drives and actuators or sensors in their plant with the correct time reference.

4.1 Oscilloscope I4.0 function

The term oscilloscope refers to the characteristic of recording real-time signals of a drive system and making them available to "higher" architecture levels outside of the "drive controller" asset. The recording of a signal is mapped as a sequence of amplitude values, with each amplitude value being assigned a clear system time. Simply speaking, the amplitude values are scanned at equidistant time intervals (as with a digital storage oscilloscope). Here, real-time signals are understood to be quasi-analogue (for example motor phase current or intermediate circuit voltage) or digital (for example quick stop or pulse inhibition) signals, which are recorded in the chronological resolution on which the drive system is based. Typical cycle times in the drive system could be 500 µs (speed control circuit) or 125 µs (current control circuit).

The system time serves to create a relationship between different signals from different actuators and sensors. End-to-end use of a real-time clock (RTC) would be a suitable candidate for the system time. It may also be possible to obtain an exact time using time-sensitive networking (TSN). The general precision time protocol in accordance with IEEE 1588 is used for the synchronisation of networks.

Every oscilloscope signal consists of a signal type and a number of scan values. The number of scan values is unlimited. The signal type of an oscilloscope signal has the attributes:
- Identifier (e.g. Motor_Current_Phase_U)
- Data type (e.g. integer 32 bit as fixed-comma signal or integer 16 bit floating-point signal)
- Quasi-analogue signal or binary signal
- Unit (e.g. A, V, W)
- Measurement tolerance (e.g. in LSB)

Each scan value of an oscilloscope signal consists of
- Algebraic sign (with passive sign convention) – not with binary signals
- Numeric value (pre-decimal and post-decimal positions according to the data type)
- Scan time based on the specified real time/plant time

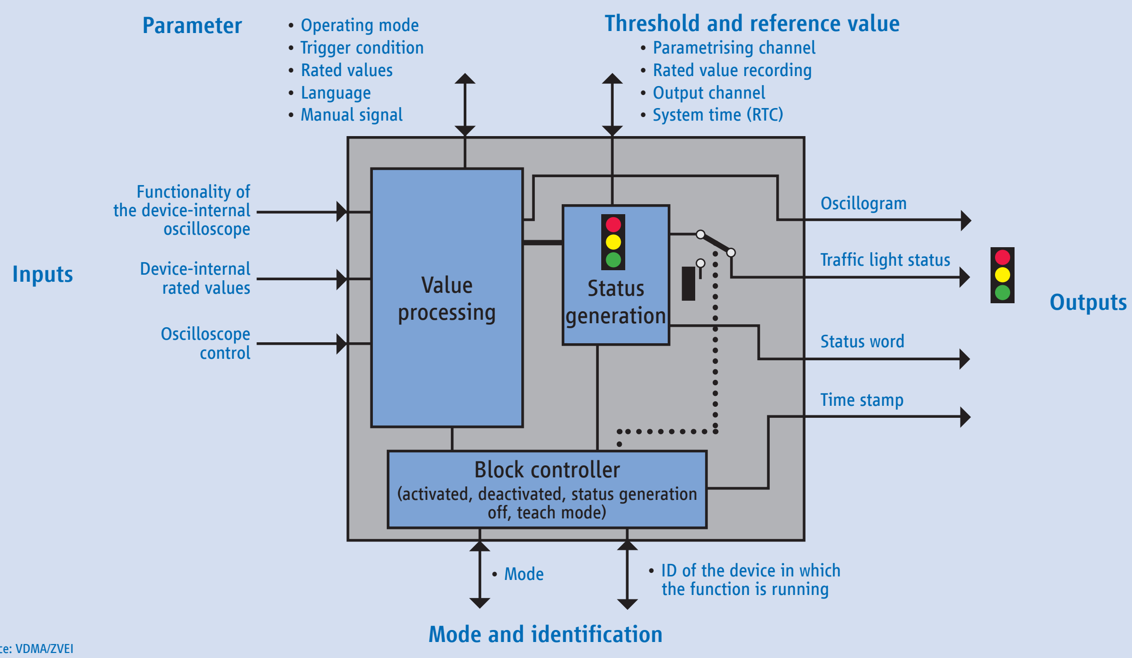
A standardised oscilloscope allows faster commissioning of drives, machines and plants. Here, the benefit is provided by standardised operation, selective choice of relevant/required information, selection of trigger conditions, as well as superimposition of information from various subsystems.

During operation, the oscilloscope can be used to record the process signature of a drive, a machine or a plant and to evaluate this online. In the event of deviations, if necessary the operator can intervene before an error occurs (in a component and/or in the production/ process material) to maintain secure operation and prevent damage.

Using a standardised interface, the device can inform the I4.0 oscilloscope about which measured values are available in which quality:

- Number of channels that can be recorded simultaneously
- Size of the memory area (total)
- Minimum scan rate
- Time reference and internal resolution
- List of process signals/parameters with data type, standardisation and unit
- List of trigger signals (if different from process signals)

Fig. 12: Block Diagram of Oscilloscope I4.0 Function



Source: VDMA/ZVEI

Inputs for the oscilloscope function

During initialisation, the input functionality of the device-internal oscilloscope is used to provide information about which options are available for recording data from the electrical drive.

The device-internal measured values are read as a data package in a firmly defined or individually agreed format and are thus available for further processing. The function requires the measurement signals recorded in the device in the form of data including a time stamp.

The control oscilloscope input influences the function in real time. For example, the oscilloscope function can be parametrised, started, stopped, or configured for data output.

Parameters of the oscilloscope function

Users can set the behaviour of the oscilloscope function via various parameters.

The operating mode of the oscilloscope affects the way the information is provided:

- In "discrete" operating mode, the recorded data can be requested when the trigger has been initiated and the recording has ended successfully.
- In "continuous" operating mode, the selected data is transferred continuously.

Further parameters are used to specify the trigger condition as well as to select the measurement signals.

Optionally, the "manual entry" parameter can be used to extend the recording, for example to compare a fixed reference signal with the latest recording. The "manual" mode must be used for this (see below).

The language selection affects the plain text information such as help texts or the labelling of the measurement signals.

Threshold value and reference value of the oscilloscope function

The parametrising channel, the measured value recording or the output channel can be monitored as the threshold value for the status output.

The system time on the accessing side (user, control) can be transferred as a reference value. A real- time clock (RTC) should be used here to relate the oscilloscope recording to other signals of the plant. If the system time is specified, the time stamps supplied by the device can be related to it.

Mode and identification of the oscilloscope function

The mode signal is used to influence the internal processing in the function block. Possible values are:

- "activated": supplies the recorded data packets
- "deactivated": the I4.0 function oscilloscope does not supply any data (independently of possible recordings within the device itself)
- "manual": add a manual entry to the oscilloscope recording (see "manual entry" parameter above)
- "simulate": set up an oscillogram with artificially generated entries for test purposes
- "status generation off": perform the function without outputting a status or traffic light status
- "reset": delete current oscillogram and reset the I4.0 function

A unique ID of the device in which the function is running is exchanged for identification purposes. This should contain both class and instance information.

Current value preparation, status formation and block control of the oscilloscope function

The internal processing of the oscilloscope function consists of

- interpreting the device-internal recorded rated values
- preparing the data packets for standardised output
- adjusting the time stamp to the system time, if necessary

- providing context-sensitive information about the recording and
- forming and outputting the status and traffic light status

Outputs of the oscilloscope function

The result of the recording is output at the output as an oscillogram. This consists of data packets with a header, channel description and data points. The device-internal time stamp has been converted to the system time.
The function makes statements regarding the validity of the output by means of the status word:

- "valid": The oscilloscope recording was completed successfully and a valid recording is available at the output
- "invalid": No data packets can be received at this time, for instance because the oscilloscope is waiting for the trigger condition to occur
- "measurable": The oscilloscope is currently working on a measurement value recording (current oscilloscope status = "wait" or "running" or "finished")
- "defect/fault": The recording failed or could not be started

The traffic light status translates these accordingly:

- "green": Good (status "valid")
- "amber": Warning (status "invalid" or status "measurable")
- "red": Error (status "defect/fault/no condition report")

The returned time stamp specifies which time the oscillogram and status formation refer to.

According to the VDMA standard sheet, maintenance strategies can be specified for function blocks, if applicable and sensible. For the oscilloscope, these are the following application options:

- During commissioning: triggers for certain events or error patterns during commissioning; recording of "good samples" as a reference for later operation
- During operation: continuous measured-value recording during operation; detection of deviations from specified reference; automated detection of changes in repeated/cyclical processes; detection of unexpected events or their accumulation
- In the event of servicing: determination of fault causes: triggers on certain events or error patterns; look back to operation before fault

4.2 Further I4.0 functions

During the ongoing work by the ZVEI working group, alongside the subject of eCl@ss, further I4.0 functions for electrical drives are being developed and comprehensively standardised. The following brief summaries of initial specific examples provide an insight into how actively drive technology is connected to I4.0 and how this intersection will be implemented in the Drive 4.0:

Fault memory/warnings

During commissioning and operation, messages regarding events or operating conditions may be generated. These range from information (e.g. reference run events, switching, operating mode) to warnings (e.g. overload/current limit or position error) up to faults (e.g. limit switch reached or motor blocked). A standardised interface can help users access these messages in the higher level control or when using remote access.

Auto-tuning

A modern commissioning tool guides users quickly and easily through the individual steps of commissioning a PDS. The access to a motor database, an electronic nameplate or, in the future, even to the contents of the asset administration shell makes entering individual motor parameters unnecessary. By setting the parameters for the motor and corresponding electronics, the commissioning tool not only causes the motor to rotate, but also provides analysis, diagnosis and auto-tuning functions. With the aid of the auto-tuning function, it is possible for the PDS to set and/or optimise itself by reading in and analysing relevant target and actual values. The basis for this is a function block similar to that in the VDMA standard sheet. The actual value preparation, block control and status formation blocks are basic components. There is also the option to expand the function with application-specific settings, such as clockwise/anticlockwise running or drive must not rotate.

The results are available as status information and data set information and can be used via the I4.0 communication methods.

Energy management

In the process and manufacturing industry, alongside throughputs and reliable operation, the consumption of electrical power is playing an increasingly important role: it is necessary to retrieve energy data with regard to the costs being generated, but this information is also required, for instance, for load management in relation to the energy transition, for example in the form of 15-minute peak values of the power consumption.

Every converter/inverter that is assigned to a PDS has current sensors, which can be used to determine the active power delivered to the machine as well as the power extracted in the intermediate circuit. If the converter has a diode rectifier, the fundamental frequency reactive power and the distortion power absorbed on the mains side can also be estimated without the need for additional current sensors on the mains side. When using an active-infeed converter (rectifier/inverter with active semi-conductor switches, usually IGBT), the mains-side current sensors and the mains voltage measurement can also be used to determine the absorbed reactive and active power. In this way, performance data is provided that can be transferred to a higher-level control. These data can then be used to determine (or at least estimate) losses in the inverter and the motor, and thus the efficiency and heat output.

Maintenance log function

Maintenance and servicing expenses during the use phase have a significant impact on the life cycle costs (TCO) for an electrical drive system. The “maintenance log” function promotes economical operation and supports condition monitoring and predictive maintenance concepts. It provides meaningful and complete information regarding the maintenance status as well as the time and money spent on planned and unplanned maintenance activities. The prepared data creates transparency for optimisations and increased efficiency, while at the same time forming the basis for product observations and future investment decisions. During the usage phase of the PDS, the operator receives various data with maintenance, support and service information that is of interest to all participants in the value creation process. This data is stored chronologically in the asset administration shells of the I4.0 components, thus creating an intelligent and continuously updating logbook across the entire period of use.

5 Outlook

The members of the ZVEI ad-hoc working group of Industrie 4.0 for electrical drive systems are continuing to work on a comprehensive concept for Drive 4.0. The current tasks of the working group focus on standardising the properties, data and functions in the scope of the eCl@ss classification system. In addition, the group is discussing other possible models for providing cross-manufacturer information such as OPC-UA and HTTP.

The interest that other working and research groups have taken in the results so far demonstrate that this working group is among the forerunners in the field of I4.0 thanks to its pooling of knowledge and intensive work with the topic at a factual level. The Industrie 4.0 electrical drives ad-hoc working group will continue to provide support in this area and make the results of its work available to other interested parties. Initial results have been and will be presented in panel discussions at SPS/IPC/Drives and the Hannover Messe as well as in this information brochure. Shortly, a white paper on the subject of Drive 4.0 will follow, in which the current results and those obtained up to that point will be discussed in more detail.

In the next step, a prototypical implementation will be realised based on the detailed description of the operating principle and the interface to the cross-manufacturer functions. In collaboration with the Technical University of Darmstadt, the group intends to create a demonstrator that will use a standardised interface in the asset administration shells of drives from different manufacturers to access initial I4.0 functions and then implement these in the drives – thus making the vision of Drive 4.0 a reality.

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