NettedAutomation GmbH

Information & Communication Systems

General Information

IEC 61850 and IEC 61400-25

GLOBAL Standards for all Energy Systems

Generation, Transmission, Distribution, ... Smart Grids –
Design, Specification, Engineering, Configuration, Automation,
SCADA, Measuring, Condition Monitoring;
Information Modeling, Exchange and Management

Stack and API Integration
Embedded Controller, Software Support
Gateways (DNP3, Modbus, IEC 60870-104, ...)
Consultancy, Training

3,200+ Experts from 800+ Companies from 75+ Countries trained (2012-11)

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IEC 1906 AWARD

UCA International Users Group

USE61400-25
IEC 61400-25 user group

Dipl.-Ing. Karlheinz Schwarz, Karlsruhe/Germany
Editor of IEC 61850 and IEC 61400-25 (Wind Power Plants)
Member of IEC TC 57 WG 10, WG 17 (DER), WG 18 (Hydro Power Plants)
Member of IEC TC 88 PT 25 (IEC 61400-25, Wind Power Plants)
Convenor of IEC TC 88 IEC 61400-25-6 (Condition Monitoring)

You get comprehensive, first-hand, and neutral knowledge and experience

IEC 61850 & IEC 61400-25 SCC

Motivation: sustainable interoperability

The standards IEC 61850 „Communication networks and systems for power utility automation“ and IEC 61400-25 „Communications for monitoring and control of wind power plants“ provide support for **sustainable interoperability: Information Models, Information Exchange Methods, Protocol Mappings, and System Configuration Language (SCL)** for Power Systems (Generation, Transmission, and Distribution for HV, MV, and LV, ...).

Data Models

Logical Nodes (LN) represent real-world **Inputs, Outputs, Ratings, and Settings of functions** or **equipment**. A LN provides a list of named data objects (DO). The LN “XCBR” represents a real “circuit breaker” with the data object (DO) “Pos” (Position)**.** IEC 61850-7-2 defines **Information Exchange Methods**, e.g., for the position (with Client/Server services, GOOSE, SMV). **Data flow** is specified by a **SCL** file (IEC 61850-6).

IEC 61850-7-4xx

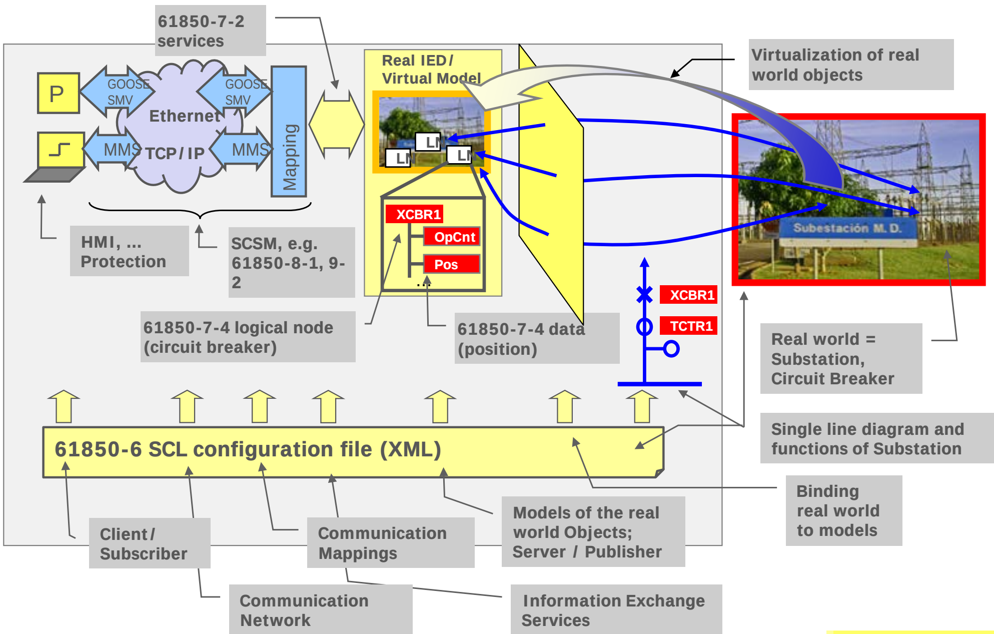
Substations (7-4)
160 LN
900 DO

Hydro Power (410)
63 LN
350 DO

Decentralized Energy Res. (420)
50 LN
450 DO

IEC 61400-25-2

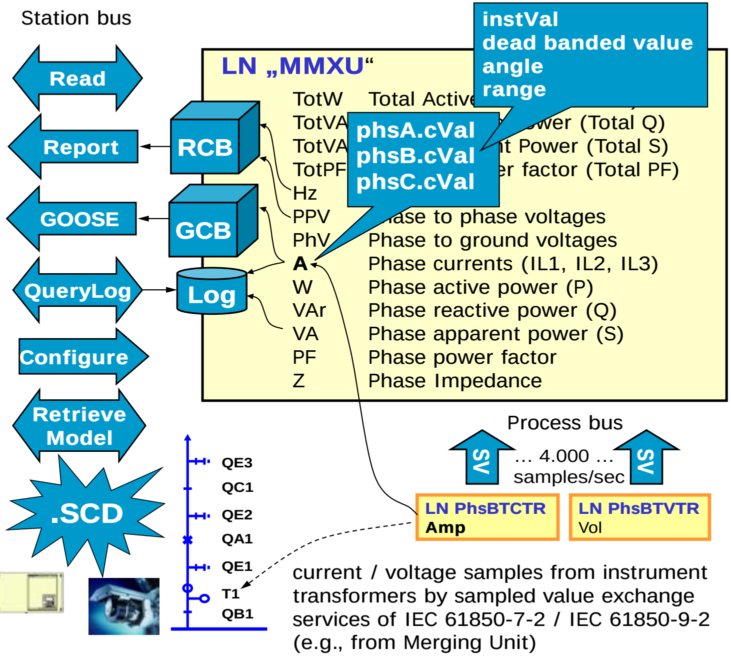
Wind Power
16 LN
250 DO



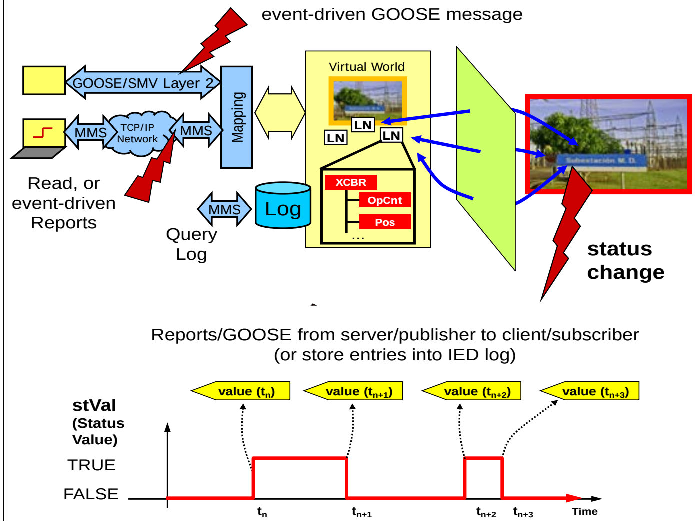
Example see reverse side

Example: Measurement LN “MMXU” represents power, voltages, currents, impedances, ... in a three-phase electrical system. The values can be communicated by various services. The LN “MMXU” comprises values for measurements, monitoring, configuration, settings, description, and substitution. These values can be communicated by various services like read (polling), reporting, GOOSE, logging and log query. Recording and logging are build upon monitored value changes. The SCL configuration file .SCD (System Configuration Description) specifies the single line diagram of the substation, the information model, the parameters of the control blocks for reporting and logging, GOOSE, SV, the binding to the process and the data flow.

LN and data objects



Information flow (example)



NettedAutomation GmbH

Information & Communication Systems

25+ Years of Excellence

International Standards for Power Systems

Generation, Transmission, Distribution, ..., Smart Grids; Design, Specification, Bidding, Engineering, Configuration, Automation, SCADA, Condition Monitoring, Information Management ...

We bring standards, smart people, intelligent devices, tools, and systems together to build Smarter Grids!

IEC 1906 AWARD

Supplier information, capabilities, and experience profile

Supplier information

Company	**NettedAutomation GmbH**
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Foundation	2000

Our knowledge and experience are asked all over – more and more!

3,000+ Experts from 750+ Companies from 75+ Countries trained (2012-08)

Ownership	Privately held by **Dipl.-Ing. Karlheinz Schwarz**	
Registered	Amtsgericht Karlsruhe HRB 8866	
General Manager	Ingeruth Schwarz	
Major Customers	Users:	AXPO, Bayernwerk, Badenwerk, Con Edison NYC, ENERGI E2, E.ON, Endessa, EdF, EdP, Energex, ETRANS, EVS, EWE, GdF, HEW, Manitoba Hydro, Hydro Quebec, Itaipu Binacional Hydro Power Plant Brazil, KEPCO, Mercedes Benz, PowerLink Australia, RWE, Stattkraft, TNB Malaysia, Terna, Transba, Transpower NZ, Vector, VEW, Vattenfall, ...
	Vendors:	AEG, Beck, Beckhoff, ABB, Alstom, AREVA, Bosch, BTC, Doble, E+H, IDS, Eberle, GE, Hirschmann, Kloeckner & Möller, LG, OMICRON, Pepperl & Fuchs, Phoenix Contact, PSI, Repas AEG, Schweitzer Engineering Labs, Siemens, TNB, VATECH SAT, SMA, VESTAS Wind, Voith Hydro, ...
	Consultants:	KEPRI, SKM, Teshmont, ...

More than 30 training sessions in 2011

Vendor independent, up-to-date, neutral, and experienced!

The primary service of NettedAutomation is to provide **consulting** services to all enterprises for feasibility studies, information modeling, system specification, implementation and use of devices and systems; **education and hands-on training** for users, system integrators and vendors in all aspects of Standards used for Power Systems; **support** for marketing, information dissemination, procurement for distributed systems, specifying procurement requirements; and **evaluation** of bidder proposals for devices, systems, tools, and open communications. The application domains cover generation, transmission, and distribution, Smart Grids, RTUs, SCADA and EMS systems, protection, automation and condition monitoring systems.

NettedAutomation has long-time experience in IEC 61850, IEC 61400-25, IEC 60870-5-10x, IEC 60870-6 TASE.2, IEC 62351, DNP3, IEC 61970 CIM, IEC 61968, IEC 61158, IEC 61499, IEEE 802.3, and ISO 9506 MMS to name just a few.

To keep abreast of the latest technical development, NettedAutomation is actively involved in workshops, seminars, hands-on training, task forces, and committees of various professional organizations such as ISO, IEC, IEEE, CEN, CENELEC, DKE, VDI, ZVEI, NIST SGIP, UCA IUG, and USE-IEC61400-25.

Curriculum vitae of Karlheinz Schwarz

Dipl.-Ing. **Karlheinz Schwarz** (58) received his diploma degree in Information and Automation Technology at the University of Siegen (Germany) in 1982. He is married and has four children and seven grandchildren.

As a manager with Siemens Automation & Drives (communication systems) he represented the positions of Siemens and the German national committee in the international standardization of MAP, MMS, MMS companion standards, Fieldbus, and other standardization projects from 1984 until 1997.

He is president of SCC (Schwarz Consulting Company), Karlsruhe (Germany) specializing in distributed automation systems. He is an independent consultant in the area of information modeling, systems and information integration, system and device engineering and configuration, open information exchange, and open communications since 1992. Mr. Schwarz has immense experience in the migration from proprietary or other solutions to standard compliant solutions.

He is involved in many standardization activities within IEC (TC 57, TC 65, and TC 88), ISO (TC 184), CENELEC (TC 65 CX), IEEE (SCC 36 "UCA", 802), and DIN since 1985. He is engaged in representing main industry branches in the global standardization and providing consulting services to users and vendors. Mr. Schwarz is a well-known authority in the application of mainstream information and communication technologies. He provides guidance in the migration from proprietary solutions to advanced seamless and standard-based solutions applicable in substations, and power generation units, and between these and with local, regional, and central SCADA systems. Specifically, his contributions to the publication of many standards are considered to be outstanding.

He has been awarded with the IEC 1906 Award in 2007 ***"For his strong involvement in the edition of the IEC 61850 series, its promotion inside and outside IEC, and specifically its adaptation for wind turbine plant control."***

http://www.nettedautomation.com/download/IEC1906-Award.pdf

Publications:

http://www.nettedautomation.com/marketing/scc_publications/index.html

NettedAutomation's Capabilities and Experience Profile

Learn firsthand what you need to know about these standards and products!

We assist companies in examining open communications and distributed systems technologies in substation automation, Smart Grids, and many other application areas outside the utility industry (for which IEC 61850 was originally designed). We support the design and implementation of IEDs compliant with IEC 61850 and other standards. Support for procurement requirements and evaluation of bidder proposals for IEC 61850 related devices, systems and tools can be provided. We have long term experience in implementing and organizing IEC 61850 and IEC 61850 based pilot projects.

Mr. Schwarz is the principal teacher and trainer of the seminars and training services offered and organized by NettedAutomation GmbH. We have given lectures all over

http://www.nettedautomation.com/seminars

We offers consulting services outlined above for a wide range of information and device modeling as well as standards-based configuration, communication systems and technical applications oriented to the automation of discrete and continuous automation related to:

- International Fieldbus standard, IEC 61158 (IEC TC 65)
- European Fieldbus, EN 50170 (CENELEC TC 65 CX)
- National Fieldbus standards like PROFIBUS, FIP, P-Net
- Actuator Sensor Interface (ASI) or IEEE 802 LAN/WAN
- Utility Comm. Architecture (UCA™), IEEE SCC 36
- Communication networks and systems for power utiliy automation, IEC 61850 (IEC TC 57)
- Telecontrol equipment and system, IEC 60870-5-10x
- Communications for monitoring & control of wind power plants, IEC 61400-25 (IEC TC 88) and IEC 61400-25-6 on Information models for condition monitoring systems (IEC TC 88)
- Communications Systems for Distributed Energy Resources (DER), IEC 62350 (IEC TC 57)
- Hydroelectric power plants – Communication for monitoring and control, IEC 62344 (IEC TC 57)
- Intercontrol Center Communications Protocol (ICCP), IEC 60870-6 TASE.2 (IEC TC 57)
- Common information models (CIM), IEC 61970 (IEC TC 57)
- Accreditation, Testing and Certification of IT products (DIN Test Lab Auditor), Quality Management
- Standard for the Exchange of Product Model Data (STEP)
- Application and Function block modeling IEC 61499 (IEC TC 65)
- Process Control Functionblocks and Device Description Language, IEC 61804 (IEC TC 65)
- Open Systems Application Frameworks, ISO 15745 (ISO TC 184 SC5)
- Manufacturing Automation Protocol (MAP), MiniMAP/FAIS
- Manufacturing Message Specification, MMS, ISO 9506 (ISO TC 184)

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Appendix: Personal education and qualifications of Karlheinz Schwarz

1. Education

1958 – 1962 Elementary School

1962 – 1965 Secondary School

1965 – 1967 Secondary School (Gymnasium)

1967 – 1969 Technical School

1969 – 1972 Apprenticeship as electrical mechanic and electronics (Siemens)

1973 – 1974 Service technician responsible for alarm systems (Siemens: fire alarm systems, burglar alarm systems, ...)

1975 – 1977 Academic high school (Hessenkolleg)

1977 – 1982 Study of electrical engineering and IT at University Siegen (degree: Dipl.-Ing.)

1981 – 1997 Employee at Siemens Automation (responsible for standardization of comms)

1992 – present Consultant and trainer for communication and automation (see above and below)

2. Training experience since 2002

Mr. Schwarz has trained almost 3,000 experts all over. Most seminars have been conducted as in-house courses. Attendees from more than 700 companies have attended. Attendees from small, medium and big utilities and big vendors have attended. An excerpt is shown in the following table:

Year	Training in Countries	Courses	Attendees
2002	China	2	30
2003	Denmark, Spain	2	22
2004	Spain, Germany, France, USA, China, South Africa, Malaysia	8	199
2005	South Korea, Mexico, Denmark, Canada, Switzerland, Germany, South Africa, Australia, Israel	12	299
2006	Germany, Italy, Spain, India, Canada, UK, Portugal, France, Austria, USA	18	545
2007	Russia, Germany, Portugal, USA, France, Canada, South Korea, Australia, New Zealand	11	252
2008	Germany, Slovenia, Canada, USA, France, Malaysia, South Korea, Australia, New Zealand, Sweden	20	379
2009	Mexico, Russia, Italy, Germany, Malaysia, USA, Australia	15	220
2010	Iceland, Spain, Ireland, Argentina, Brazil, Germany, Japan, Denmark, USA, Philippines, Sweden, Australia, France	20	276
2011	France, UK, Germany, Australia, South Korea, Switzerland, Zimbabwe, Canada, Belgium, USA, China, Austria, Brazil	33	542
2012 (Sept)	Germany, India, Belgium, Israel, Italy, Sweden, USA, South Korea, China, Taiwan	18	262
		159	***3.026***

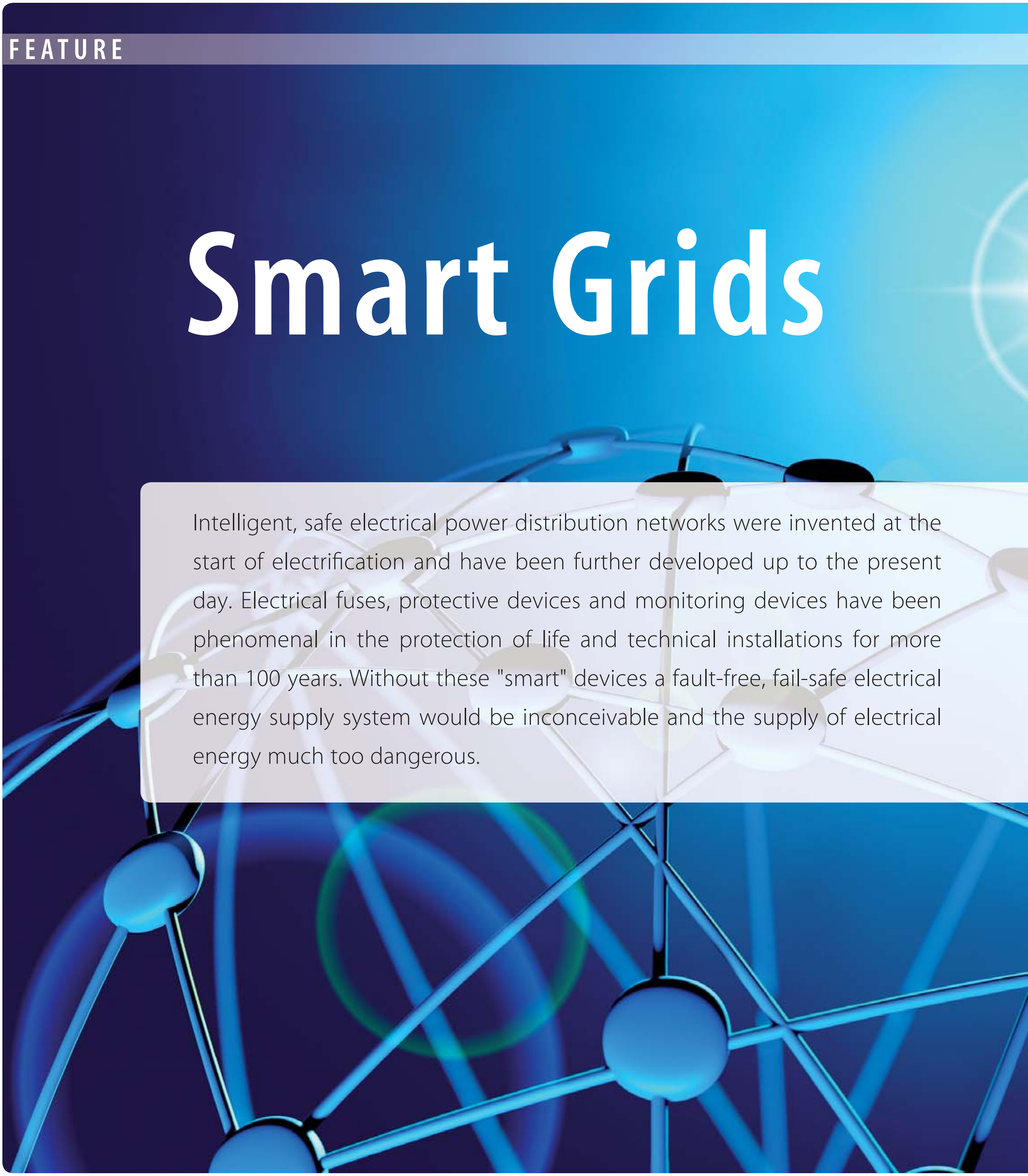
3. Standardization experience

Mr. Schwarz is (was) a principal contributor in the following standardization projects (either project member or as the technical lead), representing many German industries (users and vendors):

ISO	ISO TC 184/SC5	Architecture, Communications, Integration Frameworks	Member	1985-2012
	ISO TC 184/SC5/WG 5	Open Systems Application Frameworks	Member	1985-2005
	ISO TC 184/SC5/WG 2	Communications and interconnection (MMS, ...)	Mem-ber/Chairman	1985-2005/1998-2005
IEC	IEC TC 57	Power Systems Control and Associated Communications	Member	1992-2012
	IEC TC 57 SPAG	Strategic Policy Advisory Group	Invited Guest	
	IEC TC 57 WG 07	Protocols compatible with ISO/OSI and ITU	Member	1992-2000
	IEC TC 57 WG 10	Power system IED communication and associated data models / Communication and systems within Substations (IEC 61850)	Member/editor of 61850	1995-2012
	IEC TC 57 WG 17	Communications Systems for Distributed Energy Resources (DER) – based on IEC 61850	Member	2004-2012
	IEC TC 57 WG 18	Hydroelectric power plants – Communication for monitoring and control – based on IEC 61850	Member	2004-2012
	IEC TC 57 WG 19	Interoperability within TC 57 in the long term	Member	2005-2012
	IEC TC 65 WG 6	Functionblocks (IEC 61499)	Member	1990-2002
	IEC TC 65 PJWG	Device Profiles	Member	1998-2002
	IEC TC 65C WG 1	Message data format for information transferred on process and control data highways, Profiles	Member	1983-2006
	IEC TC 65C WG 6	Fieldbus (IEC 61158)	Member	1997-2000
	IEC TC 65C WG 7	Functionblocks and Data Descriptive Language (IEC 61804)	Member	1996-1999
	IEC TC 88 PT 25	Communications for monitoring and control of wind power plants (IEC 61400-25-1/-2/-3/-4/-5) – based on IEC 61850	Member/editor of 61400-25	2001-2012
	IEC TC 88 PT 25 / IEC 61400-6	Communications for monitoring and control of wind power plants (IEC 61400-25-6) – Logical node classes and data clas-ses for condition monitoring	Convenor	2006-2011
IEEE	IEEE 802.3 /.15	LAN, WAN	Member	1998-2001
	IEEE SCC 36	Utility Communication Architecture	Member	1996-2000
CENELEC	CENELEC TC 65 CX	Fieldbus Communication	Member	1992-2000
CEN	CEN TC 310/TG ICOM	Task Group on industrial communications	Member	1994-1996
MMS Forum	EPRI, Electric Power Research Institute	Communications and application modelling in the area of power utilities (UCA, ICCP)	Member	1992-1998
NAM	DKE/NAM/NI 96.5	Architektur und Kommunikation	Member	1985-1998
	DKE/NAM/NI GA 96.5.2	Kommunikation und Datenaustausch (MMS, ...)	Chairman	1985-2002
DKE	DKE FB 9 AK AP	FB 9 Arbeitskreis Arbeitsplanung	Member	1989-2003
	KG-ILT	Koordinierungsgruppe Industrielle Leittechnik	Member	1989-2003
	K 261	Mirror of IEC TC 8: System aspects of electrical energy supply	Member	2003-2008
	DKE K 950	Kommunikation und Informationslogistik	Member	1998-2001
	DKE AK 956.0.2	Kommunikationsdienste, Process Control	Member	1992-1997
	DKE K 956	Feldbus	Member	1986-2012
	DKE AK 956.3.1	Functionblocks and Data Descriptive Language	Chairman	1995-206
	DKE K 952	Netzleittechnik	Vice Chair-man/member	1992-2012
	DKE AK 952.0.7	Protocols compatible with ISO/OSI and ITU	Member	1992-2005
	DKE AK 952.0.10	Stationsleittechnik	Member	1995-2012
	DKE AK 952.0.17	Kommunikation für verteilte Energieversorgung (TC 57 WG 17)	Member	2005-2012
	DKE K 383.0.1	Kommunikation für Windenergieanlagen	Chairman	2001-2012
GMA	GMA AK 4.2	Kommunikation in verteilten Systemen	Member	1996-1998
VDMA	Fachverband InCom	Industrial Communications	Member	1990-1996
ZVEI	ZVEI GA IK	Gemeinschaftsausschuss Industrielle Kommunikation	Member	1986-2012

FEATURE

Smart Grids



Intelligent, safe electrical power distribution networks were invented at the start of electrification and have been further developed up to the present day. Electrical fuses, protective devices and monitoring devices have been phenomenal in the protection of life and technical installations for more than 100 years. Without these "smart" devices a fault-free, fail-safe electrical energy supply system would be inconceivable and the supply of electrical energy much too dangerous.

RELIABLE ENERGY DELIVERY

– A 19th century invention

Since the 19th century engineers have developed, tested, used on a large-scale and continuously improved suitable solutions for the safe and reliable operation of the rapidly growing supply of ever more applications with electrical energy. During the sustained further development of the supply systems, it is necessary to handle the available resources (energy sources, technical installations and individuals with experience) as well as the laws of physics both responsibly and in a "smart" manner.

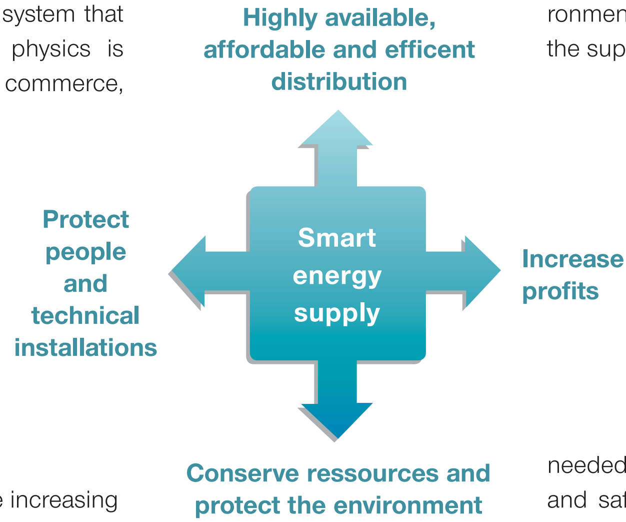
Smart grids help to make it possible to use physics safely and reliably for the benefit of man – in the past, today and in the future

Smart energy supply

The system for the supply of electrical energy has been in construction for more than 130 years. Along with the high-availability provision of electrical energy, the protection of lives and technical installations has had a significant impact on the development of the supply system. Special concepts, processes and devices were "smart" from the start – the intelligent, selective shut down of a faulty electrical circuit or an intelligently planned redundant system topology result in minimal interruption in supply in the event of a malfunction.

> **ENERGY COMMUNICATION AT THE FORUM "LIFE NEEDS POWER" AT THE HANNOVER MESSE**
>
> **Electrical distribution network operator:**
> "We cannot change Ohm's or Kirchhoff's laws."
>
> **Lawyer:**
> "Objection! Every law can be changed.
> Even the constitution with a 2/3 majority."

Such a smart energy supply system that strictly follows the laws of physics is increasing viewed by politics, commerce, science and the public in relation to the conservation of natural resources and the protection of the environment, as well as in relation to the aim of generating profits. Smart grids are viewed as an effective instrument to achieve these goals.



The energy revolution and the increasing interest in renewable energy sources and storage options (for instance pumped storage, gas or heat storage systems) are increasingly frequently viewed in conjunction with new technological capabilities for the quick and safe exchange of information – a core topic of smart grids.

The term "smart grid" as an intelligent energy supply system involves, according to the DKE and IEC smart grid road maps, "the networking, monitoring, control and regulation of intelligent energy producers, storage systems, power consumers and network equipment in energy transmission and distribution networks with the aid of information and communication technology (ICT). The objective is, based on transparent energy-efficient, cost-efficient, safe and reliable system operation, to achieve the sustainable and environmentally acceptable assurance of the supply of energy."

These days a differentiation is made between **smart markets** (in which the market participants who offer or require energy organise themselves) and **smart grids** (the technical installations and processes to be further developed that are needed for high availability, efficient and safe supply based on the laws of physics). Even though both are closely linked, they do provide some orientation in the maze of discussions.

Smart markets with the high volatility of renewable energy sources place comprehensive requirements on smart grids; meeting these requirements requires above all that the solutions are in harmony with the laws of physics for the electrical system. Controlling the volatility of the availability of water and sunlight in the supply of foodstuffs by means of storage, transport and distribution can be taken as an example for the smart supply of energy of the future. The volatile availability of solar and wind energy could contribute to a secure, high-availability, efficient supply by means of increasing storage.

How secure is our supply of energy?

The current raw materials for energy (gas, oil, coal, uranium, ...) and also the volatile sources of energy such as the sun, water and wind are only secure to a limited extent. This uncertainty preoccupies above all the future smart market – it is of lesser importance during the consideration of smart grids.

Smart measures to make the supply of electrical energy secure (in the context of high availability) have been developed and continuously improved since the 1880s. During network planning for the higher voltage networks, the so-called (n-1) and (n-2) criteria have been used for some time – these criteria state that in the event of one (or two) failures due to malfunctions in any item of equipment (generator, transformer, cable, ...) the network as a whole must safeguard the supply within the stipulated limits. Higher costs for their implementation are justified because, for instance, interruptions in the supply to large areas can be prevented by redundant cable routing or power stations.

The European transmission systems are coupled together into an integrated European network and some are also integrated into a grid control network so that, on the failure of a component in a system, or in case of an imbalance in the generation and consumption of power in a sub-system, help can be obtained from a neighbouring system. These transmission systems can quite rightly be termed high-voltage smart grids.

In distribution networks (medium voltage, low voltage) on the other hand the risk of an interruption in the supply for minutes or hours is accepted in the majority of cases. Here the distribution network is often not constructed based on the (n-1) criterion. Accordingly few or even no technical features are provided that could automatically compensate for the failure of a component or an imbalance between generation and consumption.

In the area of energy supply systems a large number of system-related limits and parameters (trigger current for circuit breakers, frequency, voltage, insulation on a cable, ...), secondary devices (measuring systems, controllers, regulators, ...) and primary devices (transformers, circuit breakers, inverters, ...) as well as in future many components at the integration levels (above all the communication infrastructure such as Ethernet switches, routers, backup power supplies) must be constantly monitored, and that mostly in real-time. In the case of developing malfunctions it may be necessary to intervene with control measures within milliseconds. If action is not taken until a component fails, then an entire system may easily collapse with unpredictable consequences for people and the environment if a fail-safe supply is imperative.

Since the start of electrification, particularly high value has been placed on the protection of individuals against physical contact with the electrical system. Worldwide it is state-of-the-art to protect people against the hazards of electrical power. A series of IEC standards and other standards define suitable measures that have made possible a high safety standard.

In relation to electromagnetic compatibility (EMC), electronic devices in the area of the supply of electrical energy must meet particularly high requirements that go way beyond the requirements in the office or industrial environment. The "IEC Smart Grid Standardization Roadmap" from 2010 clearly refers to these requirements. In the second version of the familiar American "NIST Framework and Roadmap for Smart Grid Interoperability Standards" (2012) these requirement were recently placed alongside the requirements for communication security. The availability of an automation or communication component must be much higher in an energy supply system than in the office or residential sector.

Furthermore physically extensive integration levels require high security in relation to the availability and vulnerability of the infrastructure and the supply systems, in the past the topic of security has been largely ignored during the implementation. In the future energy supply, this topic must be taken significantly more into account in the implementation and the solutions must be much more rigorously applied.

Smart solutions for a secure energy supply are required for generation, transport, distribution and the power consumers – in public distribution networks just as in public buildings and offices, as well as in other items of infrastructure such as transport systems or the Internet.

What will be new in the future?

The reliable and secure operation of the future electrical supply system places new challenges on engineers, businessmen and politicians, and has done so particularly since the turn of the century. Necessary changes are to be expected due to:

→ The rapidly growing number decentral feed points, the transition from central to more decentral electricity generation,

→ The development of renewable energy generation,

→ The development of the integration level and

→ The ageing distribution network infrastructure.

These changes must be made "open heart" (that is while providing supply) against the background of the following issues:

→ An increasingly ageing and therefore reducing technical expertise,

→ The demand for more energy efficiency,

→ The short time for implementation and

→ The high expectations on profitable investments in increasingly networked supply systems for electrical energy, gas, heat and transport.

The broad and intense discussion to be observed in recent times and the publication of comprehensive studies and opinions from politics, research institutes, associations, federations and industry is unprecedented in the construction of the electrical supply system. What is so interesting about the supply of electrical energy in the future? For many manufacturers who traditionally operate in the area of industrial automation, or in the area of network technology, the Internet or cloud computing, the increasingly necessary equipment for the integration infrastructure in distribution networks appears to be a massive new market.

Can Internet technologies and general automation solutions help?

„**Energy-on-demand** is considered by many to be solution for the efficient usage of energy."

Internet for energy

The BDI (Bundesverband der Deutschen Industrie e.V.) stated the following on the topic of the smart grid: "Information and communication technology will have a key role during the development of a supply of energy suitable for the future. It is the basis for the realisation of a future **energy internet**, that is the intelligent electronic networking **of all components in the energy system.** ... The biggest challenge here is to create an **integration level between business applications and the physical network** that makes possible the communication between complex IT components distributed across heterogeneous networks and organisational boundaries."

Is such an integration level primarily of service to the smart market or the smart grid at the distribution level, or both? The components installed today at the higher voltage levels are already effectively networked (CIM for grid control centre internal communication, telecontrol for communication with grid control centres and power generation systems as well as IEC 61850 for substations and power generation systems). With the need to integrate thousands of times more components in the lower voltage levels than in the higher voltage levels, it is still largely unclear which tasks they will have and how these can help also in the long-term to maintain the stability of the supply of electrical power at its current level.

Energy-on-demand is considered by many to be solution for the efficient usage of energy. In the context of social networks power consumers could suddenly develop volatile consumption behaviour and synchronously increase or reduce their consumption either in a limited area or over a large area, an event that could have unexpected effects on the systems and in some cases could result in the collapse of the system.

A key question for the realisation of future systems is knowledge of possible and probable failure scenarios. How many feed points

„**Development** must bee understood as continous "further" development of the existing systems with all their complex aspects."

and loads in the distribution networks can be controlled at which points using communication, and which regulation mechanisms could compensate for these effects adequately and quickly enough such that the distribution networks can be operated stably at all levels at all times?

Even under the assumption that all effects are known and corresponding mechanisms for stable system operation have been developed and tested, key questions remain unanswered: who is to finance this automation infrastructure and the related Internet-based integration levels foreseen and, above all, who is to implement, install, integrate, utilise and further develop it? ■

Dipl.-Ing Karlheinz Schwarz
NettedAutomation GmbH

CONCLUSION

The construction of automation infrastructures and integration levels for the supply of energy requires resources that go way beyond current notions and the resources that are available in the short-term. Financial aid for smart energy supply systems must not be primarily an "economic stimulus package" for the integration levels. The aspects such as the electrical safety, the high availability of the supply of energy, the ageing electrical and information technology infrastructure and above all the ageing personnel for the further development and operation of the electrical system must have a significantly higher priority.

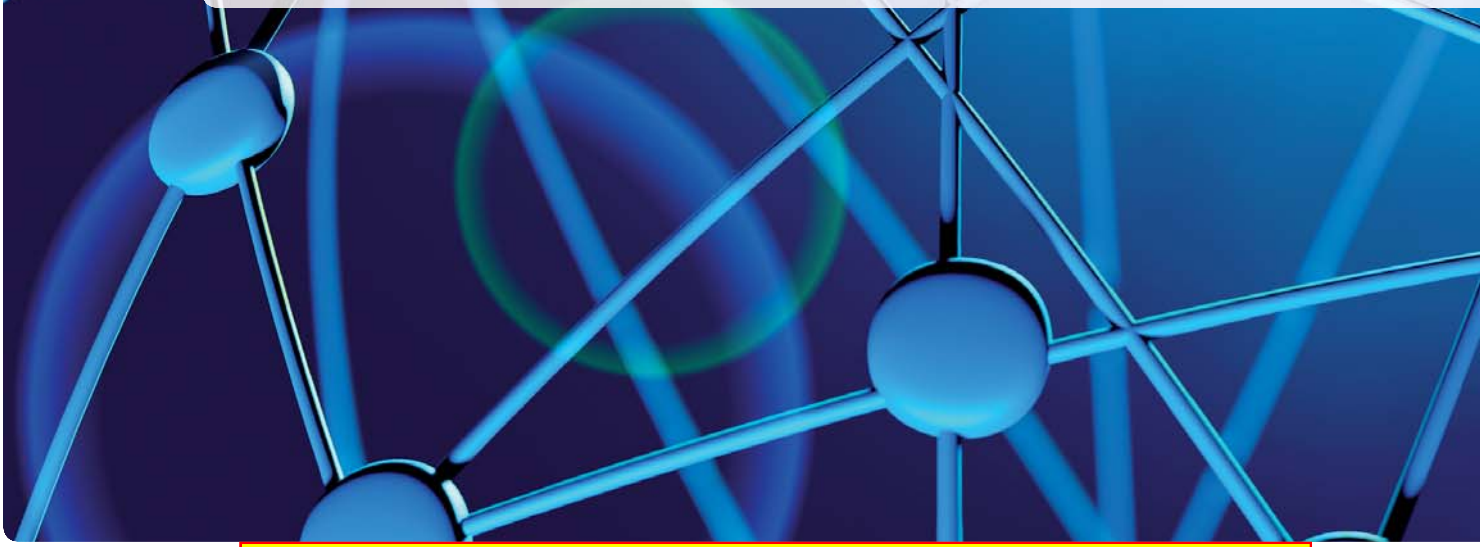
The future supply of energy must be understood as a whole. Development must be understood as continuous "further" development of the existing systems with all their complex aspects. Only then can the familiar security of supply of the past also be ensured in the future. The scope and also the required short implementation period will overshadow all the experience of the past 130 years.

The energy revolution currently in planning and the concomitant development of a step-by-step structural change and a closer meshing of the energy networks for electricity, gas, heat and electric mobility, as well as the related necessary infrastructure will be more of a marathon than a sprint. Inter-disciplinary collaboration above all among the electrical engineers and power engineers must be significantly expanded. IEC standards and other standards can, above all against the background of limited development resources, make an important contribution to the simplification of solutions at the integration levels.

The smart grids that will result from the energy revolution will combine the inventions of several hundred years.

Smart Grids

Intelligente und sichere elektrische Energieversorgungsnetze wurden bereits zu Beginn der Elektrifizierung erfunden und bis heute weiterentwickelt. Elektrische Sicherungen, Schutz- und Überwachungseinrichtungen sind seit über 100 Jahren phänomenale Geräte zum Schutz von Leben und technischen Einrichtungen. Ohne diese „smarten" Geräte wäre ein fehlerfreies und ausfallsicheres elektrisches Energieversorgungssystem undenkbar und die Versorgung mit elektrischer Energie viel zu gefährlich.



SICHERE – ENERGIE – VERSORGUNG

– Eine Erfindung des 19. Jahrhunderts

Ingenieure haben seit dem 19. Jahrhundert für die schnell wachsende Versorgung von immer mehr Anwendungen mit elektrischer Energie, geeignete Lösungen für den sicheren und zuverlässigen Betrieb entwickelt, erprobt, großtechnisch eingesetzt und permanent verbessert. Im Rahmen der nachhaltigen Weiterentwicklung der Versorgungssysteme muss mit den verfügbaren Ressourcen (Energiequellen, technischen Einrichtungen und Menschen mit Erfahrung) sowie die physikalischen Gesetzmäßigkeiten verantwortungsvoll und „smart" umgegangen werden.

Smart Grids helfen, die Physik zum Wohl der Menschen sicher und zuverlässig nutzbar zu machen – gestern, heute und morgen.

Ein System – viele Ziele

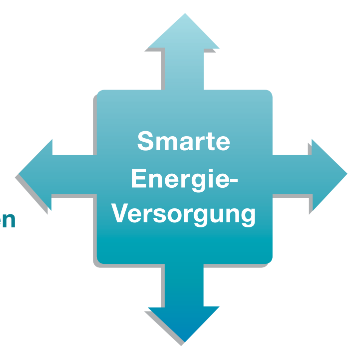
Das System der elektrischen Energieversorgung befindet sich seit mehr als 130 Jahren im Aufbau. Neben der hochverfügbaren Bereitstellung elektrischer Energie hat der Schutz von Leben und technischen Einrichtungen den Ausbau des Versorgungssystems maßgeblich geprägt. Spezielle Konzepte, Verfahren und Geräte waren von Anfang an „smart“ – eine intelligente, selektive Abschaltung eines defekten Stromkreises oder eine intelligent geplante redundante Netz-Topologie führen im Störungsfall zu einer minimalen Versorgungsunterbrechung.

ENERGIEKOMMUNIKATION AUF DEM FORUM „LIFE NEEDS POWER” DER HANNOVER MESSE

Stromnetzbetreiber:
„Wir können die Gesetze von Ohm und Kirchhoff nicht ändern.”

Jurist:
„Einspruch! Jedes Gesetz kann man ändern.
Mit 2/3 Mehrheit sogar das Grundgesetz.”

Ein solch smartes Energieversorgungssystem, das streng physikalischen Gesetzmäßigkeiten folgt, wird in der Politik, Wirtschaft, Wissenschaft und der Öffentlichkeit zunehmend im Zusammenhang mit dem Schonen von in der Erde vorkommenden Ressourcen und der Umwelt sowie dem Streben nach Gewinnsteigerung betrachtet. Smart Grids werden als probate Mittel zum Erreichen dieser Ziele betrachtet.



Die Energiewende und das zunehmende Interesse an erneuerbaren Energiequellen und Speichermöglichkeiten (wie beispielsweise Pumpspeicher, Gas- oder Wärmespeicher) werden immer öfter im Zusammenhang mit neuen technologischen Möglichkeiten des schnellen und sicheren Austauschs von Informationen gesehen – einem Kernthema von Smart Grids.

Der Begriff „Smart Grid“ als intelligentes Energieversorgungssystem umfasst nach den DKE- und IEC-Smart-Grid-Roadmaps „die Vernetzung, Überwachung, Steuerung und Regelung von intelligenten Erzeugern, Speichern, Verbrauchern und Netzbetriebsmitteln in Energieübertragungs- und Verteilungsnetzen mit Hilfe von Informations- und Kommunikationstechnik (IKT). Ziel ist es, auf Basis eines transparenten energie- und kosteneffizienten sowie sicheren und zuverlässigen Systembetriebs, die nachhaltige und umweltverträgliche Sicherstellung der Energieversorgung zu erhalten.“

Neuerdings wird in **Smart Markets** (in denen sich die Marktteilnehmer, die Energie anbieten oder nachfragen, organisieren) und **Smart Grids** (die weiter zu entwickelnden technischen Einrichtungen und Verfahren, die für die hochverfügbare, effiziente und sichere Versorgung auf der Basis der physikalischen Gesetzmäßigkeiten benötigt werden) unterschieden. Obwohl beide eng miteinander verbunden sind, sorgen sie für etwas Orientierung im Dschungel der Diskussionen.

Smart Markets mit der hohen Volatilität der erneuerbaren Energiequellen stellen umfangreiche Anforderungen an Smart Grids; sie zu erfüllen, erfordert vor allem, dass die Lösungen mit den physikalischen Gesetzen des elektrischen Netzes in Einklang stehen. Die Beherrschung der Volatilität des Wasser- und Sonnenangebots in der Versorgung

mit Nahrungsmitteln durch Speicherung, Transport und Verteilung kann als Lehrbeispiel für die smarte Energieversorgung der Zukunft dienen. Die volatilen Angebote an Sonnen- und Windenergie könnten durch zunehmende Speicherung zur sicheren, hochverfügbaren und effizienten Versorgung beitragen.

Wie sicher ist unsere Energieversorgung?

Die derzeitigen Energie-Rohstoffe (Gas, Öl, Kohle, Uran, ...) und auch die volatilen Energiequellen wie Sonne, Wasser und Wind sind nur bedingt sicher. Diese Unsicherheit beschäftigt vor allem den zukünftigen Smart Market – bei der Betrachtung von Smart Grids ist sie von untergeordneter Bedeutung.

Smarte Maßnahmen, um die elektrische Energieversorgung sicher (im Sinne von hochverfügbar) zu gestalten, wurden seit den 1880er Jahren entwickelt und permanent verbessert. Bei der Netzplanung für die oberen Spannungsebenen werden schon lange die sogenannten (n-1)- und (n-2)-Kriterium angewendet – sie besagen, dass bei einem (oder zwei) störungsbedingten Ausfällen eines beliebigen Betriebsmittels (Generator, Transformator, Leitung, ...) das Netz in seiner Gesamtheit die Versorgung innerhalb der vorgegebenen Grenzen sichern muss. Höhere Kosten für deren Implementierung sind gerechtfertigt, weil beispielsweise durch redundante Leitungswege oder Kraftwerke Versorgungsunterbrechungen großer Gebiete vermieden werden können.

Die europäischen Übertragungsnetze sind in einem europäischen Verbundnetz und einige auch in einem Netzregelverbund miteinander gekoppelt, um beim Ausfall einer Komponente in einem Netz oder bei Ungleichgewicht von Stromerzeugung und -abnahme in einem Teilnetz Hilfe aus einem benachbarten Netz in Anspruch nehmen zu können. Diese Transportnetze können zu Recht als Hochspannungs-Smart-Grids bezeichnet werden.

In Verteilungsnetzen (Mittelspannung, Niederspannung) wird meist das Risiko einer Versorgungsunterbrechung im Minuten- bis Stundenbereich in Kauf genommen. Hier wird oft auf einen Netzausbau nach dem (n-1)-Kriterium verzichtet. Entsprechend sind wenige bis gar keine technischen Einrichtungen vorgesehen, die einen Ausfall einer Komponente oder die gestörte Balance zwischen Erzeugung und Abnahme selbstständig kompensieren könnte.

Im Bereich der Energieversorgungssysteme müssen viele systemrelevante Grenzen und Parameter (Auslösestrom für Leistungsschalter, Frequenz, Spannung, Isolation einer Leitung, ...), Sekundär-Geräte (Messsysteme, Steuerungen, Regelungen, ...) und Primär-Geräte

(Transformatoren, Leistungsschalter, Wechselrichter, ...) sowie in Zukunft viele Komponenten der Integrationsebenen (vor allem der Kommunikations-Infrastruktur wie Ethernet-Switches, Router, Stromversorgungen) ständig und meistens in Echtzeit überwacht werden. Bei sich anbahnenden Störungen muss gegebenenfalls innerhalb von Millisekunden regelnd eingegriffen werden. Wird gewartet bis eine Komponente versagt, dann kann ein ganzes System leicht kollabieren mit unabsehbaren Folgen für Menschen und Umwelt, wenn eine ausfallsichere Versorgung unablässig ist.

Von Anfang der Elektrifizierung an wurde auch ein besonders hoher Wert auf den Schutz des Menschen vor Berührung des elektrischen Netzes gelegt. Weltweit ist es Stand der Technik, den Menschen vor den Gefahren der elektrischen Spannung zu schützen. Eine Reihe von IEC- und anderen Normen definiert geeignete Maßnahmen, die einen hohen Sicherheitsstandard ermöglicht haben.

Elektronische Geräte im Bereich der elektrischen Energieversorgung müssen auch besonders hohe Anforderungen bezüglich der elektromagnetischen Verträglichkeit (EMV) erfüllen, die weit über die Anforderungen aus dem Büro- oder Industrieumfeld hinausgehen. Die „IEC Smart Grid Standardization Roadmap“ von 2010 weist deutlich auf diese Anforderungen hin. In der zweiten Ausgabe der bekannten amerikanischen „NIST Framework and Roadmap for Smart Grid Interoperability Standards“ (2012) werden diese Anforderungen neuerdings neben die Anforderungen der Kommunikations-Sicherheit (Security) gestellt. Die Verfügbarkeit einer Automatisierungs- oder Kommunikationskomponente, muss in einem Energieversorgungssystem viel höher sein, als im Büro- oder Heimbereich.

Darüber hinaus erfordern ausgedehnte Integrationsebenen eine hohe Sicherheit im Sinne von Verfügbarkeit und Verwundbarkeit der Infrastruktur und der Versorgungssysteme, bisher hat das Thema Security praktisch wenig Beachtung bei der Implementierung erfahren. In der zukünftigen Energieversorgung muss das Thema deutlich mehr Eingang in die Implementierungen finden und die Lösungen müssen viel konsequenter angewendet werden.

Smarte Lösungen für eine sichere Energieversorgung werden für die Erzeugung, den Transport, die Verteilung und die Verbraucher benötigt – in öffentlichen Netzen genauso wie in öffentlichen Gebäuden und Betrieben sowie in anderen Infrastrukturen wie Verkehrssysteme oder das Internet.

Was ist in Zukunft neu?

Das zuverlässige und sichere Betreiben des zukünftigen elektrischen Versorgungssystems stellt insbesondere seit der letzten Jahrhundertwende Techniker, Kaufleute und Politiker vor neue Herausforderungen. Notwendige Veränderungen sind zu erwarten wegen:

- der schnell wachsenden Anzahl von dezentralen Einspeisungen, dem Übergang von einer zentralen zu einer mehr dezentralen Stromerzeugung,
- des Ausbaus der erneuerbaren Energieerzeugung,
- des Aufbaus einer Integrationsebene und
- der alternden Netz-Infrastrukturen.

Diese Veränderungen müssen am „offenen Herz“ (das heißt im laufenden Versorgungs-Betrieb) vor dem Hintergrund folgender Tatsachen vorgenommen werden:

- einer zunehmend alternden sowie reduzierten technischen Expertise,
- der Forderung nach mehr Energieeffizienz,
- der kurzen Zeit zur Umsetzung und
- der hohen Erwartungen an rentable Investitionen in zunehmend vernetzten Versorgungssystemen für elektrische Energie, Gas, Wärme und Verkehr.

Die seit einiger Zeit zu beobachtenden breiten und heftigen Diskussionen sowie die Veröffentlichung umfangreicher Studien und Stellungnahmen aus der Politik, Forschungseinrichtungen, Verbänden, Vereinen und

„**Energy-on-Demand** wird von vielen als Lösung für den effizienten Umgang mit Energie betrachtet."

aus der Industrie hat es zu keiner Zeit beim Aufbau des elektrischen Versorgungssystems gegeben. Was ist so interessant an der elektrischen Energieversorgung der Zukunft? Für viele traditionell im Bereich der industriellen Automatisierung oder im Bereich der Netzwerktechnologie, dem Internet oder dem Cloud-Computing operierenden Hersteller scheint die zunehmend notwendige Ausrüstung in den Integrations-Infrastrukturen in Verteilungsnetzen ein riesiger neuer Markt zu sein.

Können hier die Internet-Technologien und allgemeine Automatisierungslösungen helfen?

Internet der Energie

Der BDI (Bundesverband der Deutschen Industrie e.V.) führt zum Thema Smart Grid aus: „Der Informations- und Kommunikationstechnologie kommt bei der Entwicklung einer zukunftsfähigen Energieversorgung eine Schlüsselrolle zu. Sie ist die Basis für die Realisierung eines zukünftigen **Internets der Energie**, das heißt der intelligenten elektronischen Vernetzung aller **Komponenten des Energiesystems**. Die größte Herausforderung besteht indes darin, eine **Integrationsebene zwischen betriebswirtschaftlichen Anwendungen und dem physikalischen Netz** zu schaffen, welche eine Kommunikation komplexer, über heterogene Netze und Firmengrenzen hinweg verteilter IT-Komponenten ermöglicht."

Dient eine solche Integrationsebene vornehmlich dem Smart Market oder dem Smart Grid auf Verteilungsebene oder beiden? Die heute installierten Komponenten in den oberen Spannungsebenen sind bereits gut vernetzt (CIM für die netzleitstelleninterne Kommunikation, Fernwirktechnik für Kommunikation mit Netzleitstellen und Erzeugungsanlagen sowie IEC 61850 für Schaltanlagen und Erzeugungsanlagen). Bei der Notwendigkeit der Integration von tausendmal mehr Komponenten in den unteren als in den oberen Spannungsebenen ist noch weitgehend unklar, welche Aufgaben sie haben werden und wie diese helfen können, auch langfristig die Stabilität der Stromversorgung auf dem heutigen Niveau zu halten.

Energy-on-Demand wird von vielen als Lösung für den effizienten Umgang mit Energie betrachtet. Im Rahmen von sozialen Netzwerken könnten Verbraucher plötzlich volatiles Verbrauchsverhalten entwickeln und

„**Entwicklungen** müssen als kontinuierliche „Weiter"-Entwicklungen der vorhandenen Systeme mit all ihren komplizierten Aspekten verstanden werden."

begrenzt oder großflächig ihren Verbrauch synchron ein- oder abschalten, was zu unerwarteten Rückwirkungen auf die Netze und unter Umständen zu Netzzusammenbrüchen führen könnte.

Eine wesentliche Frage bei der Realisierung zukünftiger Netze ist die Kenntnis von möglichen und wahrscheinlichen Ausfallszenarien. Wie viele Einspeisungen und Lasten an welchen Stellen im Netz können kommunikativ gesteuert werden und welche Regelmechanismen können diese Einflüsse soweit und so schnell kompensieren, dass die Netze auf allen Ebenen in jedem Augenblick stabil betrieben werden können?

Selbst unter der Annahme, dass alle Einflüsse bekannt und entsprechende Mechanismen zum stabilen Netzbetrieb entwickelt und erprobt wurden, so bleiben wesentliche Fragen unbeantwortet: Wer soll diese Automatisierungs-Infrastruktur und die dafür vorgesehenen Internet-basierten Integrationsebenen finanzieren und – vor allem – wer soll sie implementieren, installieren, vernetzen, nutzen und weiter entwickeln? ■

Dipl.-Ing Karlheinz Schwarz
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FAZIT:

Der Aufbau von Automatisierungs-Infrastrukturen und Integrationsebenen für die Energieversorgung erfordert Ressourcen, die weit über die derzeitigen Vorstellungen und kurzfristig verfügbaren Ressourcen hinausgehen. Die Förderung smarter Energieversorgungssysteme darf nicht vorrangig ein „Konjunkturförderprogramm" für die Integrationsebenen sein. Die Aspekte wie die elektrische Sicherheit, die hohe Verfügbarkeit der Energieversorgung, die alternde elektro- und informationstechnische Infrastruktur und vor allem das alternde Personal für die Weiterentwicklung und den Betrieb des elektrischen Netzes müssen eine deutlich höhere Priorität erhalten.

Die zukünftige Energieversorgung muss als Ganzes verstanden werden. Entwicklungen müssen als kontinuierliche „Weiter"-Entwicklungen der vorhandenen Systeme mit all ihren komplizierten Aspekten verstanden werden. Nur so kann auch in Zukunft die bisher gewohnte Versorgungssicherheit gewährleistet werden. Bezogen auf den Umfang als auch die gewünschte kurze Umsetzungszeit werden alle bisherigen Erfahrungen der zurückliegenden 130 Jahre in den Schatten gestellt.

Die derzeit in Planung befindliche Energiewende und damit einhergehend der Aufbau einer schrittweisen Strukturveränderung und einer engeren Verflechtung der Energienetze für Strom, Gas, Wärme und Elektromobilität sowie die dafür notwendigen Infrastrukturen werden mehr einem Marathon als einem Sprint ähneln. Eine domänenübergreifende Zusammenarbeit vor allem mit den Elektro- und Energietechnikern muss deutlich ausgebaut werden. IEC- und andere Normen können – vor allem vor dem Hintergrund der begrenzten Entwicklungs-Ressourcen – einen wichtigen Beitrag zur Vereinheitlichung von Lösungen bei den Integrationsebenen leisten.

Die Smart Grids, die im Rahmen der Energiewende entstehen, werden Erfindungen mehrerer Jahrhunderte vereinen.

Monitoring and Control of

Power Systems and Communication Infrastructures

based on IEC 61850 and IEC 61400-25

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Monitoring of Power System and Communication Infrastructures based on IEC 61850 and IEC 61400-25

Karlheinz Schwarz, SCC, Karlsruhe/Germany

1 Introduction

The focus of the first edition of IEC 61850 “Communication networks and systems in substations” was on substation operational aspects (mainly protection and control). Various groups have identified that IEC 61850 is the basis of further applications, e.g., monitoring of functions, processes, primary equipment, and the communication infrastructure in substations and other power system application domains. The second edition of the first 14 parts IEC 61850 (with the new title “Communication networks and systems for power utility automation“) and other extensions provide further definitions to keep the high quality and availability of power systems, to reduce commissioning time and life cycle costs.

Edition 2 of IEC 61850 provides new data objects for (condition) monitoring. Many new data objects are added for critical measurements like temperatures, oil levels, gas densities, maximum number of connections exceeded et cetera. Such extensions cover the monitoring of equipment like switchgear, transformers, on-load tap changers, automatic voltage regulation devices, gas compartments, and lines; generators, gearboxes, and towers in wind turbines; communication infrastructure like Ethernet switches and routers. Myriads of sensors are needed to monitor the condition of the wind power foundation, tower, rotors, gearboxes, generators to name just a few. The standard IEC 61400-25-2 extends IEC 61850 with condition monitoring data objects for wind turbines. IEC 61850-7-4 (core information models), IEC 61850-7-410 (extensions for hydro power plants), IEC 61850-7-420 (decentralized energy resources), and IEC 62351-7 (security) provide a huge list of new data objects for general monitoring purposes.

The abstract data objects are the basis for a sustainable interoperability in the power industry – abstract means, they can be mapped to more than protocol; sustainable means, they can be used “forever”. The abstract objects can be mapped to MMS as defined in IEC 61850-8-1 or (according to IEC 61400-25-4) to Web Services, OPC-XML, IEC 60870-5-10x, or DNP3.

The new extensions are a pivotal point for the interoperability of exchanging monitoring information in the future electric power systems – they can make the power systems smarter than they were in the past. This paper presents and discusses the benefits and challenges of the various model extensions in edition 2 of IEC 61850 and other related standards. Realizations in practical use in power utilities will be presented, too.

2 Information modeling in IEC 61850

Information models are one of the key elements of the standard series IEC 61850 and related standards. Information models represent measurements and status information taken at the process level, and other kinds of processed information like metering information. The information models are independent of any communication protocol and network solution. They are intended to have a “long life” – a Phase C Voltage in a 50 Hz system is a Phase C Voltage today, tomorrow, in 20 years, in Karlsruhe and in Reykjavik.

Figure 1 shows the different levels of standard definitions: from “long-life” at the top to “short-life” at the bottom.

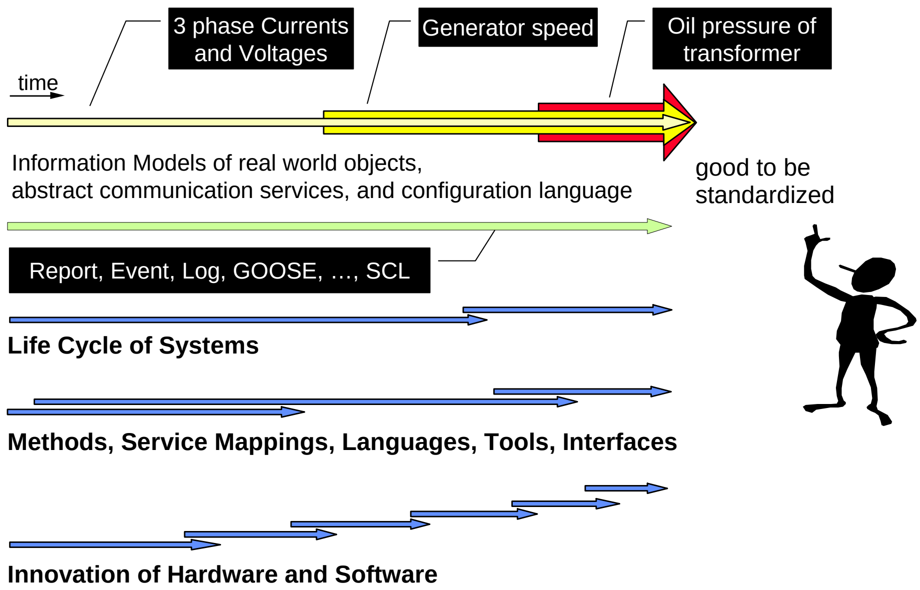

Figure 1: Information models and implementation issues

The models are organized in Logical Nodes containing Data Objects. A Logical Node is for example the “MMXU”: The measurements and calculated values of a three phase electrical system. Figure 2 depicts the application of the standard Logical Node “MMXU” for different voltage levels.

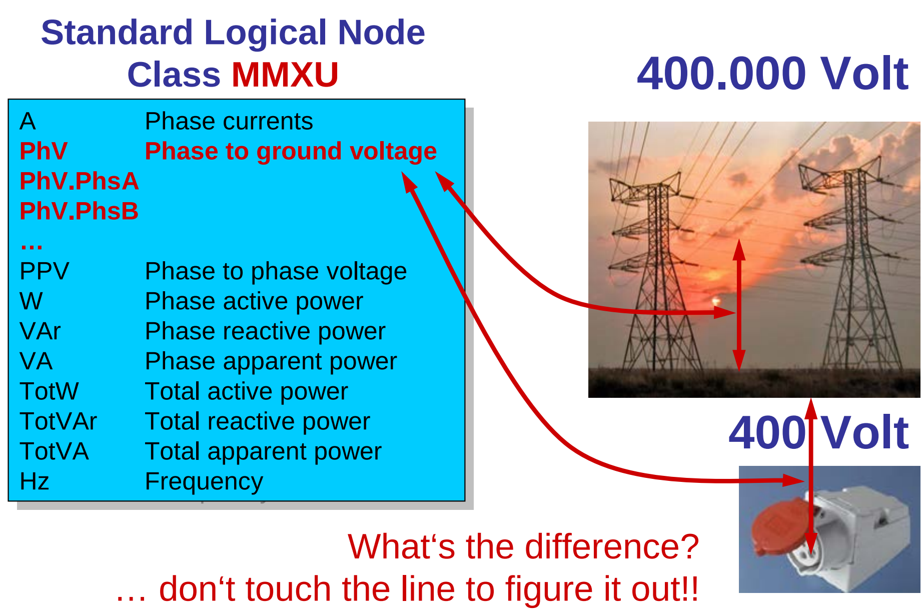

Figure 2: Information model of electrical values

IEC 61850 and related standards define thousands of “signals” as Data Objects organized in Logical Nodes. The list of more 280 standardized Logical Nodes can be found in the Annex.

3 Information models of IEC 61850-7-4 Edition 2

The first Edition of IEC 61850-7-4 “Compatible logical node classes and data classes” contained some 90 Logical Nodes and 500 Data Objects (see Figure 3). They mainly were intended to provide information for control and protection of substation equipment. A few years after the IEC TC 57 WG 10 defined the core document IEC 61850-7-4 Edition 1 several groups started to extend the models for additional application domains. One of the first crucial areas of extensions was the condition monitoring of wind turbines as well as circuit breakers.

Figure 3 shows the current status of the IEC 61850 documents that provide models. The Edition 2 of IEC 61850-7-4 is out for FDIS ballot until February 2010.

150 Logical Nodes (Ed2) – 90 (Ed 1)
800 Data Objects (Ed2) – 500 (Ed 1)

60 Logical Nodes
350 Data Objects

Document	Title	Publication	Edition 2
7-3	Basic communication structure – Common data classes	IS Ed1:2003-05	FDIS 2010-06
7-4	Basic communication structure – Compatible logical node classes and data classes	IS Ed1:2003-05	FDIS 2010-02
7-410	Hydroelectric power plants - Communication for monitoring and control	IS Ed1:2007-08	CD 20xx
7-420	Communications systems for distributed energy resources (DER) - Logical nodes	IS Ed1:2009-03	CD 20xx
7-5	Basic communication structure – Usage of information models for substation automation applications	DC 2010-08	
7-500	Use of logical nodes to model functions of a substation automation system	DC 2010-08	
7-510	Use of logical nodes to model functions of a hydro power plant	DC 2009-12	
7-520	Use of logical nodes to model functions of distributed energy resources	Draft 2010	
7-10	Web-based and structured access to the IEC 61850 information models	DC 2009-12	
		current work in 2009/2010	current work in 2009/2010

updated 2009-12-28

50 Logical Nodes (Draft 2008-05)
450 Data Objects (Draft 2008-05)

Figure 3: Information models in IEC 61850

The second edition specifies more than 150 Logical Nodes. The major technical changes with regard to the first edition are as follows:

- Corrections and clarifications according to information letter;
- Extensions for new logical nodes for the power quality domain;
- Extensions for the model for statistical and historical statistical data;
- Extensions regarding IEC 61850-90-1 (substation-substation communication);
- Extensions for new logical nodes for monitoring functions according to IEC 62271;
- New logical nodes from IEC 61850-7-410 and IEC 61850-7-420 of general interest.

Examples of new Logical Nodes in IEC 61850-7-4 Edition 2 are Logical Nodes for Functionblocks, for Transducers, and Monitoring and Supervision.

Logical Nodes for Functionblocks

The following Logical Nodes expose information used in Functionblock applications:

1. Counter – FCNT
2. Curve shape – FCSD
3. Generic filter – FFIL
4. Control function output limitation – FLIM
5. PID regulator – FPID
6. Ramp function – FRMP
7. Set-point control function – FSPT
8. Action at over threshold – FXOT
9. Action at under threshold – FXUT

An example of a PID loop control with a Logical Node "FPID" representing its attributes (or input and output signals) is shown in Figure 4.

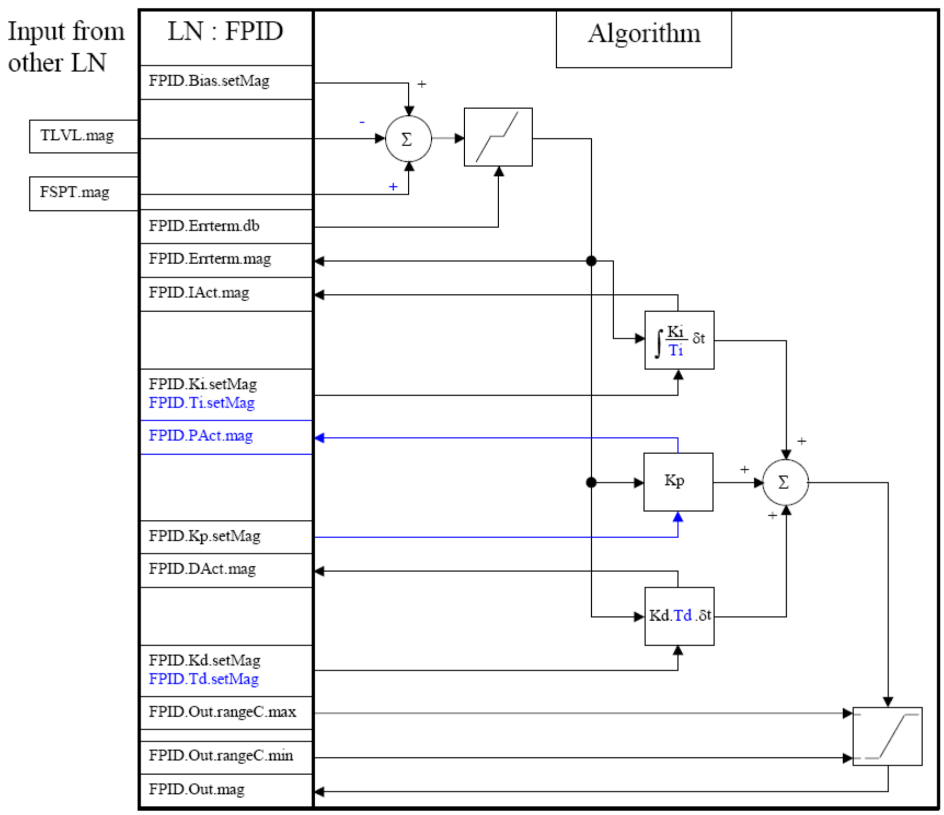

Figure 4: PID Logical Node

Note that IEC 61850 DOES NOT specify the PID loop control algorithm, logig, or function. IEC 61850-7-4 Logical Nodes provide the "interface" or the presentation of the signals, the configuration of the object models and the exchange of the values. The Data Object "KP" (Proportional gain) can be set by an ACSI service. Or the Data Object "DAct" (Derivative action) can be read, reported, logged, or sent by a GOOSE message. All Data Objects can be monitored by using the IEC 61850-7-2 service "Reporting" and "Logging".

Many other new Logical Nodes are included in the second edition of IEC 61850-7-4. There is one crucial area to mention: The new Logical Nodes for sensor (transducer) data. Several of these new and other Logical Nodes have been moved from the Edition 1 of IEC 61850-7-410 (Hydro) to IEC 61850-7-4 Edition 2.

Logical Nodes for Transducers (Sensors)

The following list contains 18 new “T” Logical Nodes for transducers; transducers more or less represent raw values from sensors:

1. Angle – TANG
2. Axial displacement – TAXD
3. Current transformer – TCTR
4. Distance – TDST
5. Liquid flow – TFLW
6. Frequency – TFRQ
7. Generic sensor – TGSN
8. Humidity – THUM
9. Media level – TLVL
10. Magnetic field – TMGF
11. Movement sensor – TMVM
12. Position indicator – TPOS
13. Pressure sensor – TPRS
14. Rotation transmitter – TRTN
15. Sound pressure sensor – TSND
16. Temperature sensor – TTMP
17. Mechanical tension / stress – TTNS
18. Vibration sensor – TVBR
19. Voltage transformer – TVTR
20. Water acidity – TWPH

Most of these Logical Nodes just represent the sampled values from a sensor. The Logical Node for Pressure sensor “TPRS” is shown as an example in Table 1.

Table 1: Logical Node for Pressure sensor

TPRS class			
Data object	**Explanation**		**M/ O/ C**
LNName	The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, Clause 22.		
Data objects			
EEHealth	External equipment health		O
EEName	External equipment name plate		O
Measured values			
PresSv	Sampled value of pressure of media [Pa]		C
Settings			
SmpRte	Sampling rate setting		O
Condition C: The data object is mandatory if the data object is transmitted over a communication link and therefore it is visible.			

All “T” Logical Nodes have a Data Object “EEHealth” that provides a simple status information “green”, “yellow” or “red” of the real underlying sensor (called ExternalEquipment – EE). They have further a Data Object “EEName” which comprises a huge list of mainly optional information that provides general details about the sensor. The external equipment name plate exposes the following information (without further explanation): vendor, hwRev, swRev, serNum, model, location, name, owner, ePSName, role, primeOper, secondOper, latitude, longitude, altitude, and mrID.

Logical Nodes for Supervision and Monitoring

The Logical Nodes for supervision and monitoring of the Logical Node group “S” comprise also a lot of new models (seven new Logical Nodes):

1. Monitoring and diagnostics for arcs – SARC
2. Circuit breaker supervision – SCBR (new)
3. Insulation medium supervision (gas) – SIMG
4. Insulation medium supervision (liquid) – SIML
5. Tap changer Supervision – SLTC (new)
6. Supervision of Operating Mechanism – SOPM (new)
7. Monitoring and diagnostics for partial discharges – SPDC (new)
8. Power Transformer Supervision – SPTR (new)
9. Circuit Switch Supervision – SSWI (new)
10. Temperature supervision – STMP (new)
11. Vibration supervision – SVBR (new)

The new Logical Node “Circuit breaker supervision – SCBR” (see Table 2) for example comprises a huge number of new Data Objects that represent a more detailed status of circuit breakers than an “EEHealth” Data Object. These Data Objects of have been defined as part of a new Logical Node “SCBR” instead of adding them to the well know Logical Node “XCBR”. For a specific real circuit breaker only a subset of the Data Objects may be applicable. Or there may even be a need to define further Data Objects; this can be done easily according the name space concept of IEC 61850-7-1 (which is already defined in Edition 1).

Almost all Data Objects of the “SCBR” are optional. Optional usually means that a vendor of an IEC 61850 compliant device can decide to implement only the mandatory Data Objects – in order to be fast on the market and having a standard conformant device (with the minimum of objects). Very often utility people or system integrators are surprised that a device has just a few objects – they would like to have more. It is up to the utilities to request from the vendors to implement more than just the minimum. This is – of course – completely outside the influence of the standardization groups. The Data Objects of the Logical Node “SCBR” are listed in Table 2. These Data Objects have been discussed by several groups of domain experts of switch gears prior to the inclusion into the Edition 2.

In addition to the features build into the measured value models (common data class “MV”; see also the communication services explained further down) there are some crucial Data Objects like “AbrAlm” (Contact abrasion alarm) and “AbrWrn” (Contact abrasion warning) that define a concrete semantic (meaning) of the object. An alarm may be communicated by a GOOSE message and a software at the subscriber side may act automatically on the receipt of this GOOSE message. The alarm and warning levels are defined in the settings “AbrAlmLev” (Abrasion sum threshold for alarm state) and “AbrWrnLev” (Abrasion sum threshold for warning state). The levels may be configured during device configuration or they may be configured by a communication service (SetDataValues) at runtime.

Table 2: Logical Node “Circuit breaker supervision – SCBR”

Status information	
OpCntRs	Resettable Operation Counter
ColOpn	Open command of trip coil
AbrAlm	Contact abrasion alarm
AbrWrn	Contact abrasion warning
MechHealth	Mechanical behavior alarm
OpTmAlm	Switch operating time exceeded
ColAlm	Coil alarm
OpCntAlm	Number of operations (modeled in the XCBR) has exceeded the alarm level for number of operations
OpCntWrn	Number of operations (modeled in the XCBR) exceeds the warning limit
OpTmWrn	Warning when operation time reaches the warning level
OpTmh	Time since installation or last maintenance in hours
Measured values	
AccAbr	Cumulated abrasion
SwA	Current that was interrupted during last open operation
ActAbr	Abrasion of last open operation
AuxSwTmOpn	Auxiliary switches timing Open
AuxSwTmCls	Auxiliary switches timing Close
RctTmOpn	Reaction time measurement Open
RctTmCls	Reaction time measurement
OpSpdOpn	Operation speed Open
OpSpdCls	Operation speed Close
OpTmOpn	Operation time Open
OpTmCls	Operation time Close
Stk	Contact Stroke
OvStkOpn	Overstroke Open
OvStkCls	Overstroke Close
ColA	Coil current
Tmp	Temperature e.g. inside drive mechanism
Settings	
AbrAlmLev	Abrasion sum threshold for alarm state
AbrWrnLev	Abrasion sum threshold for warning state
OpAlmTmh	Alarm level for operation time in hours
OpWrnTmh	Warning level for operation time in hours
OpAlmNum	Alarm level for number of operations
OpWrnNum	Warning level for number of operations

It is likely that new vendors of IEC 61850 conformant devices will specialize in the domain of condition monitoring and offer more possibilities than traditional vendors. The trend is quite obvious: There are a lot of new solutions for monitoring one or the other part of the process that will hid the road in 2010. The monitoring operation usually does not have a direct link to the automation and protection. It is lees critical than protection functions and devices. Most equipment in the electrical system (mainly at distribution level) is not monitored at all today – operators are quite “blind” on what’s going on in distribution networks. With the event of Smart Grids (or Smarter Grids) this is likely to change dramatically.

4 Information models of IEC 61850-7-410 Edition 2 for Monitoring

The Standard IEC 61850-7-410 Edition 1 “Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Hydropower plant logical nodes” defines some 60 Logical Nodes and 350 Data Objects for various hydropower plant applications.

The Logical Nodes in IEC 61850-7-410 Edition 1, that where not specific to hydropower plants (mainly those that represent transducers, supervision and monitoring information), have been moved to Edition 2 of IEC 61850-7-4 and they will be removed from Edition 2 of IEC 61850-7-410. Most of the modeling examples and background information that was included in IEC-61850-7-410 Edition 1 will be transferred to a technical report TR 61850-7-510.

Edition 2 of IEC 61850-7-410 will include additional general-purpose and supervision and monitoring Logical Nodes, not included in IEC 61850-7-4 (Edition 2), but required in IEC 61850-7-410 in order to represent the complete control and monitoring system of a hydropower plant.

The following Logical Nodes for supervision and monitoring (Group “S”) have been specified for Edition 2 of IEC 61850-7-410:

1. Supervision of media flow – SFLW
2. Supervision of media level – SLEV
3. Supervision of the position of a device – SPOS
4. Supervision media pressure – SPRS

Each of these Logical Nodes comprises measured values, status information and settings.

Details are still under discussion in IEC TC 57 WG 18 which is responsible for the Edition 2 of IEC 61850-7-410.

5 Information models of IEC 61850-7-420 Edition 1 for Monitoring

The Standard IEC 61850-7-420 Edition 1 “Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes” defines some 50 Logical Nodes and 450 Data Objects for various DER domains.

Most Logical Nodes have some status information and measurements that can be used for monitoring. They are usually not defined in separate “S” Logical Nodes.

IEC 61850-7-420 defines the following specific Logical Nodes that are intended to provide special measurements for monitoring various physical processes:

1. Temperature measurements – STMP
2. Pressure measurements – MPRS
3. Heat measurement – MHET
4. Flow measurement – MFLW
5. Vibration conditions – SVBR

The details of the Logical Nodes could be found in IEC 61850-7-420. One example is shown in the following example.

The crucial Data Objects of the Logical Node “MFLW” (Flow measurement) are listed in Table 3. These models are more comprehensive than those that will be defined in IEC 61850-7-4 Edition 2; they may be used for any other application domain as well.

One of the crucial benefits of IEC 61850 is this: Which Data Object is ever missing in any Logical Node, it could be defined as an extension. IEC 61850-7-1 defines the rules for defining new Logical Nodes, new Data Objects or even new common data classes. The concept is called the “name space concept”.

Table 3: Logical Node "Flow measurement – MFLW"

Measured values	
FlwRte	Volume flow rate
FanSpd	Fan or other fluid driver speed
FlwHorDir	Flow horizontal direction
FlwVerDir	Flow vertical direction
MatDen	Material density
MatCndv	Material thermal conductivity
MatLev	Material level as percent of full
FlwVlvPct	Flow valve opening percent
Controls	
FlwVlvCtr	Set flow valve opening percent
FanSpdSet	Set fan (or other fluid driver) speed
Metered values	
MtrVol	Metered volume of fluid since last reset

6 Information models of IEC 61400-25 for Monitoring

Some Data Objects are already defined in the current published standard IEC 61400-25-2 "Communications for monitoring and control of wind power plants – Information models". The Logical Node Wind turbine transmission information (WTRM) comprises the Data Objects that represent wind turbine (mechanical) transmission information. The data represent usual transmission topology, consisting of a slow speed shaft, multistage gearbox, a fast shaft and a (hydraulically driven) mechanical brake. In case of a divergent transmission topology (e.g. direct drive, single stage gearbox) or different mounted equipment (e.g. sensors, electromechanical brake), users are free to adapt or extend the data classes. Table 4 shows the Logical Node "WTRM" of the standard IEC 61400-25-2 published in January 2007. Most of the Data Objects of this Logical Node provide monitoring information of the transmission system.

Table 4**:** Logical Node "WTRM"

Data object	Description
Status information	
BrkOpMod	Status of shaft brake
LuSt	Status of gearbox lubrication system.
FtrSt	Status of filtration system
ClSt	Status of transmission cooling system
HtSt	Status of heating system
OilLevSt	Status of oil level in gearbox sump
OfFltSt	Status of offline filter
InlFltSt	Status of inline filter
Measured values	
TrmTmpShfBrg1	Measured temperature of shaft bearing 1
TrmTmpShfBrg2	Measured temperature of shaft bearing 2
TrmTmpGbxOil	Measured temperature of gearbox oil
TrmTmpShfBrk	Measured temperature of shaft brake (surface)
VibGbx1	Measured gearbox vibration of gearbox 1
VibGbx2	Measured gearbox vibration of gearbox 2
GsLev	Grease level for lubrication of main shaft bearing

GbxOilLev	Oil level in gearbox sump
GbxOilPres	Gear oil pressure
BrkHyPres	Hydraulic pressure for shaft brake
OfFlt	Offline filter contamination
InlFlt	Inline filter contamination

Several other Logical Nodes offer Data Objects that can be used for monitoring purposes.

The standard IEC 61400-25-6 “Communications for monitoring and control of wind power plants – Logical node classes and data classes for condition monitoring” is intended to provide more sophisticated Data Objects that can be used for higher level diagnosis.

IEC 61400-25 defines information models and information exchange models for monitoring and control of wind power plants. The modeling approach (for information models and information exchange models) of IEC 61400-25-2 and IEC 61400-25-3 uses abstract definitions of classes and services such that the specifications are independent of specific communication protocol stacks, implementations, and operating systems. The mappings of these abstract definitions to specific communication profiles are defined in IEC 61400-25-4 (see **Figure 5**). The definitions in parts IEC 61400-25-1 to IEC 61400-25-5 apply also for part 6.

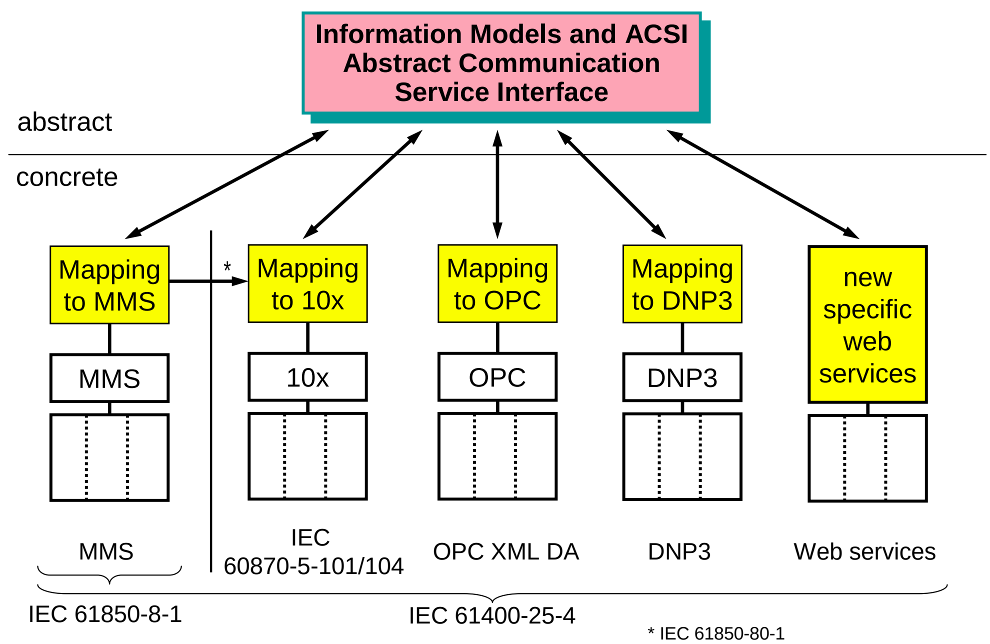

Figure 5: The mappings of IEC 61400-25-4

The purpose of part 6 is to define an information model for more specialized condition monitoring information and to define how to use the existing definitions of part IEC 61400-25-2 and to define the required extensions in order to describe and exchange information related to condition monitoring of wind turbines. The models of condition monitoring information defined in this standard may represent information provided by sensors or by calculation.

In the context of this standard condition monitoring means a process with the purpose of observing components or structures of a wind turbine or wind power plant for a period of time in order to evaluate the state of the components or structures and any changes to it, to detect early indications of impending failure.

Condition monitoring is most frequently used as a Predictive or Condition-Based Maintenance technique (CBM). However, there are other predictive maintenance techniques that can also be used, including the use of the Human Senses (look, listen, feel, smell) or Machine Performance Monitoring techniques. These could be considered to be part of the condition monitoring.

Condition monitoring techniques that generate information to be modeled include, but are not limited to techniques such as:

- Vibration measurements and analysis,
- Oil debris analysis,
- Temperature measurement, and
- Strain gauge measurement.

Components and structures can be monitored by using automatic instrumentation as well as using a manual process.

The condition monitoring functions may be located in different physical devices. Some information may be located in a turbine controller device (TCD) while other information may be located in an additional condition monitoring device (CMD). Various actors may request to exchange data located in the TCD or CMD. A SCADA device may request the information from a TCD or CMD; a CMD may request information from a TCD and vice versa. The information exchange between any two devices requires the use of information exchange services defined in IEC 61400-25-3 or added in part 6.

The use case of having the condition monitoring functions located in the turbine controller device is a special use case. That use case does not require information exchange services for the information exchange between the condition monitoring functions and the turbine controller functions. The case of having separate devices is the more comprehensive use case. This is used as the typical topology in this part of the standard. The special case of both functions in one device could be derived from the most general use case.

It may also be required to build a hierarchical model of automatic turbine controller and condition monitoring devices/functions. A simple condition monitoring device (CMD; providing measured values and status information and very basic monitoring capabilities). This CMD may retrieve information from the underlying CMD or TCD and may further process and analyze the measured values and status information.

In condition monitoring systems predefined triggers are applied to initiate a sequence of events, for example issuing an alarm to the local SCADA system or sending a message to a monitoring centre in order to prevent further damage on components or structures. In general such messages can be used by a Condition Monitoring Supervision function to generate actionable information which can be used by a service organization to create work orders and initiate actions. Figure 6 illustrates the information chain of a system using condition monitoring to perform condition based maintenance.

Figure 6 illustrates how data are refined and concentrated through the information chain, ending up with the ultimate goal of condition based maintenance – actions to be performed via issuing work orders to maintenance teams.

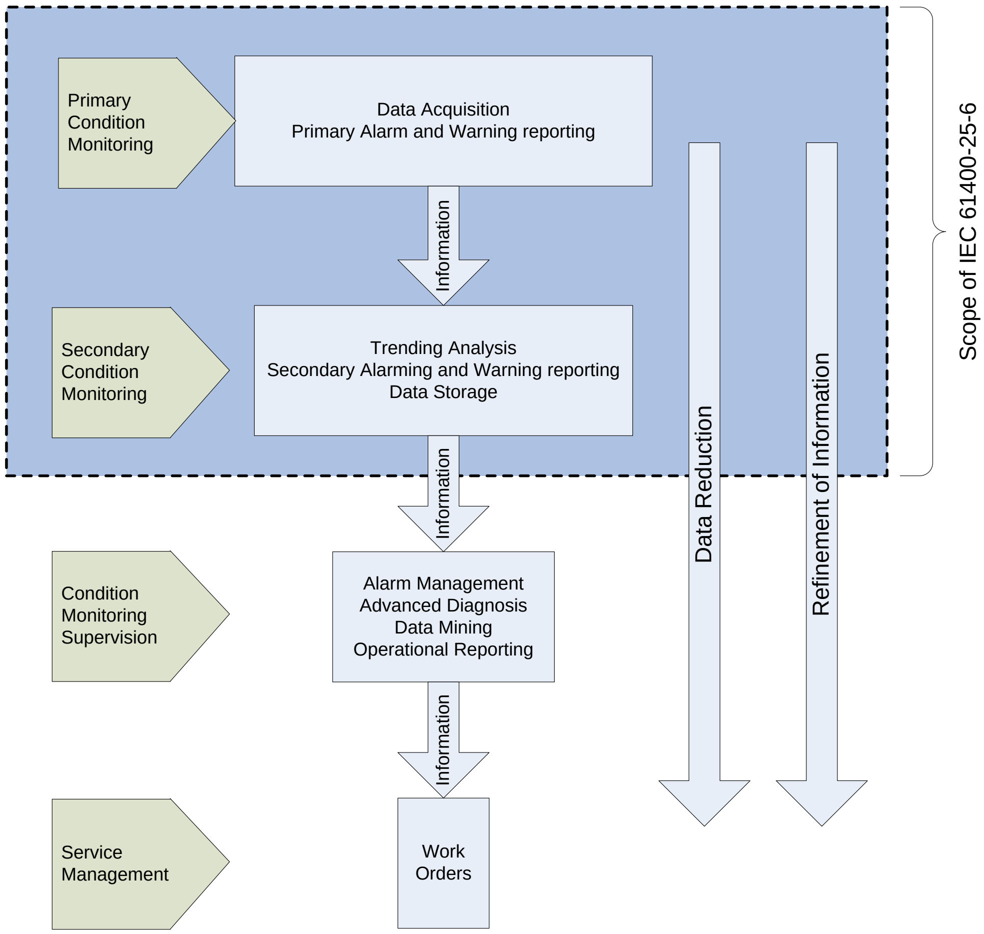

Figure 6: The information chain of condition based maintenance

Figure 6 shows the scope of IEC 61400-25-6 and the typical information chain of condition monitoring systems. The local (primary) part of the chain could be named as condition monitoring localized in the wind turbine and the wind farm SCADA system, but the local functionality can vary from system to system. The centralized (secondary) data retrieval performed by for example a control centre system is often named as a back-office system. The decreasing sizes of the boxes illustrate the data reduction and the transformation of data into more useful information with an enhanced value.

The FDIS (Final Draft International Standard) of part IEC 61400-25-6 is expected to be available in early 2010.

7 Communication services for monitoring

The part IEC 61850-7-2 (ACSI – Abstract communication service interface) and IEC 61400-25-3 define the basics for information models and services and part IEC 61850-7-4 and IEC 61400-25-2 (Logical Nodes and Data Objects) defines concrete information models (the Data Objects that represent the values to be monitored). It is crucial to understand that the standards IEC 61850 and IEC 61400-25 do not define new process data – the standards assign useful names and types to real-world data. These names are valid internationally.

The ACSI provides the following basic definitions we need for monitoring:

- Logical Nodes are used as containers of any information (Data Objects) to be monitored,
- Data Objects are used to designate useful information to be monitored,
- Retrieval (polling) of the values of Data Objects (GetDataObjectValues),
- Send events from a server device to a client (spontaneous Reporting),
- Store historical values of Data Objects (logging),
- Exchange sampled values (current, voltages and vibration values),
- Exchange simple status information (GOOSE), and
- Recording functions with COMTRADE files as output.

These basic definitions are explained in the following with regard to the use case “monitoring”.

Logical Nodes

Many Logical Nodes are explicitly defined to represent a list of Data Objects that relate to measurements like temperature, pressure, level, gas density, etc. Many other logical nodes are a mix of controllable Data Objects, objects for settings, protection, and so on.

An example of a Logical Node comprising only monitoring information is the Logical Node “Circuit breaker wear supervision” (SCBR) of the draft edition 2 of IEC 61850-7-4 is shown in Table 5 (this and the following Logical Node tables are just showing an excerpt of Data Objects).

Table 5**:** Circuit breaker wear supervision Logical Node (SCBR)

Data object	**Description**
Status information	
Col1Opn	Open command of trip coil 1
Col2Opn	Open command of trip coil 2 (usually as backup protection coil)
AbrAlm	Contact abrasion alarm
AbrWrn	Contact abrasion warning
Measured values	
AccAbr	Cumulated abrasion coefficients
TripA	Current that was interrupted during last open operation
ActAbrCoef	Abrasion coefficient of last open operation
Settings	
AbrAlmLev	Abrasion coefficient sum threshold for alarm state
AbrWrnLev	Abrasion coefficient sum threshold for warning state

Operating a breaker and especially tripping a short circuit causes always some abrasion (or erosion) of the breaker contacts. The supervision relates to a single phase since each phase has its own contact.

The first seven Data Objects can be used for monitoring purposes; the last two are used for settings limits. The communication services applicable are explained below.

Data Objects

There are several categories of Data Objects that provide various aspects of the monitoring process:

- Status information (single or double point information),
- Measured information (analogue values measured or calculated, and
- Settings (set ratings or limits for monitoring)

The standards related to IEC 61850 define hundreds of Data Objects of these categories.

Some basic aspects with regard to monitoring are explained in the following paragraphs:

Status information: In most cases there is a need to provide several details of the status. IEC 61850-7-3 provides these attributes by, e.g., the common data class SPS (single point status as defined in IEC 61850-7-3):

– stVal	BOOLEAN	TrgOp=dchg
– q	Quality	TrgOp=qchg
– t	TimeStamp	

Any change of the value of the status with the standard name “stVal” can be used to trigger a report (comprising the values for stVal, q and t) to be sent to clients or to trigger to log the values of stVal, q and t to one or multiple logs. It is also possible that a client reads these values (stVal, q and t) at any time to get the values of the last change or the current value.

These values may also be used to be sent as content of a GOOSE messages. GOOSE messages are sent by multicast to any IEDs (Intelligent Electronic Device) connected to the same subnetwork. Even a sampled value message may sent the values (stVal, q and t) continuously with the same rate (e.g. 4 kHz) as the current and voltage samples from CTs and VTs.

Independent of the use of reporting, logging, GOOSE, or sampled value exchange, the data to be exchanged has to be specified by a DataSet. A DataSet contains a list of references to Data Objects and parts of it (the so-called functionally constraint data, FCD, or data attributes, FCDA).

A DataSet may comprise several status information and a few measurements for example.

Measured values: IEC 61850-7-3 provides attributes for measured values. The most common class is the common data class MV (measured value) with the following attributes:

– instMag	AnalogueValue	
– mag	AnalogueValue	TrgOp=dchg
– range	ENUMERATED	TrgOp=dchg
– q	Quality	TrgOp=qchg
– t	TimeStamp	
– units	Unit	
– db	INT32U	
– zeroDb	INT32U	
– sVC	ScaledValueConfig	
– rangeC	RangeConfig	

Any change of the magnitude value (with the standard name “mag”) can be used to trigger a report (of mag, range, q and t) to be sent to clients or to trigger to log these values to one or multiple logs. It is also possible that a client reads these values at any time to get the last change. The values may also be used for other services like GOOSE.

The use of mag (a deadband or filtered value) and range in conjunction with reporting and logging is explained below.

The attribute units, db, sVC and rangeC are used to configure the engineering unit (e.g., V for Volt), the multiplier (M for Mega), the deadband value for filtering the analogue value, the scale factor and offset (for integer values) and the range configuration. Those attributes that have a impact on the monitoring of measured value are explained below.

Statistical and historical statistical information

Measurement Data Objects usually (in Edition 1) refer to RMS (root mean square) values or just current values, provided at the time when they have been measured. In many applications there is a need to refer also to statistical values of a measurement, e.g., maximum value of an hour or

15 minutes interval. The statistical values require some minor extensions of the first edition of IEC 61850-7-x. The standard IEC 61400-25-2 has already published the solution for statistical data.

In many application domains such as wind power plants, it is required to provide additional information of a basic analogue value:

- **Statistical information** (for example, minimum value calculated for a specified time period, for example, minimum value of last 1 hour)
- **Historical statistical information** (for example, log of minimum values of the sequence of values calculated above, for example, last 24 hourly values)

This additional information may be derived from the basic analogue values. It may be the only information provided – depending on the application requirements.

The models for the statistical and historical statistical data are explained conceptually in Figure 7.

On the left hand side are the basic data representing the cur-rent values (PRES), i.e. some instantaneous analogue (or integer) values that are contained in the logical node instance XXYZ.

The upper half depicts the method defined for statistical values. The first example is the instance XXYZ1 of the logical node class XXYZ. The analogue values represent the calcu-lated maximum values derived from the instance XXYZ. The logical node XXYZ1 has special setting data that indicate that the values are maximum values and that the calculation method is "periodic". The period starts after a start command or by local means. At the end of the period the calculated maximum values of the instance XXYZ1 are overwritten by the new values.

The maximum values can be used to calculate the minimum maximum values in – of course – a much longer period than for the maximum calculation in XXYZ1. The instance XXYZ2 may represent the minimum value of the max value of the last 10 days.

Setting parameters other than PERIOD may be used to specify calculation modes. A calculation mode set to TOTAL means that the calculated maximum values are calculated since the first start of the device or of the involved application. A calculation mode set to SLIDING means that the calculated maximum values are calculated over a sliding window whose width can be set by means of a special interval type setting (e.g. hour, day, week).

The lower part of the figure shows the conceptual model of the historical statistical data. In this model the calculated val-ues (in this case the maximum values with calculation mode set to PERIOD) are stored in sequence in a log. The calcula-tion in the example starts at midnight of 2004-10-03. The in-terval is 1 h. After that first hour the first log entry is written. After the second hour the second entry contains the value of the second hour. After five (5) hours the log contains the values of the last three hours (intervals 02-03, 03-04, 04-05).

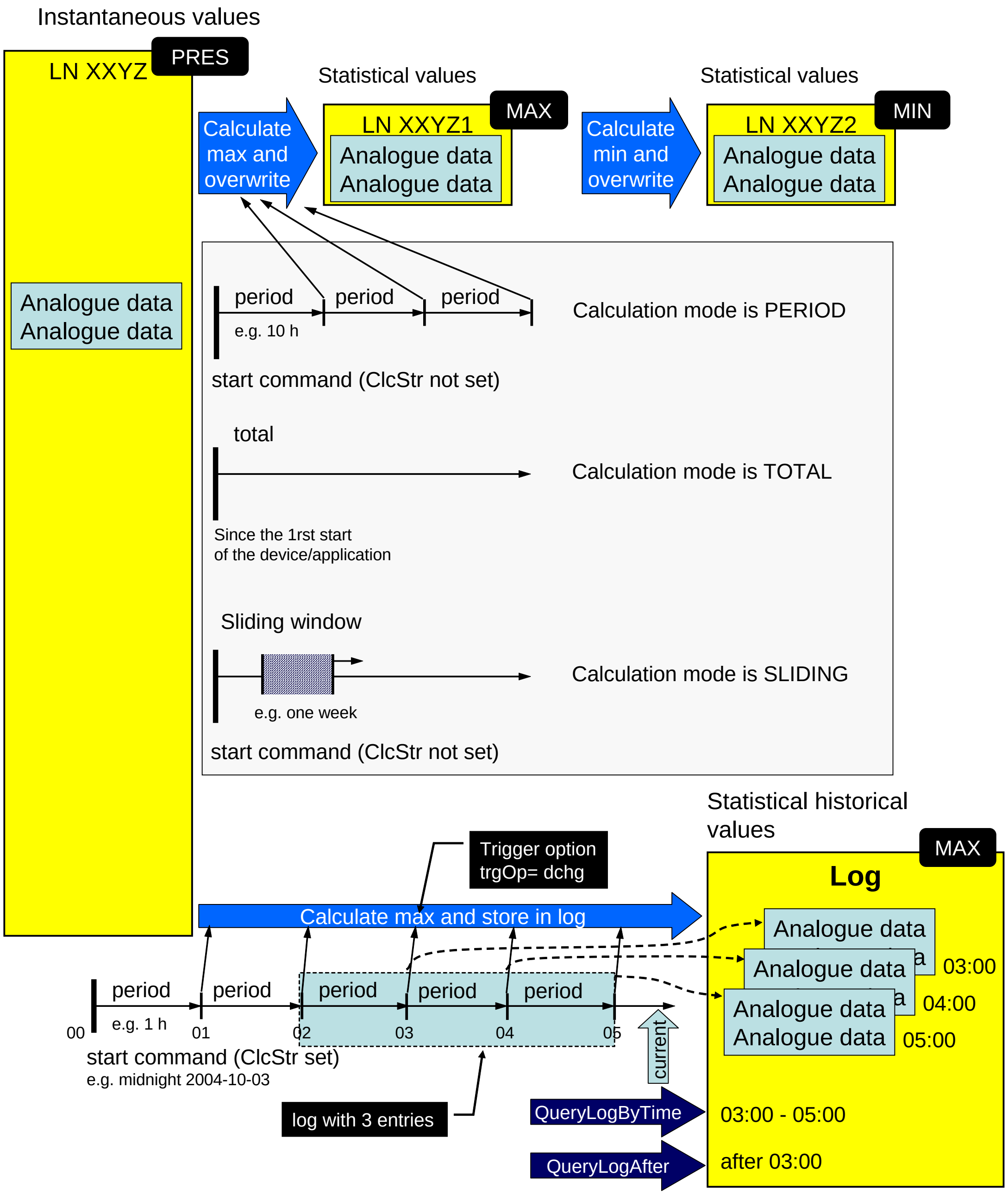

Figure 7: Statistical and Historical Statistical Data Objects (1)

The statistical data model is based on the calculation of analogue values contained in other logi-cal nodes. The top logical node LN XXYZ in Figure 2 refers to three technologi-cal logical nodes of the same Type (for example MMXU). The top logical node (LN XXYZ) represents the instanta-neous measured values. The second and third logical nodes are the statistical logical nodes, i.e., the logical nodes that represent the calculated values (LN XXYZ1 represents the MIN values, the LN XXYZ2 the MAX values).

The two logical nodes on the left of the bottom in Figure 2 (XXYZ1 and XXYZ2) represent mini-mum (MIN) and maxi-mum (MAX) values of the analogue data represented in the top logical node (XXYZ). The two logical nodes make use of the setting data ClcSrc (calculation source). The common data class of ClcSrc is ORG, “object reference setting group” and is used to reference the source logical node for the calculation. For both logical nodes, ClcSrc has the value XXYZ. Each logical node with analogue data can be used as a source. Addi-tionally, they have the data ClcStr (calculation start) and ClcExp (calculation expired) and the setting data ClcPerms (calculation period), ClcSrc (calculation source), and ClcMod (calculation mode).

With the settings ClcMod, ClcMthd, ClcPer and ClcSrc, the behavior of the logical node can be controlled. For periodic calculation, the “event” ClcExp set to TRUE can be used as an event to report the new value (the statistical value) by the re-port control block or it may be logged as historical statistical data for later retrieval.

The data names of the “Data” in all logical nodes shown **Figure 8** are the same, i.e., in all three logical nodes. The data are contained in different logical node instances (XXYZ, XXYZ1, and XXYZ2). These result in the following refer-ences: XXYZ.Data1, XXYZ1.Data1, and XXYZ2.Data1.

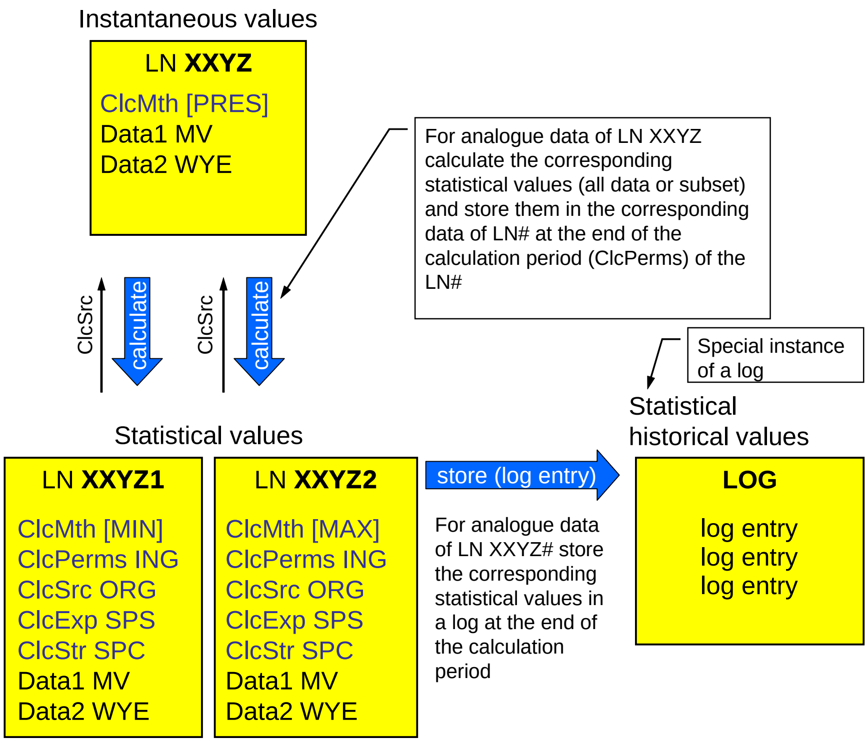

Figure 8: Statistical and Historical Statistical Data Objects (2)

Settings: Setting Data Objects are used to set specific val-ues for limits and other purposes. The purpose is usually de-fined with the semantic of a Data Object.

In the example of the Logical Node SCBR the two settings are used to monitor when to change status values of the warn-ing AbrWrn and the alarm Data Object AbrAlm. These Data Objects are single point status objects that can be used by the various communication services.

Retrieve (poll) the values of Data Objects

Any Data Object, any part of it and any group of them (optionally through a DataSet) can be read from a client. The corresponding services are GetDataValues and GetDataSetValues.

A DataSet may be defined by the service CreateDataSet (online), during configuration, or it may be built in.

Send events from a server device to a client (spontaneous Reporting)

Reporting is one of the most powerful service models in IEC 61850. It allows to configure the reporting behavior of the server device in a wide range of possibilities.

The basic concept of reporting is that values to be reported are specified by a DataSet object. The DataSet is a list of references to the objects to be reported; each referenced object is called a member of the DataSet. If a change of a value of one of the members happens the server creates a report message and sends the new value to the corresponding client. The change is also called a trigger – to trigger sending a report.

The trigger options are defined in the Data Objects (in Logical Nodes). There are, for example, two trigger options (data value change and quality value change) defined for each status Data Object derived from the common data class SPS:

SPS (single point status):

– stVal BOOLEAN TrgOp=dchg
– q Quality TrgOp=qchg
– t TimeStamp

The two Data Objects of the Logical Node SCBR (from above) are derived from the common data class SPS:

“AbrAlm” – Contact abrasion alarm and “AbrWrn” – Contact abrasion warning

If the cumulated abrasion coefficients “AccAbr” has reached the value of the “AbrWrnLev” (as configured by “AbrWrnLev” -abrasion coefficient sum threshold for warning state) the value of “AbrWrn” changes and can be reported if the object is a member of the corresponding DataSet.

Setting Data Objects are used to set specific values for limits and other purposes. The purpose is usually defined with the semantic of a Data Object.

In the example of the Logical Node “SCBR” the two settings are used to monitor when to change status values of the warning “AbrWrn” and the alarm Data Object “AbrAlm”. These Data Objects are single point status objects that can be used by the various communication services.

The example has shown that any analog value (measurement or calculated value) can be monitored for limit violations. This approach of defining Data Objects for the analogue value “AccAbr”, the limit configurations “AbrWrnLev” and “AbrAlm-Lev” and the warning “AbrWrn” and alarm “AbrAlm” is quite often used in the Logical Nodes in edition 2 of IEC 61850-7-4 and in other documents.

The measured value common data class “MV” contains already some mechanisms to monitor analogue values.

IEC 61850-7-3’s common data class MV (measured value) has the following values with regard to reporting:

– mag AnalogueValue TrgOp=dchg
– range ENUMERATED TrgOp=dchg
– q Quality TrgOp=qchg
– t TimeStamp
– db INT32U
– rangeC RangeConfig

The use of the attributes mag and range are shown in Figure 9 and Figure 10.

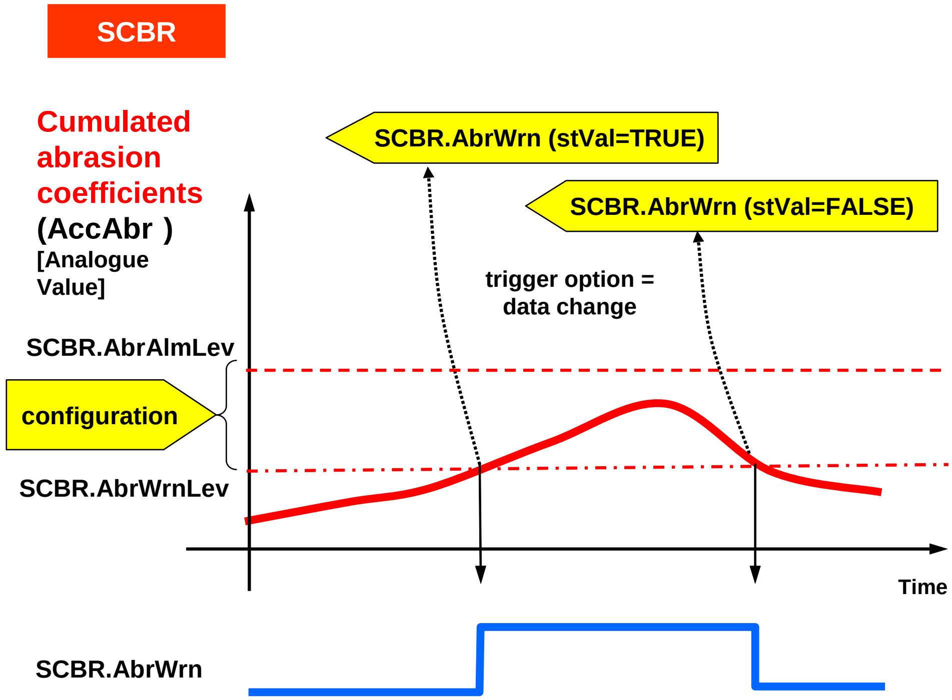

Figure 9**:** Deadband Filtering and Reporting (logging)

The analog value "AccAbr" is monitored for relative changes configured by "db" (deadband configuration). The deadband configuration specifies a relative change in per cent of the whole value range: Min to Max. In our case the value is 10 per cent. Any change of the value by +/10 per cent issues a trigger that can be used to report or log the new value.

The deadband configuration value can be configured during engineering, IED configuration, or online with the SetData-Value service. The smaller the value the more reports may be generated. It is up to the system integrator or operator (later on) to make sure that the whole system is configured in a way that not too many reports are generated. If for thousands of Data Objects the configuration parameter db is very small and the change rate of the values is high then it could happen that the IEDs and the network are flooded. Be aware everything is limited!

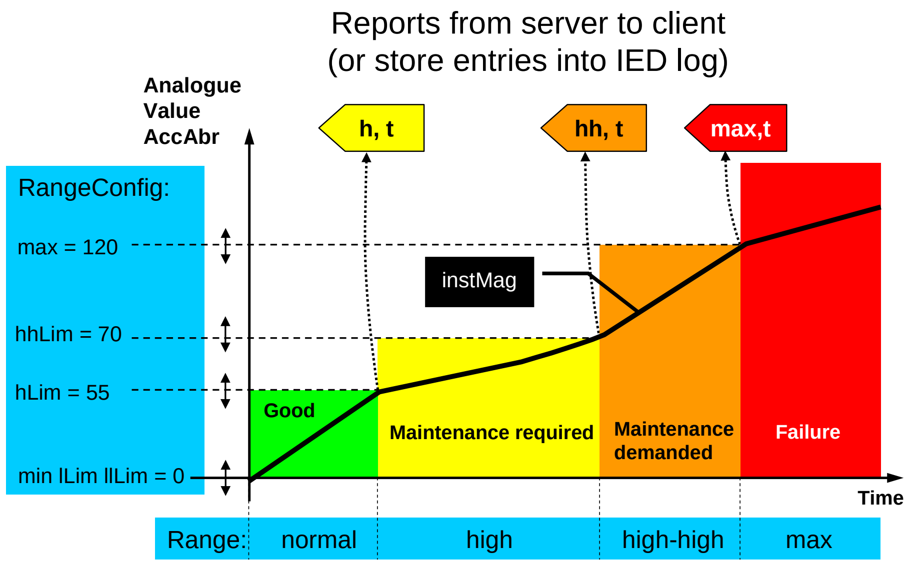

Figure 10: Range monitoring and reporting (logging)

The range monitoring uses the limits specified by the range configuration values for min, llLim, lLim, hLim, hhLim and max. Each time the analog value AccAbr crosses one of these limits a trigger is issued. The triggers can be used to report the analog value with the range value min, low-low, low, normal, high, high-high, and max. In addition to these two values the quality information q and timestamp t can be communicated with the report. Instead or in addition to the report the values may be placed into a log.

The meaning of the range values can de defined by the application. In the example it is defined as good, maintenance required, maintenance demanded, and failure. This approach (which is build-in in each analog value derived from the common data class “MV”) is different to the approach discussed earlier with the warning and alarm Data Objects and the configuration of the two limits as Data Objects. There is one difference: the Data Objects “AbrAlm” (Contact abrasion alarm) and “AbrWrn” (Contact abrasion warning) represent already a semantic. The two Data Objects can easily be used for GOOSE messaging to trigger an automatic function, e.g. to block operation or to control something in the substation.

A comprehensive modeling approach for monitoring of analog values is expected to be written by IEC TC 57 WG 10. This could be used for modeling monitoring of analog values in future applications. It is the freedom of the modelers to model the monitoring function one way or the other. All possibilities defined in the various standards today are conformant to IEC 61850 in general.

Store historical values of Data Objects (logging)

The logging of values of members of a DataSet is exactly the same as the reporting – except that the values are stored in a local buffer (the log – a circular buffer) and that clients have to initiate queries to retrieve logged data values.

The query log service is simple and straight forward: A client specifies the log to be queried, a starting time and ending time, a start time, or an ending time. In the first case all values stored between the two times are transmitted, in the second case all values after the start time are provided and in the third case all values before the ending time will be sent to the client.

For different applications it is recommended to think about how to best configure the logging: one log or multiple logs. A DataSet which causes frequent changes that may be logged for a short period (e.g., one day) may use a separate log. Because other Data Objects (not frequently changing) in another DataSet may have to be logged for a year or more. Putting these two streams in one log would cause the low frequent values being overwritten by the high speed values.

Be aware that reporting and especially logging is now migrating from control center SCADA systems down to the IED level. The functions reporting and logging are providing are well known – but usually implemented in SCADA systems; often on top of RTUs (remote terminal units).

Exchange of sampled values (SV)

The sampled value exchange mechanism has been defined in IEC 61850-7-2 and IEC 61850-9-2 for replacing the many wires carrying analog signals of voltage and current measurements. The samples to be transmitted are defined by a DataSet. A DataSet may contain analog and any other type of data, e.g., status values.

For the use of sampled value exchange in so-called Merging Units (MU) the UCA IUG (UCA International Users Group) has defined an implementation guide “9-2LE”. This guide provides a set of concrete settings for the DataSet and the control block. The DataSet comprises a fixed set of four currents and four voltages. Two sampling rates are defined: 80 samples/period for protection and 256 samples/period for metering. First Merging Units are available.

The sampled value exchange method can also be used for the high speed transmission of vibration data. Think of a huge hydro power plant with some 50 generators. Each and every set of generator and turbine has a lot of sensors that monitor the turbine, generator, and other components. There is now way to continuously record all samples of vibration sensors. The vibration sensor cold trigger a report sent to the maintenance department indicating a warning level. The maintenance people can now start a sampled value control block to send high speed samples from the field up to the office. At the subscriber of the sample stream there could be a analyzing tool that does some online analysis of the sample stream as it arrives. After some time of analysis the publisher may be disabled sending a high frequency stream of samples.

Exchange simple status information (GOOSE)

GOOSE (Generic Object Oriented Substation Event) is used to reliably distribute events very fast in the whole substation (subnetwork). The values to be sent are also specified by a DataSet. The DataSet members may be status information or any other values. After a change of any member of the DataSet the GOOSE message is sent immediately and repeated in a very high frequency. After several repetitions the frequency turns down to a low value (may be every 100 ms). Every 100 ms the receiver (subscriber) can expect new GOOSE message.

If the subscriber does no receive the message after 100 ms, it can expect that the sender (publisher) or the communication network have a serious problem. With that mechanism it is possible to monitor the publisher and communication system continuously. This is not possible in today’s wire based exchange of status information.

Recording functions with COMTRADE files as output

The recording functions are defined in IEC 61850-7-4 by a set of Logical Nodes included in the group R – protection related Logical Nodes. They are used to model typical (and well known) recording functions in different devices that have (already!) recording capabilities. The recording mechanisms are NOT defined in IEC 61850.

RDRE is a Logical Node representing the acquisition functions for voltage and current wave forms from the sensors (CTs and VTs), and for position sensors (usually binary inputs). Calculated values such as frequency, power and calculated binary signals can also be recorded. “RDRE” is used also to define the trigger mode, pre-trigger time, post-trigger time, pre-fault, post-fault, etc. attributes of a disturbance-recording function.

The Logical Node “RADR” is used to represent a single analog channel, while “RBDR” is used for the binary channels. Thus the disturbance recording function is modeled as a logical device with as many instances of “RADR” and “RBDR” Logical Nodes as there are analog and binary channels of the real recorder function available.

8 RWE R&D Process Bus Project

The IEC Standard 61850 is usually used for station and bay level communication. The standard comprises also a digital communication with the process level. This allows to integrate primary substation equipment, in particular electronic instrument transformers in a standardized way into the digital communication of the substation automation system (SAS).

RWE (second biggest German utility) has launched a multi-vendor project with the objective of collecting experience with this new process bus technology in a real 380/110 kV substation environment. An already existing 380/110 kV power transformer and its related bays were equipped with the new process bus technology in parallel to the existing active SAS. Two non-conventional CTs and VTs have been added to the primary equipment. The digital interface of an instrument transformer is the so called “merging unit”. Samples from conventional instrument transformers using the 100V/1A interface can also communicate using a merging unit as a sample value publisher. Thus a merging unit operates as a decentralized A/D-converter.

The communication network consists of two fully redundant ring busses. Several devices are connected: merging units, protection devices, bay controllers, electronic circuit breaker devices, a voltage controller, a tap changer controller, power transformer monitoring, an HMI and the gateway to the existing SAS.

The topology is based on the so-called "9-2LE" (light edition) published by the UCA users group based on IEC 61850-9-2 Edition 1. According to the specification the data volume per merging unit is about 5 MBit/s for 50 Hz and about 6 MBit/s for 60 Hz comprising one set of 3-phase current and voltage samples. Other time critical data (e.g. GOOSE messages) and also non time critical data (e.g. file transfer) could be transmitted over the same architecture. Figure 11 shows the topology of the process bus and the substation.

One of the key requirements was the implementation of a transformer monitoring system based on appropriate Logical Nodes and Data Objects as well as a selection of crucial client-server communication services. Additional monitoring information is provided by circuit breaker IEDs.

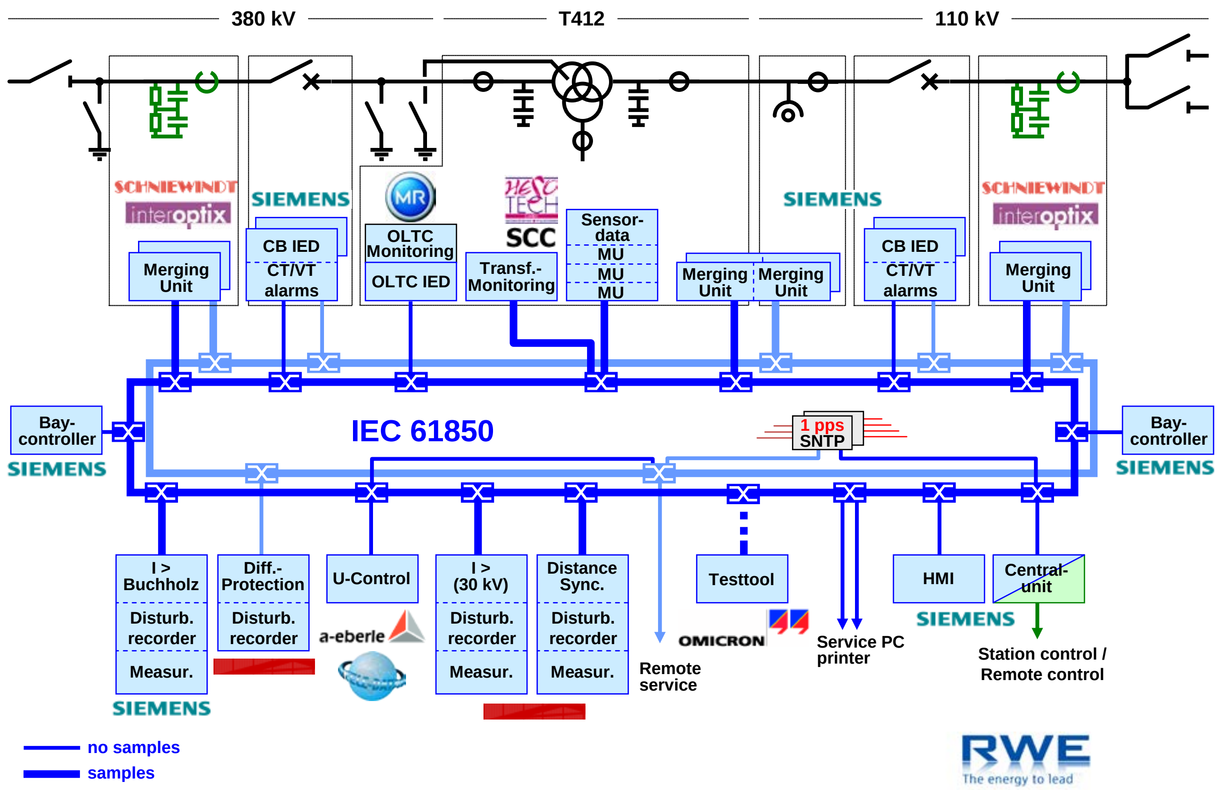

Figure 11: Topology of RWE Process Bus project

The Transformer and the load tap changer are monitored by two separate monitoring systems providing each an IEC 61850 server with the appropriate list of Logical Nodes and Data Objects. The transformer monitoring information models are listed in Table 6.

Table 6: Logical Nodes for Transformer Monitoring

LN	Data Object
MMXU1	Measurements 380 kV
MMXU2	Measurements 110 kV
MMXU3	Measurements 30 kV
YPTR1	Transformer
SIML1	Insulation measurement Transformer
SIML2	Insulation measurement circuit breaker
CCGR1	Transformer cooling group 1
CCGR2	Transformer cooling group 2
CCGR3	Transformer cooling group 3
CCGR4	Transformer cooling group 4
CALH1	Summary alarm
ZAXN1	Monitoring 3 phases of cooling group 1

ZAXN2	Monitoring 3 phases of cooling group 2
ZAXN3	Monitoring of cooling group 1
ZAXN4	Monitoring of cooling group 2

The process bus interface to the primary equipment provides all crucial information about their status. The key benefit is that all the information from the process level is communicated in a standardized way. Proprietary communication links – using may vendor specific solutions – are replaced by a single solution supported by multiple vendors.

The communication services can be used to retrieve the crucial status information of the primary equipment.

The transformer monitoring system comprises the information models shown in Figure 12 and Figure 13.

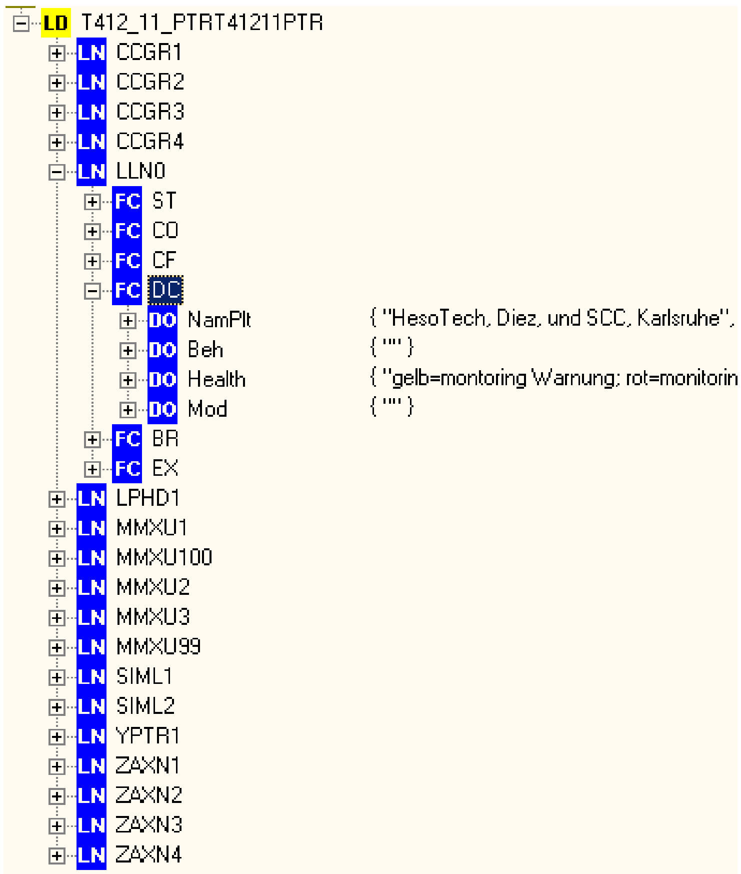

Figure 12**:** Transformer monitoring model for RWE R&D project (1)

Details, e.g., implemented in the SIML1 Logical Node are depicted in Figure 14.

Figure 13**:** Transformer monitoring model for RWE R&D project (2)

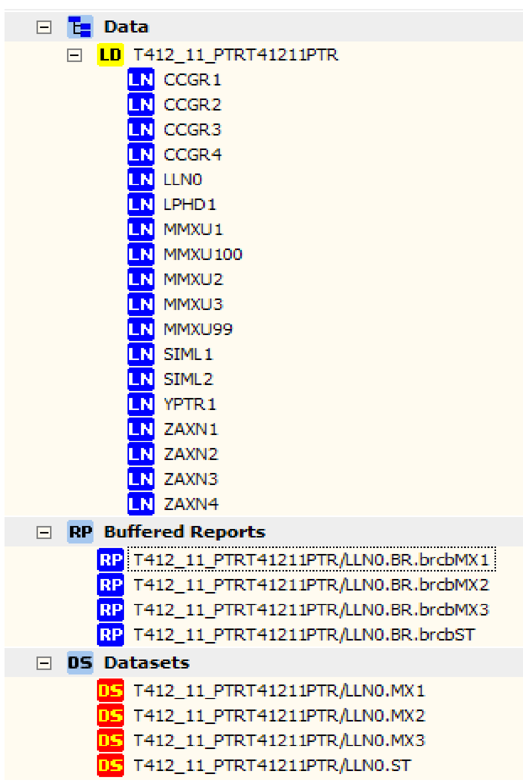

Figure 14**:** Transformer monitoring model for RWE R&D project (3)

The server for the transformer monitoring and the merging unit for the current and voltage samples of the transformer measurements are implemented in a standard PLC – Programmable Logic Controller (see Figure 15).

Figure 15: Transformer monitoring and merging unit IEDs

The whole transformer monitoring system is configured through an SCL file defining all needed objects, services, and the binding of the model to the real data of the monitor. The real data values are contained in a database. The binding of the model to the database is accomplished by the so-called <sAddr> attribute in SCL. The binding is automatically done by an interpreter in the IEC 61850 server software.

Once the pilot project is fully functional, protecting, controlling, and monitoring the substation , this is likely the first time where a comprehensive process bus is installed and operating.

9 Web-based and structured access to the IEC 61850 information models

With the use of IEC 61850 in domains outside the substation automation, the number of logical nodes and data objects published is increasing. Today, we have already more than 300 logical nodes defined in different parts of IEC 61850 and IEC 61400-25. There exist many associations between these different documents, but no easy hyperlinked browsing possibility exists. The maintenance of the defined information models always needs to be linked to a new complete document with a large collection of information models.

When experts of new application domains start to use the concepts of IEC 61850 and the existing information models as a base, the domain experts first need to easily identify what already exists. Therefore, it would be preferable to find and browse all information models at one place (preferably at the IEC website).

IEC is supporting the publication of standards as databases – the procedure of the standardization of the information models is defined in Annex J "Procedures for the maintenance of the IEC standards in database format" of the IEC Supplement to ISO/IEC Directives.

It is intended to convert the publication of Logical Nodes and common data classes as being published today in different parts of IEC 61850 and IEC 61400-25 into a web based and structured access solution.

IEC 61850-6, Edition 2 has included in Annex C.2 a XML schema based on SCL type template definitions for the purpose of formally describing IEC 61850 information models as a base to formally document and maintain the models of different IEC 61850 application domains, and facilitate automatic checking of IED data models against these definitions. It is foreseen to describe in the future the standard IEC 61850 information models using that schema. So, in the future, XML documents shall replace the word documents of the parts IEC 61850-7-3 and IEC 61850-7-4xx as well as IEC 61400-25-2 as the normative documents.

Based on these XML documents, several web-based access possibilities can be implemented. Different users need to be able to access the models through a web-based interface:

- Editors of the standard and working group members need to be able to browse existing models, to add new models and to maintain the existing models.
- National committees need to be able to review the draft models and to comment and vote on the models.
- Any interested people shall be able to browse the semantic and details of the models and to download the formal XML documents of the models.

Note that it will still be possible to automatically derive other representations like pdf and html from the XML files.

An example of a Web-based interface to an IEC standard is the Database for IEC 61360:

http://std.iec.ch/iec61360

As part of that work in a first step a Technical Report IEC 61850-7-10 will be prepared that describes the requirements of the different users and the possible approaches for its implementation.

The web-based access and the procedures involved in maintaining the models shall be described in the report and shall be based on Annex J "Procedures for the maintenance of the IEC standards in database format" of the IEC Supplement to ISO/IEC Directives.

10 Conclusions

In highly automated substations and power plants, almost no limitations exist with regard to make the information from the process (status values, measurements, events on limit violations, any monitoring data) available to any entity that needs the information for controlling, monitoring, service, diagnosis, network analyzing, testing, or asset management. The acquisition of any needed process information increases the stability of the system because any failure or trend that may lead to a failure can be made visible.

The electric power delivery system is using IEC 61850, IEC 61400-25, and its extensions in substations, for power quality monitoring applications, for the control and monitoring of wind power plants, control and monitoring of distributed energy resources (DER), and the control and monitoring of hydro power plants.

The condition monitoring possibilities rely on four aspects (standardized in IEC 61850 and IEC 61400-25):

- Standard Data Objects for values to be monitored,
- Standard communication services,
- Fast and reliable communication protocols, and
- Standard configuration language to specify or document the huge amount of information

It is very likely that especially the monitoring applications will be the focus for the next couple of years. Protection and automation of substations is well understood, implemented and used. Many physical aspects are not yet sensed by advanced or even simple sensors.

The standards are providing more and more condition monitoring Data Objects. The services allow for the exchange of these values in real-time (sampled values and GOOSE) as well in client/server relations.

11 References

[1] IEC 61850-1, Communication networks and systems in substations – Part 1: Introduction and overview

[2] IEC 61850-2, Communication networks and systems in substations – Part 2: Glossary

[3] IEC 61850-3, Communication networks and systems in substations – Part 3: General requirements

[4] IEC 61850-4, Communication networks and systems in substations –- Part 4: System and project management

[5] IEC 61850-5, Communication networks and systems in substations – Part 5: Communication requirements for functions and devices models

[6] IEC 61850-6, Communication networks and systems in substations – Part 6: Configuration description language for communication in electrical substations related to IEDs

[7] IEC 61850-7-1, Communication networks and systems in substations – Part 7-1: Basic communication structure for substation and feeder equipment – Principles and models

[8] IEC 61850-7-2, Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)

[9] IEC 61850-7-3, Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes

[10] IEC 61850-7-4, Communication networks and systems in substations – Part 7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes

[11] IEC 61850-8-1, Communication networks and systems in substations – Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO/IEC 9506-1 and ISO/IEC 9506-2) and to ISO/IEC 8802-3

[12] IEC 61850-9-1, Communication networks and systems in substations –- Part 9-1: Specific communication service mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link

[13] IEC 61850-9-2, Communication networks and systems in substations – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3

[14] IEC 61850-10, Communication networks and systems in substations – Part 10: Conformance testing

[15] IEC 61400-25, Wind turbines – Part 25: Communications for monitoring and control of wind power plants

Easy, Affordable and Fast Integration of IEC 61850 in Small Power System Devices

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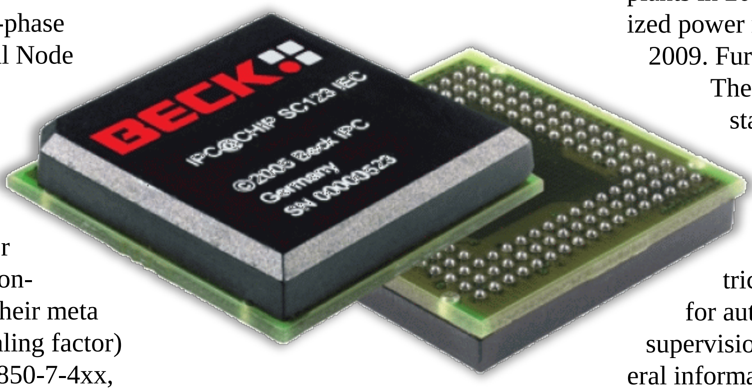
High financial and time expenditures for the implementation of IEC 61850 in control systems and other devices prevented so far a broad market penetration of the standard in the lower voltage levels and in distributed power generation. A reasonable and cost effective solution is now available with the Beck IPC@CHIP. The development of IEC 61850 conformant interfaces in power delivery systems – particularly renewable and decentralized power producers and consumers – can now be realized within very short time to market.

The standard series IEC 61850 [1] defines comprehensive information models, mechanisms for information exchange, a configuration language and a mapping to general communication protocols. It offers a unique and common architecture for many application domains [2,3]. The aspects are mainly the following:

General and user-specific information models like measured values of the voltage of the three-phase electrical network (Logical Node MMXU), rotor speed of a wind turbine (WTUR), switching position of the circuit-breaker (XCBR), temperature measured value (STMP) or the values of a PID loop controller (FPID) as well as their meta data (like SI-Units and scaling factor) are in the focus of IEC 61850-7-4xx, IEC 61850-7-3 and IEC 61400-25-2) [4-7].

Abstract methods for the change of information (ACSI - abstract communication service interface, according to IEC 61850-7-2) offer the most crucial services for the direct access (Read, Write, and Control), Reporting (spontaneous and cyclic; with monitoring of limits and changes), sequences of events (SoE: Sequence OF events), event archives in the devices (Logging), control, configuring and retrieving the self-description of the devices (IEC 61850-7-2 and IEC 61400-25-3) [8,9]. In addition two methods are defined for the transmission of critical information in real time: for the fast exchange of sensor data (typical several thousand sampled values per second of currents and voltages) and the fast exchange of critical information within the millisecond range.

Mapping of the abstract information and exchange methods to the application layer protocols as defined



in IEC 61850-8-1, IEC 61850-9-1, IEC 61850-9-2, and IEC 61400-25-4 [10-13]. The communication stacks for transferring the messages use among other protocols mainly TCP/IP and Ethernet (IEC 61850-8-1 and IEC 61400-25-4).

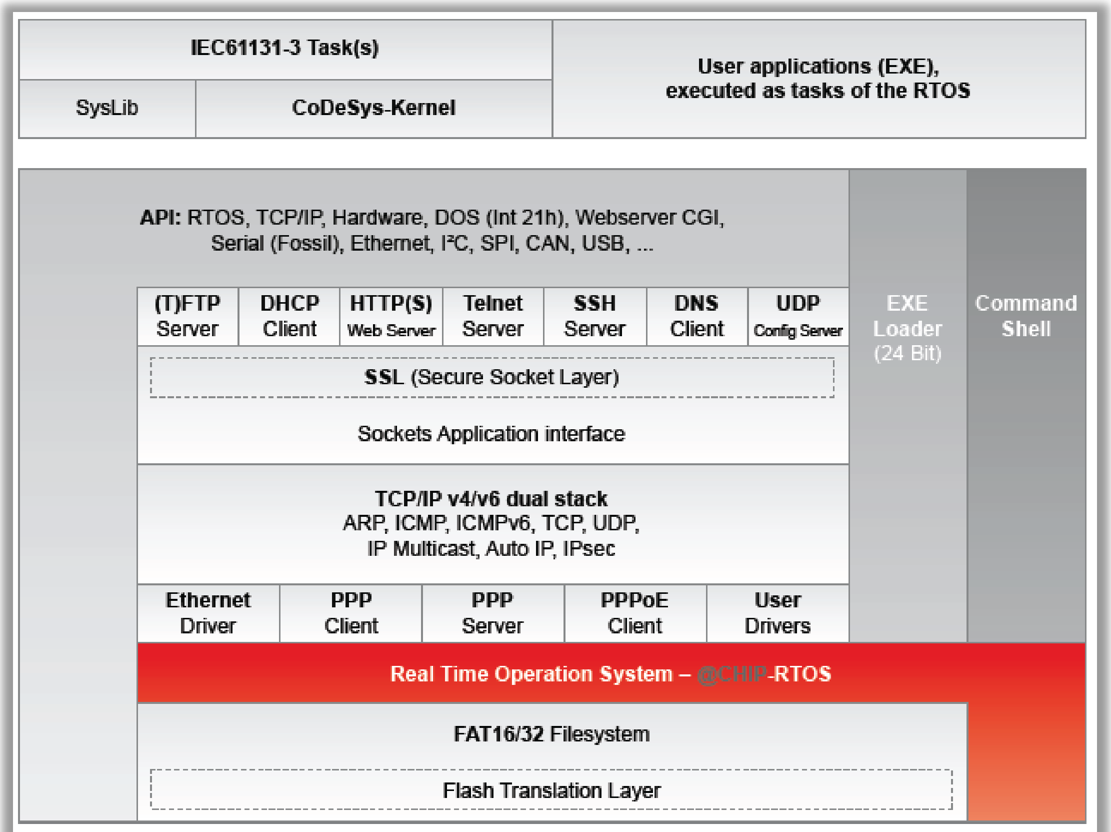
XML based configuration language for the complete description of a plant (IEC 61850-6) and a single device: Description of the plant topology, communication, information models, linkage of sources of information to destinations, and the binding of the models to the process and to internal equipment structures [14].

Toolbox for Multivendor systems

The standard series consists of 14 parts; published between 2003 and 2005. It is a tool box for building multivendor systems for substation protection and automation. The first extensions were published in 2007 in IEC TC 88 (Wind Turbines) with IEC 61400-25-4 for wind power plants. Extensions for hydro-electric power plants in 2007 and for the decentralized power resources followed in 2009. Further parts are in process.

The first fourteen parts of the standard series and the extensions (above all the information models) cover crucial information needed in the electrical power supply network for automation, protection and supervision. Meanwhile many general information models for the applications in general automation domains are defined in the second edition of part IEC 61850-7-4. One of the most crucial and interesting parts is part IEC 61850-90-7 (IEC 61850 object models for inverters in distributed energy resources (DER) systems).

The issue of the information exchange by means of MMS (Manufacturing Message Specification - ISO 9506) and ASN.1 (Abstract Syntax Notation 1 - ISO 8824/8825) – although it is required in the communication stacks of devices – however it is of subordinated importance, if it concerns the contents of the standards. With the realization of standard-



IPC@CHIP® RTOS architecture

conformant products MMS is key because before two devices can communicate in the client-server relation there is a need of an MMS stack on each end of the communication channel – a server and a client.

Applications of IEC 61850

IEC 61850 is used globally in many thousand plants of medium and high voltage networks. All large manufacturers of substations such as ABB, AREVA, GE, Siemens, Toshiba and many smaller manufacturers use IEC 61850 as the preferred solution. In the context of many Smart Grid projects in North America, in Asia and Europe IEC 61850 is regarded as the most important protocol standard. Beyond that, IEC 61850 – particularly because of the uniform and recently defined general information models – is used increasingly also in industrial and process automation systems.

In the contrast to the fieldbus standard IEC 61158 with (too) many standardized solutions in a single standard with almost 100 parts, IEC 61850 has only one protocol stack for TCP/IP-based client-server communication and two simple protocols using native switched Ethernet for real time communication. In many enterprises IP networks are very common. This allows directly and without special modifications to directly employ MMS based client-server communication. All information models of all devices can be accessed this way, fast and without detours from everywhere – also safely with TLS (Transport Layer Security). TLS is required by IEC 61850-8-1 and selected in IEC 62351 – the sister standard of IEC 61850.

These solutions could be achieved so far mostly just by very high financial and temporal expenditures. The implementation of the MMS client-server stack was usually realized by purchasing extensive and relatively expensive licensed software packages. The expected expenditures for porting the licensed MMS software and/or the development of MMS software were estimated so high that in many cases the application of IEC 61850 was questioned – especially when it comes to small devices.

Although the focus of the application of the standard series clearly is on the models and configuration language (which are independent of MMS), the implementation mainly depends on the acceptance of MMS. This is especially true for the use of IEC 61850 in simpler applications. MMS is however necessary for standard-conformant information exchange between clients and servers – no question. IEC 61850 does not support alternative protocols fortunately! The question is now, are there alternative MMS implementations – above all – for the application of IEC 61850 for simple applications? Yes! Thanks to the efforts taken by SystemCorp (Bentley, Western Australia) [15] and Beck IPC (Pohlheim, Germany) [16] to implement IEC 61850 on a small footprint of a simple embedded controller: IEC61850@CHIP.

Chip based solution

At the Hanover fair 2010 Beck IPC presented the integrated solution for IEC 61850 successfully in co-operation with SystemCORP Pty Ltd. (Bentley, Western Australia) at the Beck IPC booth. The embedded controller demonstrated was an industrial proven component that is on the market for five years in industrial automa-

tion systems. It is a modular controller chip (IPC@CHIP). The resonance of the many hundred booth visitors exceeded expectations of all involved people of Beck and SystemCorp by far. In the meantime there are many applications all over that use the Beck IPC controller.

The substantial advantage of the embedded controller based solution is its high efficiency, performance, and the minimum expenditure needed for the implementation of IEC61850-based interfaces for clients and servers. This platform is very economical. From a programming point of view it is a PC and a PLC (programmable logic controller) – it can be programmed with C/C++ as well as with IEC 61131-3 (CoDeSys). All license costs for the compilers and the IEC 61850 communication stack and API (application program interface) are already included in the chip price. Products based on other stacks may require a run-time license fee for the IEC

61850 stack per device that is more expensive than the complete chip. Not to speak about the needed efforts of porting the stack software to your platform (HW and SW). This may take many months and even years – the author has been contacted by many companies that complained that IEC 61850 is quite complex and too expensive to implement (even when using available third party software).

The IPC@CHIP SC123 and SC143 are equipped with the real-time and multitasking operating system IPC@CHIP-RTOS. The following software functions are integrated in the RTOS of the SC123/SC143: IEC 61850, IEC 61400-25, TCP/IPv6/IPv4, SSL, SSH, IPSec, PPPoE, API for CAN, IEC 61131-3 (CoDeSys, PLC), and C/C++

The software architecture is very comprehensive, compact and extremely efficient (Figure above).

The technical specification of the Chips (SC123 und SC143) could be found in the attached document.

For different applications regarding simple integration, mass production and performance three packages are offered.

IEC 61850 lite implementation

All crucial data models, communication services and the device configuration language (SCL) are realized in the stack and API running on the chip. All models from the applications protection and automation substations of any voltage level including power generation and distribution, monitoring of the power quality, automation and monitoring of hydro-electric power plants, wind turbines, decentralized energy generation such as photovoltaic, combined heat and power, diesel generators, battery storage stations, car charging stations to name just a few. The models of the new part IEC 61850-90-7 [17] are supported. The models for PV inverter have already been implemented on the SC143 by major PV inverter vendors in 2010 and 2011.

All models needed for the applications can be uploaded by a standardized SCL files by ftp on the chip. Thus the model and communication configuration is entirely accomplished by a standardized IEC 61850-6 file (SCL – system configuration language).

The IEC 61850 software stack and API can be started by the application easily as client or as server. Both applications can co-exist on the IPC@CHIP at the same time. The stack supports IEC 61850 services inclusive GOOSE and transmission of sampled values.

The SystemCorp IEC 61850 stack and API offers a very simple interface to the application software in the form of a few calls (and call-backs) like for example “Read“, “Write“, “Update”, and “Control”. Only a binding table must be defined, with which the real values of the process or of the application are bound (linked to) the information models according IEC 61850. This table is used, in order to describe the appropriate relations between model and the real world. That relation is implemented in the SCL file by private XML elements, which are interpreted by the IEC 61850 stack and API software as well as by the application software. This model (SCL file) is used for the configuration of the server **and** the client. The API docu-

mentation is available online [18]. A video explaining the use of the API function calls and the models at the server and the client side is available [19].

All services like Read, Write, Reporting, GOOSE, data sets and so on are completely configured by a SCL file. Using the same application data, one can configure at any time further logical devices, control blocks and data records simply by an extended or new SCL file transferred to the chip.

Ready to go devices

Beside the chips Beck IPC offers also ready to go modules (com.tom) – the only need is to let your application code understand the few API calls and call-backs – that’s all you need to communicate your data values with IEC 61850 models and services. The development of different gateways to, for example, CAN, IEC 60870-5-10x,

Profibus, DNP3 or Modbus can be realized in short time. This reduces the time to marked tremendously. The modules can be equipped with a data base system which implements the binding of different protocols by configuration software which is based on a Windows configuration tool. Protocol stacks for IEC 60870-5-101/104/103 and DNP3.0 are likewise available.

The com.tom solution for telecontrol is suitable for applications with existing WAN connectivity and existing process control and monitoring applications. Communication of the com.tom BASIC solutions can also directly communicate with a dedicated Web portal. The com.tom communicates with Ethernet and other existing network infrastructures like WiFi, Bluetooth, or GPRS.

The communication with the process can be realized over a serial interface or over digital inputs or outputs. The digital inputs and outputs can be processed additionally with simple PLC functions.

The integrated Web server on the com.tom BASIC provides also a simple WEB based editor for a Web PLC that can be used to for simple control algorithms.

Development Kit Beck IPC DK61

For a cost effective and fast start into the world of IEC 61850 the development kit DK61 is likely the best approach.

The IPC@CHIP DK61 development kit is a complete development system for the embedded controller IPC@CHIP SC123 and SC143.

It contains the Paradigm C/C++ compiler with IPC@CHIP RTOS debugger and many further tools, which can be applied for the simplified development of C/C++ and IEC 61131-3 (CoDeSys) applications on the Embedded controller SC123 and SC143.

Despite the comprehensive hardware of the development board, which makes all interfaces of the SC123 and SC143 available, a start-up is possible within minutes rather than hours or days. This is due to the installed RTOS, the „Getting Started“ manuals and the examples that come with the DK61 development kit.

The extensive hard and software equipment allow a fast and efficient development of customized applications within hours and days.

All aspects of the IEC 61850 Solution on the IPC@CHIP, described above, are available and directly applicable also on the development kit. An extensive example of use with a model for process values (inputs and outputs), with reporting and GOOSE is contained in the kit. The source code of the C application program is likewise provided. C programmers can immediately begin with the programming of their application and – as described in the example – communicate their data values within a short time by IEC 61850.

Special knowledge of MMS and ASN.1 is not necessary – applications can directly use the simple API. The development of an extensive protocol stack and a user interface are not needed – the focus is now on the application of the standard series for the realization of smarter power delivery systems.

The SystemCorp stack and API is available on various embedded controller platforms, e.g., Arm 9 or Arm 11 controllers that run on Linux. The stack and API could be ported to all major platforms; DLLs and libraries for Windows and PCs are also available.

Reduce time to market

Using the approaches of SystemCorp (Lite Implementation and API) and Beck IPC (embedded controller with everything ready-to-go) will help you **control**, **predict** and **reduce** your **time to market**. If the market requires IEC 61850 integrated, e.g., into your PV converter or other devices for controlling or monitoring the electrical system (or other applications) there are several approaches (depending on the time to deliver the device to the customer) you could choose from:

Very short time to market
(week(s) up to a very few months):
Recommended to use the Beck IPC com.tom ready-to-go box with Beck IPC chip as external or internal module.

Short time to market
(few months):
to use the Beck IPC Chip on a small printed circuit board as internal module.

Longer time to market
(several months):
to use the SystemCorp software on the controller of an available design or design a new HW with a new powerful embedded controller, e.g., from Beck (running RTOS) or TQ (running Linux).

In the attachment there is a description of the path to a short time to market using the SystemCorp stack and API.

Further information

More information on the IPC@CHIP can be found in English and German:
http://www.beck-ipc.com

Details of the IEC 61850 Stack and API implemented on the IPC@CHIP are available at:
http://systemcorp.com.au/PIS10API

General information, trends and news on IEC 61850:
http://blog.iec61850.com

Monitoring and Control of Power Systems and Communication Infrastructures based on IEC 61850 and IEC 61400-25 (English):
http://www.nettedautomation.com/download/pub/DT-Tampa-Paper_2010-03-24.pdf

User Groups:
http://www.iec61850.ucaiug.org
http://www.USE61400-25.com

[1] IEC 61850: Communication networks and systems for power system automation. Some 20 parts by end of 2011: http://blog.iec61850.com/2012/01/status-of-parts-of-iec-61850-series.html

[2] IEC 61850 on a page (English): http://www.nettedautomation.com/standardization/IEC_TC57/WG10-12/iec61850/What-is-IEC61850.pdf

[3] Video on the basics of IEC 61850: http://blog.iec61850.com/2012/02/video-with-brief-introduction-to-iec.html

[4] IEC 61850-7-410: Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control.

[5] IEC 61850-7-420: Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes.

[6] IEC 61850-7-3: Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes.

[7] IEC 61400-25-2: Wind turbines – Part 25-2: Communications for monitoring and control of wind power plants – Information models.

[8] IEC 61850-7-2: Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI).

[9] IEC 61400-25-3: Wind turbines – Part 25-3: Communications for monitoring and control of wind power plants – Information exchange models.

[10] IEC 61850-8-1: Communication networks and systems in substations – Part 8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3.

[11] IEC 61850-9-1: Communication networks and systems in substations – Part 9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link.

[12] IEC 61850-9-2: Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3

[13] IEC 61400-25-4: Wind turbines – Part 25-4: Communications for monitoring and control of wind power plants – Mapping to communication profile.

[14] IEC 61850-6: Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs.

[15] System Corp Pty Ltd, Bentley, Western Australia: http://systemcorp.com.au

[16] Beck IPC GmbH, Pohlheim: www.beck-ipc.com

[17] IEC 61850-90-7: IEC 61850 object models for inverters in distributed energy resources (DER) systems (to be published early 2012) http://blog.iec61850.com/2011/08/pv-power-to-destabilize-european-power.html

[18] API online documentation: http://systemcorp.com.au/PIS10API

[19] Video on the use of SCL files for configuration of a server and a client: http://blog.iec61850.com/2012/02/video-on-use-of-iec-61850-6-scl-to.html

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Dipl.-Ing. Karlheinz Schwarz (president of Schwarz Consulting Company, SCC, and owner of NettedAutomation GmbH; Karlsruhe/Germany) specializing in distributed automation systems. He is involved in many international standardization projects (IEC 61850 – utility automation, DER, hydro power, IEC 61400-25 – wind power, IEC 61158 - Fieldbus, ISO 9506 – MMS, …) since 1984. He is engaged in representing main industry branches in the international standardization of real-time information modeling, configuration, and exchange systems. Core services are consulting and training of utility personal, system integrators, consultants, and vendors. He has educated more than 2,750 experts from more than 700 companies and more than 70 countries. The training courses are considered to be outstanding. Mr. Schwarz is a well-known authority on the application of mainstream information and communication technologies in the utility industry and general automation domain.

NettedAutomation GmbH
Information & Communication Systems

Annex

What does IEC 61850-90-7 (IEC 61850 object models for inverters in distributed energy resources (DER) systems) provide?

The following is based on IEC 61850-90-7 (final draft 2012-02)

The main purpose of the document is to define **information models** of the known functions of PV inverters. These functions are those that are **already implemented** in today's controllers of inverters installed all over. The information models defined in IEC 61850-90-7 just define **standard names** of the "signals" found in most PV inverters – the standard just follows the market. The standard also provides a **common way to access and distribute the information** needed to configure, control, and monitor real inverters. Due to the single model and communication profile (independent of the vendors) it is easy to communicate with the inverters of many different vendors with one single standard.

The advent of decentralized electric power production is a reality in the majority of the power systems of the world, driven by the need for new types of energy converters to mitigate the heavy reliance on non-renewable fossil fuels, by the increased demand for electrical energy, by the development of new technologies of small power production, by the deregulation of energy markets, and by increasing environmental constraints.

These pressures have greatly increased the demand for Distributed Energy Resources (DER) systems which are interconnected with distribution power systems, leading to high penetrations of these variable and often unmanaged sources of power. No longer can they be viewed only as "negative load". Their large numbers, their unplanned locations, their variable capabilities, and their fluctuating responses to both environmental and power situations make them difficult to manage, particularly as greater efficiency and reliability of the power system is being demanded.

This paradigm shift in management of power systems can be characterized by the following issues:

The numbers of interconnected DER systems are increasing rapidly. The advent of decentralized electric power production is a reality in the majority of power systems all over the world, driven by many factors:

- The need for new sources of energy to mitigate the heavy reliance on externally-produced fossil fuels.
- The requirements in many countries and US states for renewable portfolios that have spurred the movement toward renewable energy sources such as solar and wind, including tax breaks and other incentives for utilities and their customers.
- The development of new technologies of small power production that have made, and are continuing to improve, the cost-effectiveness of small energy devices.
- The trend in deregulation down to the retail level, thus incentivizing energy service providers to combine load management with generation and energy storage management.
- The increased demand for electrical energy, particularly in developing countries, but also in developed countries for new requirements such as Electric Vehicles (EVs).
- The constraints on building new transmission facilities and increasing environmental concerns that make urban-based generation more attractive.

These pressures have greatly increased the demand for Distributed Energy Resources (DER) systems which consist of both generation and energy storage systems that are interconnected with the distribution power systems.

DER systems challenge traditional power system management. These increasing numbers of DER systems are also leading to pockets of high penetrations of these variable and often unmanaged sources of power which impact the stability, reliability, and efficiency of the power grid. No longer can DER systems be viewed only as "negative load" and therefore insignificant in power system planning and operations. Their unplanned locations, their variable sizes and capabilities, and their fluctuating responses to both environmental and power situations make them difficult to manage, particularly as greater efficiency and reliability of the power system is being demanded.

At the same time, DER devices could become very powerful tools in managing the power system for reliability and efficiency. The majority of DER devices use inverters to convert their primary electrical form (often direct current (dc) or non-standard frequency) to the utility power grid standard electrical interconnection requirements of 60Hz or 50Hz and alternating current (ac). Not only can inverters provide these basic conversions, but inverters are also very powerful devices that can readily modify many of their electrical characteristics through software settings and commands, so long as they remain within the capabilities of the DER device that they are managing and within the standard requirements for interconnecting the DER to the power system.

DER systems are becoming quite "smart" and can perform "autonomously" most of the time according to pre-established settings or "operating modes", while still responding to occasional commands to override or modify their autonomous actions by utilities and/or energy service providers (ESPs). DER systems can "sense" local conditions of voltage levels, frequency deviations, and temperature, and can receive emergency commands and pricing signals, which allow them to modify their power and reactive power output. These autonomous settings can be updated as needed. To better coordinate these DER autonomous capabilities while minimizing the need for constant communications, utilities and ESPs can also send schedules of modes and commands for the DER systems to follow on daily, weekly, and/or seasonal timeframes.

Given these ever more sophisticated capabilities, utilities and energy service providers (ESPs) are increasingly desirous (and even mandated by some regulations) to make use of these capabilities to improve power system reliability and efficiency.

Inverter configurations and interactions

Bulk power generation is generally managed directly, one-on-one, by utilities. This approach is not feasible for managing thousands if not millions of DER systems.

DER systems cannot and should not be managed in the same way as bulk power generation. New methods for handling these dispersed sources of generation and storage must be developed, including both new power system functions and new communication capabilities. In particular, the "smart" capabilities of inverter-based DER systems must be utilized to allow this power system management to take place at the lowest levels possible, while still being coordinated from region-wide and system-wide utility perspectives.

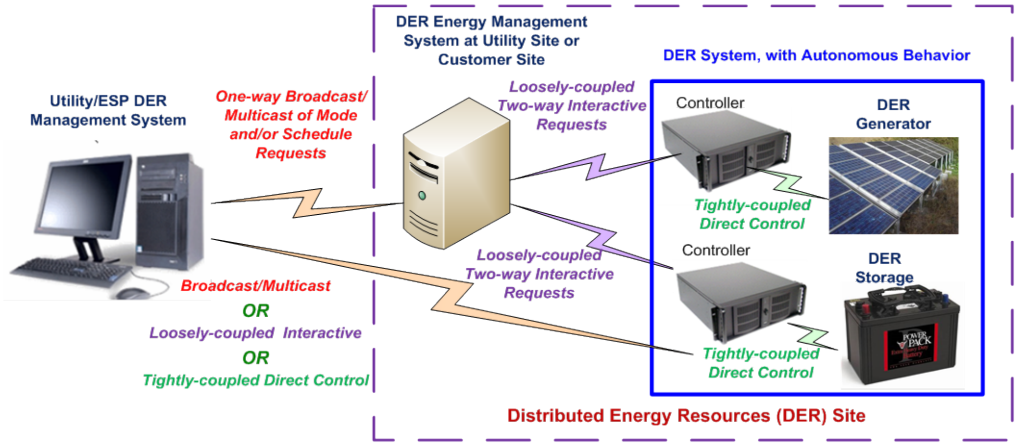
This "dispersed, but coordinated intelligence" approach permits far greater efficiencies, reliability, and safety through rapid, autonomous DER responses to local conditions, while still allowing the necessary coordination as broader requirements can be addressed through communications on an as-needed basis. Communications, therefore, play an integral role in managing the power system, but are not expected or capable of continuous monitoring and control. Therefore the role of communications must be modified to reflect this reality.

Inverter-based DER functions range from the simple (turn on/off, limit maximum output) to the quite sophisticated (volt-var control, frequency/watt control, and low-voltage ride-through). They also can utilize varying degrees of autonomous capabilities to help cope with the sophistication.

At least **three levels of information exchanges** are envisioned:

- **Tightly-coupled interactions** focused on direct monitoring and control of the DERs with responses expected in "real-time".
- **Loosely-coupled interactions** which request actions or "modes" that are interpreted by intelligent DER systems for undertaking **autonomous reactions** to local conditions or externally provided information. Information is then sent back on what actions they actually performed.
- **Broadcast/multicast** essentially one-way requests for actions or "modes", without directly communicated responses by large numbers of DERs.

These different DER management interactions are shown in the following figure.



DER Management: Interactions between Components

Inverter functions

Inverter functions range from the simple to the complex. Most inverter functions are based on settings or curves that allow them to respond autonomously to local conditions, while some require direct control commands:

- **Immediate control functions** for inverters
  - Function INV1: connect / disconnect from grid
  - Function INV2: adjust maximum generation level up/down
  - Function INV3: adjust power factor
  - Function INV4: request active power (charge or discharge storage)
  - Function INV5: request action through a pricing signal

- **Volt-var management modes**
  - Volt-var mode VV11: available vars mode with no impact on watts
  - Volt-var mode VV12: maximum var support mode based on maximum watts
  - Volt-var mode VV13: static inverter mode based on settings
  - Volt-var mode VV14: passive mode with no var support

- **Frequency-watt management modes**
  - Frequency-watt mode FW21: high frequency reduces active power or low frequency reduces charging
  - Frequency-watt mode FW22: constraining generating/charging by frequency
  - Frequency-watt mode FW23: watt generation/absorption counteractions to frequency deviations

- **Dynamic reactive current support during abnormally high or low voltage levels**
  - Dynamic reactive current support TV31: volt-var support during abnormally high or low voltage levels

- **Functions for "must disconnect" and "must stay connected"**
  - "Must disconnect" MD curve
  - "Must stay connected" MSC curve
  - Reconnect settings

- **Watt-power factor management modes**
  - Watt-power factor WP41: feed-in power controls power factor (parameters)
  - Watt-power factor WP42: feed-in power controls power factor (curves)

- **Voltage-watt management modes**
  - Voltage-watt mode VW51: smoothing voltage deviations by watt management
  - Voltage-watt mode VW52: charging by voltage

- **Non-power-related modes**
  - Temperature-function mode TMP: ambient temperature indicates function
  - Pricing signal-function mode PS: pricing signal indicates function to execute

- **Parameter setting and reporting**
  - Function DS91: modify inverter-based DER settings
  - Function DS92: event/history logging
  - Function DS93: status reporting
  - Function DS94: time synchronization

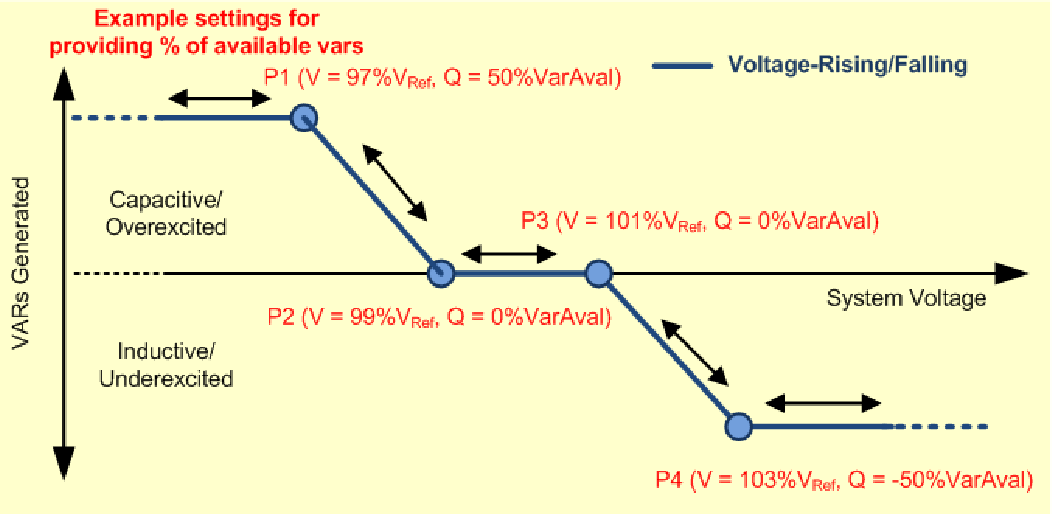
It is expected that additional functions will be added in the future, for instance for handling intentional and unintentional islanding.

The following figure provides an example of volt-var settings for this mode. It is assumed that the var value between VMin and V1 is the same as for V1 (shown as 50% VArAval, in this example). The equivalent is true for the var value between V4 and VMax (which is assumed to be 50% VArAval in this example).

Example Settings

Voltage Array (% VRef)		VAr Array (% VArAval)	
V1	97	Q1	50
V2	99	Q2	0
V3	101	Q3	0
V4	103	Q4	-50

VAr Ramp Rate Limit – fastest allowed decrease in VAR output in response to either power or voltage changes	50 [%VArAval/second]
VAr Ramp Rate Limit – fastest allowed increase in VAR output in response to either power or voltage changes	50 [%VArAval/second]
The time of the PT1 in seconds (time to accomplish a change of 95%).	10 seconds
Randomization Interval – time window over which mode or setting changes are to be made effective	60 seconds



The information needed for this application is defined in corresponding Logical Nodes of IEC 61850-90-7 and IEC 61850-7-4. From an implementation point of view the standard just provides an external view of the inverter internal information and information exchange (**for the inverter functions, e.g., volt-var control**). It could be assumed that the functions are **already implemented in the existing inverter controller**.

Italian Norm about to Require IEC 61850 for almost all PV Inverters

The CEI (Comitato Elettrotecnico Italiano) has published in December 2011 a norm that strongly proposes to use IEC 61850 to connect PV inverters (>1kV and >6 kW) to external systems (grid operator, …):

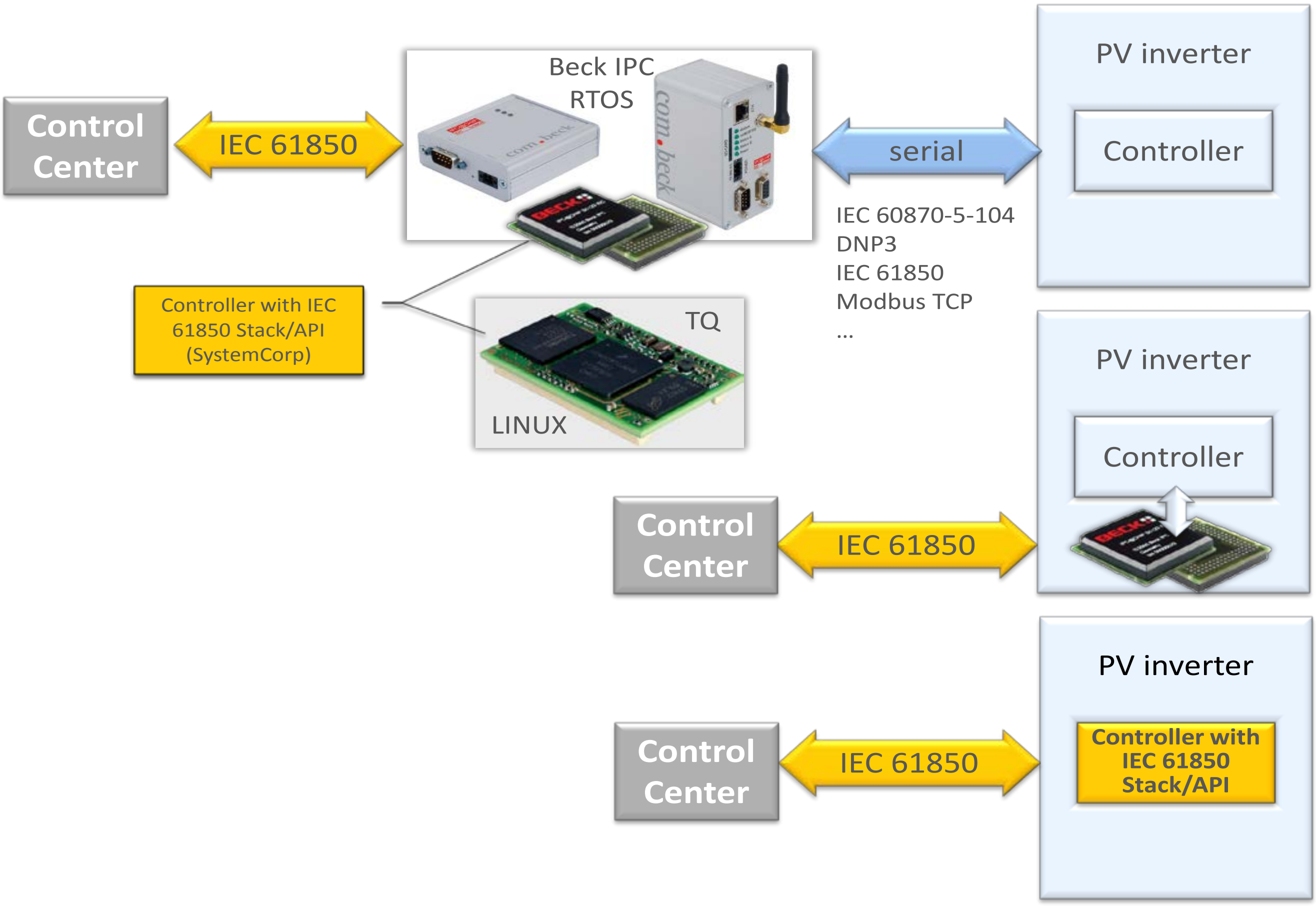
CEI 0-21 "Regola tecnica di riferimento per la connessione di Utenti attivi e passivi alle reti BT delle imprese distributrici di energia elettrica".

"Reference technical rules for the connection of active and passive users to the LV electrical Utilities"

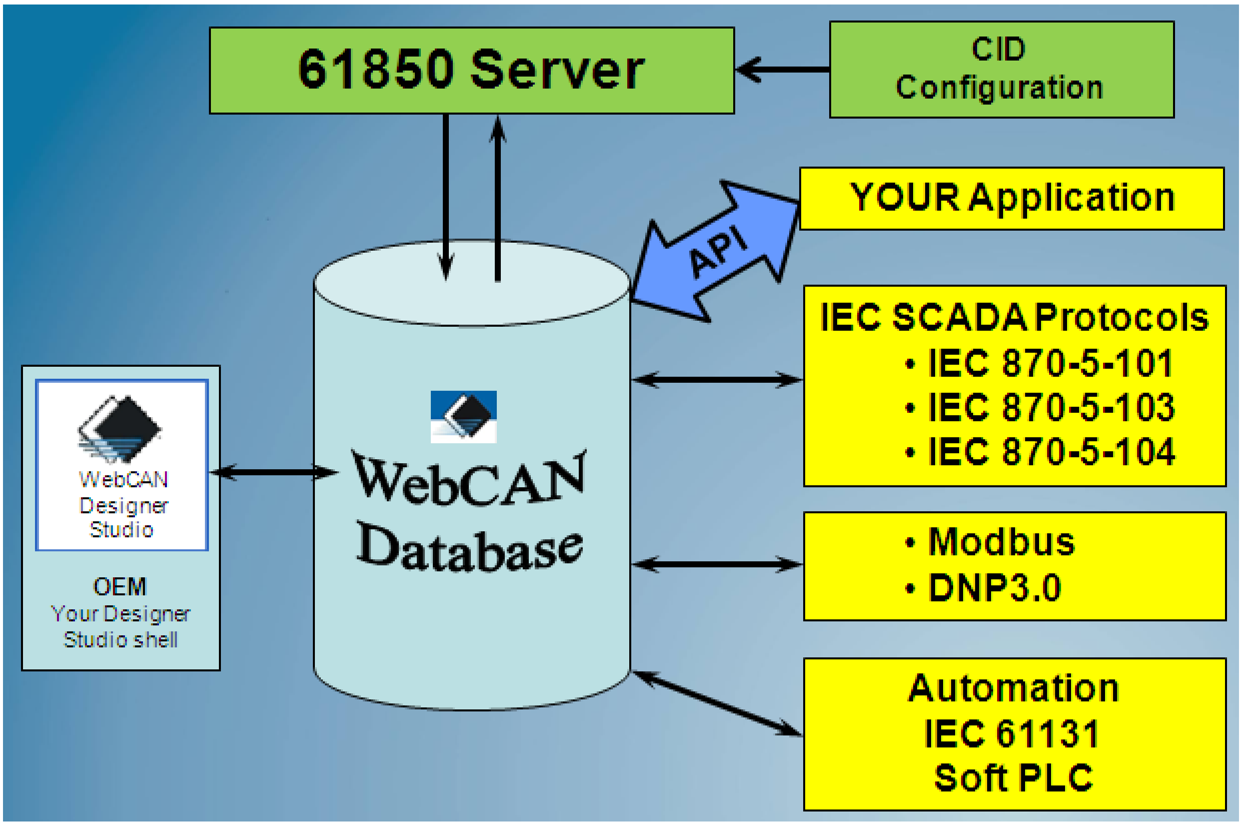
The document IEC 61850-90-7 "IEC 61850 object models for inverters in distributed energy resources (DER) systems" is about to published in a few months. This document is a perfect fit for the needs of PV inverters.

The Information Model defined in IEC 61850-90-4 has been implemented on the Beck IPC SC 143 controller by a well-known inverter company.

Various implementation architectures using gateways



Gateway Architecture of SystemCorp, Bentley (AU) - these solutions run on many platforms



SCALABLE IEC 61850 SOFTWARE STACK

A new enormously scalable, lively, and affordable IEC 61850 Software Stack is now available for Smart Grid and other application domains. SystemCORP Embedded Technology Pty Ltd offers a Lite solution across various operating systems and hardware platforms. The new stack offers an extremely easy to use API (Application Programming Interface) creating instant results for software programmers.

By Detlef Raddatz, SystemCORP Embedded Technology, Australia and Karlheinz Schwarz, Netted Automation, Germany

IEC 61850 is *THE* most successful International Standard for protection, control, and automation systems in substations. The standard is intended to be used in centralised and distributed power generation as well as in distribution, factory, and process automation domains.

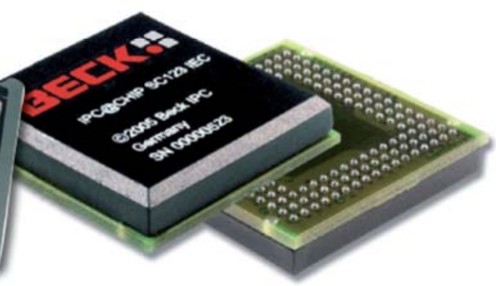
IEC 61850 is more than just a date communication protocol. The standard defines information models, information exchange services for real-time and SCADA applications in substation automation systems, renewable energy generation and power distribution systems. The configuration of systems and devices is standardised using a standardised XML file.

COMMUNICATION STACK

High costs for implementing IEC 61850 is one of the crucial factors for the standard being used in relatively few applications outside substations. This has now changed. SystemCORP Embedded Technology has developed a portable IEC 61850 communication stack suitable for different operating systems including Microsoft Windows™ and LINUX, and applicable for any application domain including protocol gateways for IEC 870-5101/103/104 and DNP3.0.

CONCEPT OF A SIMPLE API

The API provided by the stack is extremely easy to use by application programmers. It hides all details of the underlying protocols like MMS (ISO 9506). The operational API services are Set, Get, and Update. The information model of the device and the binding of the real world information to the model is completely configured by a standardised XML file (ICD file – IED Capability Description) engineered with the tool "ICD Designer". Any standardised or extended model can be created.



The stack with the simple API has been ported to multiple system platforms.

SINGLE CHIP SOLUTION

The stack has been ported onto SoC (System on Chip) processor specific operating systems such as the Beck-IPC@CHIP™. The SC143 SoC is a powerful but also an inexpensive choice for many IEC 61850 real-time applications. The controller provides the complete IEC 61850 (IEC 61400-25) MMS, GOOSE and Sampled Value communication stacks. The stacks and the device data models are configurable by a standard SCL File (IEC 61850-6) uploaded by FTP to the controller. Applications can be developed in C/C++ and IEC 61131-3. The focus shifts from communication (especially MMS) programming to user applications. The development of affordable standard conformant interfaces for distributed energy resources can now be shortened to days or weeks – from months and years.

DEVELOPMENT KIT APPLICATIONS

The fastest way getting started with real-time applications is developing application on the Beck-IPC@CHIP™ using the development kit DK61. The kit comes with all hardware and software components (including all licenses for C/C++ and IEC 61131-3 compiler and IEC 61850 software).

A "Getting started" CD ROM comes with application examples (including source code).

IEC 61850 AND LINUX

When using the IEC 61850 software stack on LINUX systems the target hardware platform and software development tool chain play an important role when porting packet driver software for GOOSE messaging. Currently the stack supports ARM™, Freescale Coldfire™ and X86 based LINUX systems.

MICROSOFT WINDOWS™

A free IEC 61850 evaluation DLL (IEC 61400-25) as a Starter Kit for Client/Server and Publisher/Subscriber is now available. The Kit contains executable software, C source code and .Net Applications (projects) as well as "Getting started manuals". The Protocol Integration Stack (PIS-10) DLL provides the same simple API. Client and server (publisher/subscriber – GOOSE) install on one or different PCs.

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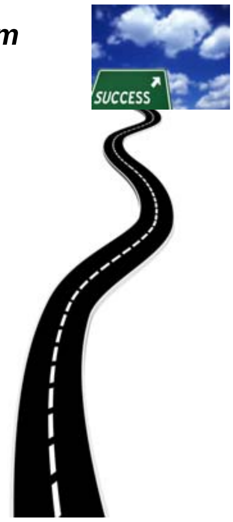
PIS-10 IEC 61850 Product Road Map



The SystemCORP Embedded Technology PIS-10 IEC 61850 Products are accessible by 5 Routes:

1. ***Hardware Specific Application – ARM, Coldfire, Power PCs***
2. ***Linkable IEC 61850 Stack Library using Linux on your Product Platform***
3. ***IEC 61850 DLL on Windows PC***
4. ***IEC 61850 Linux X86 Library – PC platform***
5. ***Beck-IPC SC143 IEC 61850 Single Chip Solution***

With any Route choose the IEC 61850 implementation – "Lite" or "eXtended":

ICE 61850 Server/Client Application "Lite"
MMS

OR

ICE 61850 Server/Client Application "eXtended"		
MMS	GOOSE	Sample Value

Choose Server and/or Client:

- ***Server and Client,***
- ***Server only, or***
- ***Client only***

After choosing the IEC 61850 Route, Lite or eXtended, and Server and/or Client you'll need:

- ***ICD Designer,***
- ***Annual Maintenance Contract (included Free in first year), and***
- ***Training***

The SystemCORP Embedded Technology IEC 61850 PIS-10 Route:	**The Alternative Route to Your IEC 61850 Embedded Applications:**
☑ API provides simple integration with IEC 61850	☐ API provides complex integration with IEC 61850
☑ We maintain the PIS-10 Library	☐ You maintain your own software
☑ Low Development Expenses	☐ Large Start-up Development Expenses
☑ Per platform license at Low Price	☐ Per product license at High Cost
☑ Less resources to develop and deploy product	☐ Longer Start-up development time and longer time to market
☑ Training: API and Online Manual + Personalized On-site Training	☐ Training: You get a DVD + Manual
☑ We Port to your System	☐ You Port to your System
☑ Low-cost annual maintenance agreement	☐ Expensive product-based annual maintenance contracts
☑ Start developing your IEC 61850 application NOW	☐ Takes months just to start developing your actual IEC 61850 application
☑ SystemCORP has own KEMA certified substation control products	☐ Only customer certified products
☑ Highly customizable single-chip solution available at a low cost	☐ Only Protocol Data Gateways with pre-defined communication protocols
☑ Downloadable Demo 61850 Tools	☐ No demo tools provided

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■ ■ ■

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- IEC 61400-25
- SCL Tool
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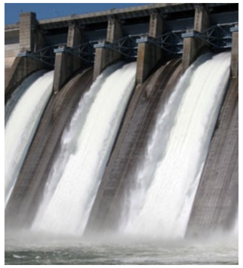
BECK THE POINT OF SYNERGY



IEC 61850 Lite Implementation

IEC 61850 Client/Subscriber and Server/Publisher Integration on the IPC@CHIP®.

The IPC@CHIP® embedded platform facilitates the quick and cost-effective integration of your information into a standardized format.

Secure Communication

IEC 61850 and IPC@CHIP® for simple to complex applications

Hardware specifikation SC1x3

- CPU SC186-EX / 96 MHz
- RAM (free) 8 MByte (approx. 7 MB)
- Flash memory SC123: 2 MByte (approx. 1 MB)
  SC143: 8 MByte (approx. 7 MB)
- Ethernet 1 x 10/100BaseT / PHY, 1 x MII
- Temp. range -25 to 85°C

IEC 61850 Software implementation

- MMS over TCP/IP
- GOOSE Publisher/Subscriber
- Sampled Values
- Data sets
- Buffered reporting
- Unbuffered reporting
- Control
- Data Logging
- Time synchronization via SNTP
- File Transfer via MMS and FTP

Programming software included

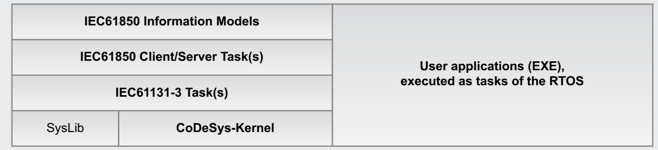
Program your application in C/C++ or IEC 61131-3 and configure the IEC 61850 API with standard SCL (System Configuration Language).

Additional benefits

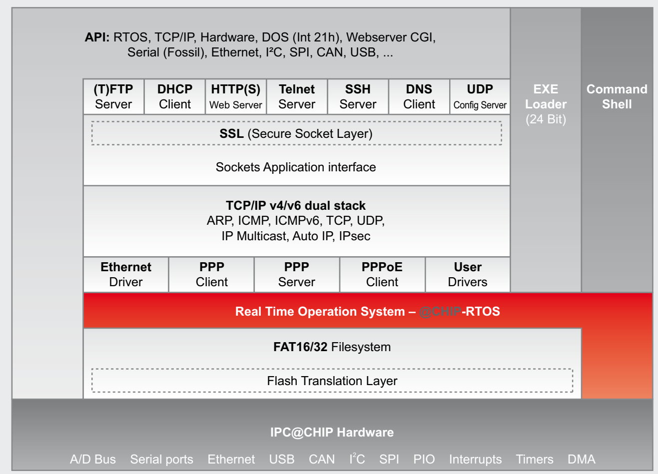
Useful source code sample files are available for free download from **www.beck-ipc.com/examples** :

- CAN
- Industrial communication (Modbus, EasyIP ...)
- etc.

Software implementation



IPC@CHIP® RTOS architecture



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IEC 61131-3 CoDeSys

EtherCAT EtherCAT Technology Group

M2M Communication 

Fieldbus 

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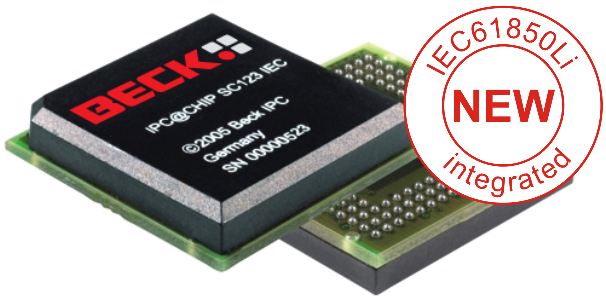
in 15 Minutes

BECK
THE POINT OF SYNERGY

Information Sheet: IPC@CHIP® SC123 / SC143



The SC123/SC143 is a further addition to the IPC@CHIP® product series, offering more performance, more memory and more functions whilst still maintaining full software compatibility with existing SC11 and SC13 controllers.

All the critical and well-established hardware functions and interfaces of SC11/SC13 are retained on the SC123/SC143, and have been enhanced with a number of additional key functions.

The new BGA design supports larger unit volumes in all aspects of industrial control and communication.

	SC123	SC143
Design	BGA177, 25x25x5mm	
CPU	SC186-EX / 96 MHz	
RAM (free)	8 MByte (approx. 7 MB)	
Flash memory (free as Flash disk)	2 MByte (approx. 1 MB)	8 MByte (approx. 7 MB)
Ethernet	1 x 10/100BaseT / PHY, 1 x MII	
Serial	4 x TTL	
CAN	2 x CAN 2.0B master / slave, 1 Mbit/s	
Other interfaces	USB1.1, I2C, SPI	
I/O	31 freely prog. PIO pins (GPIO), 3 x IRQ, 2 x external DMA, 2 timer inputs/outputs, 24-bit address bus, 16-bit data bus	
Operating voltage	3.3V	
Heat dissipation	typ. 1 Watt	
Temp. range	-25 to 85 °C	

Software

Like the well-established SC11/SC13, the IPC@CHIP® SC123 and SC143 products are equipped with the IPC@CHIP®-RTOS preinstalled real-time/multi-tasking operating system and downwards compatible API interface, and are therefore software compatible with SC11 and SC13. Existing SC1x applications can be reused after recompiling with the new Paradigm C/C++ compiler contained in the Development Kit.

The following software functions are also integrated in the RTOS of the SC123/SC143:

- IPv6 (in addition to IPv4)
- Security protocol SSL, SSH and IPSec
- PPPoE
- API for CAN controller (CANopen stack available as option)
- API for elementary USB slave and host functions, support for USB storage devices (USB sticks)
- Only one RTOS version with all available functions (incl. PPP and SNMP)

IEC 61131-3 CoDeSys SP runtime system

The runtime system is derived from CoDeSys SP 2.3 and is available as C library, which makes it easy to implement individual adaptations and enhancements. Besides the extended program memory for CoDeSys-projects the runtime system contains as well a CANopen-stack and supports all 4 serial interfaces.

IEC 61850Li (Lite implementation) integrated

IEC 61850 is a standard for utility automation systems including Smart Grids. It provides a comprehensive data models, communication services, and device and system configuration language (SCL). All models for protection, monitoring and automation for substations in transmission and distribution, monitoring of power quality, hydro power plants, wind turbines, decentralized energy resources like photo voltaic, combined heat and power, diesel gensets, or batteries can be implemented and configured by SCL files.

The IEC 61850-compliant PIS-10 software stack can be launched as a client and as a server. Both applications can coexist at the same time on the IPC@CHIP®. The stack supports IEC 61850 services including GOOSE and sampled values.

More information can be obtained from our website at http://www.beck-ipc.com

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Information Sheet: IPC@CHIP® DK61 Development Kit

The Development Kit for the IPC@CHIP® SC123 and SC143 Embedded Controller

The IPC@CHIP® DK61 Development Kit is a complete development system for the new IPC@CHIP® SC123 and SC143 Embedded Controllers.

In addition to the DK60 Development Board it also contains the Paradigm C/C++ Compiler with the IPC@CHIP® RTOS Debugger and many other tools required for creating C applications on the SC123 and SC143 Embedded Controllers.

Despite the powerful hardware features of the Development Board, providing all the interfaces of the SC123 and SC143, commissioning can be carried out easily in a few minutes thanks to the pre-installed RTOS and the supplied “First Steps” guide.

The extensive hardware and software features enable customized applications to be developed quickly and efficiently.

Programming and debugging are carried out via Ethernet as standard, and are also possible via RS232 or USB.

The DK61 contains the CoDeSys IEC61131-3 software development kit for developing custom IEC61131-3 PLC applications on the SC123/SC143.

IEC 61850Li (Lite implementation) integrated

The IEC 61850-compliant PIS-10 software stack can be launched as a client and as a server. Both applications can coexist at the same time on the IPC@CHIP®. The stack supports IEC 61850 services including GOOSE and sampled values.

DK61 Development Kit

The DK61 contains all the hardware and software components required for the fast development of custom applications:

- DK60 Development Board
- Paradigm C/C++ Compiler (Beck IPC edition for IPC@CHIP®), RTOS Remote Debugger and other tools
- CoDeSys IEC61131-3 SDK for SC123/SC143
- IEC 61850 stack (Client/Server, GOOSE) and a configuration Tool based on SCL
- 100-240V / 24V plug-in power supply unit for DK60 (with adapters for international use)
- 2 PC programming cable (RS232 and USB)
- Ethernet patch cable und cross over cable
- SD card
- Practical systainer

DK60 Development Board

The development board provides on a double Eurocard all the functions required for working with the SC123/SC143 Embedded Controllers:

- SC143-IEC Embedded Controller (96 MHz, 8 MB RAM, 8 MB Flash)
- 2 x RS232 (Sub-D socket)
- 2 x RS232/TTL (connector)
- 1 x USB1.1 (can be configured as host or device)
- 2 x CAN 2.0b
- 2 x Ethernet 100Base-T
- MMC/SD and Compact Flash socket
- Extension port for custom hardware expansions
- Directly programmable I/O pins with LED indication
- Power Fail and Reset buttons
- Power supply, 24 VDC input
- Binding of real data to IEC 61850 models by CID file loaded to controller

Read more about the IPC@CHIP® product range at: http://www.beck-ipc.com

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Test Case			KEMA Verdict	Short Test Description	Function is Integrated in PIS-10 Stack	Function in User Application	Comments
Documentation	**G**	**A**					
Doc1	M	A	PASSED			yes	Template can be provided by SET
Doc2	M	A	PASSED	Verify MICS describes the semantics of all non-standard Logical Nodes, Data Objects, Data Attributes and enumerations		yes	Template can be provided by SET
Configuration	**G**	**A**					
Cnf1	M	A	PASSED	Test if the ICD configuration file conforms to the SCL document type definition or schema (IEC 61850-6)		yes	User to create and conform to model
Cnf2	M	A	PASSED	ICD == MMS datamodel		yes	
Cnf3	M	A	PASSED	Change configuration		yes	Use ICD Designer to extract ICD from CID
Cnf4	M	A	PASSED	Check if the server capabilies in the ICD "services" section do match with the IED capabilites		yes	Manually to be added to configuration
Cnf5	M	A	PASSED	For fixed control model verify the ICD correctly initializes the ctlModel values for all controllable objects		yes	User to create and conform to model
Modelling	**G**	**A**					
Mdl1	M	A	PASSED	Verify presence of mandatory objects for each LN		yes	ICD Designer has auto-error checker
Mdl2	M	A	PASSED	Verify presence of conditional presence true objects for each LN		yes	User to define
Mdl3	M	A	PASSED	Verify non-presence of conditional presence false objects.		yes	User to define
Mdl4	M	A	PASSED	SCSM name length and object expansion		yes	**User to define**
Mdl5	M	A	PASSED	SCSM organisation of functional components		yes	User to define
Mdl6	M	A	PASSED	SCSM concerning naming of control blocks and logs		yes	User to define
Mdl7	M	A	PASSED	Verify data type of all objects for each LN.		yes	User to define
Mdl8	M	A	PASSED	Verify data attribute values from the device are in specified range (this is a continuous effort during the whole conformance test)		yes	User to define
Mdl9	M	A	PASSED	Data model extensions should be implemented according to the extension rules in IEC 61850-7-4 Annex A.		yes	User to define
Mdl10	M	A	PASSED	Check if the order of the data attributes within the Data Object types match with IEC 61850-7-3		yes	User to define
Mdl11	M	A	PASSED	Check if the order of the data objects within the Logical Node types match with IEC 61850-7-4		yes	User to define
1: Basic	**G**	**A**					
Ass1	M	A	PASSED	Associate and release a TPAA association	✓ Yes		
Ass2	M	A	PASSED	Associate and client-abort TPAA association	✓ Yes		
Ass3	M	A	PASSED	Associate with maximum number of clients simultaneously	✓ Yes		
AssN2	M	A	PASSED	Incorrect association parameters	✓ Yes		
AssN3	M	A	PASSED	Set up maximum+1 associations, last associate is refused	✓ Yes		
AssN4	M	A	PASSED	Disconnect the communication interface, the DUT should detect link lost within a specified period	✓ Yes		
AssN5	M	A	PASSED	Interrupt and restore the power supply	✓ Yes		
Srv1	M	A	PASSED	GetServerDirectory(LOGICAL-DEVICE)	✓ Yes		
Srv2	M	A	PASSED	GetLogicalDeviceDirectory	✓ Yes		
Srv3	M	A	PASSED	GetLogicalNodeDirectory(DATA)	✓ Yes		
Srv4	M	A	PASSED	GetDataDirectory / GetDataDefinition / GetDataValues	✓ Yes		
Srv5	M	A	PASSED	GetDataValues request with the maximum number of data values	✓ Yes		
Srv6	C	A	PASSED	SetDataValues of writable attributes	✓ Yes		
Srv7	C	A	PASSED	SetDataValues request with the maximum number of data values	✓ Yes		
Srv8	C	A	PASSED	Request GetAllDataValues for each functional constraint	✓ Yes		
SrvN1abcd	M	A	PASSED	a: – GetLogicalDeviceDirectory with wrong parameters b: – GetLogicalNodeDirectory with wrong parameters c: – GetAllDataValues with wrong parameters d: – GetDataValues with wrong parameter	✓ Yes		
SrvN1e	C	A	PASSED	– SetDataValues with wrong parameter	✓ Yes		
SrvN3	C	A	PASSED	SetDataValues with mismatching data type	✓ Yes		
SrvN4	M	A	PASSED	SetDataValues for read-only data values	✓ Yes		
2: Dataset sel	**G**	**A**					
Dset1	M	A	PASSED	GetLogicalNodeDirectory(DATA-SET) followed by GetDataSetValues and GetDataSetDirectory	✓ Yes		
Dset10a	M	A	PASSED	Compare GetDataSetValues with GetDataValues	✓ Yes		
DsetN1ae	M	A	PASSED	a = GetDataSetValues response- e = GetDataSetDirectory response-	✓ Yes		
5: Unbuf.Reporting	**G**	**A**					
Rp1	M	A	PASSED	GetLogicalNodeDirectory(URCB) and GetURCBValues	✓ Yes		
Rp2	M	A	PASSED	Optional fields	✓ Yes		
Rp3	M	A	PASSED	Trigger conditions	✓ Yes		
Rp4	M	A	PASSED	General Interrogation	✓ Yes		
Rp7	M	A	PASSED	Buffering events in one report	✓ Yes		
Rp8	C	A	PASSED	Verify the DUT can send reports with data objects	✓ Yes		
Rp9	C	A	PASSED	Verify the DUT can send reports with data attributes	✓ Yes		
Rp10	M	A	PASSED	Verify that all buffered events shall be sent before integrity reports can be sent (IEC 61850-7-2 clause 14.2.3.2.3.3)	✓ Yes		
RpN1	M	A	PASSED	GetURCBValues with wrong parameters	✓ Yes		
RpN2	M	A	PASSED	No triggerconditions	✓ Yes		
RpN3	M	A	PASSED	IntPd=0	✓ Yes		
RpN4	M	A	PASSED	Configure URCB when enabled	✓ Yes		
RpN5	C	A	PASSED	Exclusive use of URCB	✓ Yes		
RpN6	C	A	PASSED	Configure unsupported URCB options	✓ Yes		
6: Buf.Reporting	**G**	**A**					
Br1	M	A	PASSED	GetLogicalNodeDirectory(BRCB) and GetBRCBValues	✓ Yes		
Br2	M	A	PASSED	Optional fields	✓ Yes		
Br3	M	A	PASSED	Trigger conditions	✓ Yes		
Br4	M	A	PASSED	General Interrogation	✓ Yes		
Br7	M	A	PASSED	Buffering events	✓ Yes		
Br8	M	A	PASSED	Buffering reports on lost association, buffer overflow	✓ Yes		
Br9	M	A	PASSED	Set EntryID	✓ Yes		
Br10	C	A	PASSED	Verify the DUT can send reports with data objects	✓ Yes		
Br11	C	A	PASSED	Verify the DUT can send reports with data attributes	✓ Yes		
Br12	M	A	PASSED	Verify that all buffered events shall be sent before integrity reports can be sent (IEC 61850-7-2 clause 14.2.3.2.3.3)	✓ Yes		
BrN1	M	A	PASSED	GetURCBValues with wrong parameters	✓ Yes		
BrN2	M	A	PASSED	No triggerconditions	✓ Yes		
BrN3	M	A	PASSED	IntPd=0	✓ Yes		
BrN4	M	A	PASSED	Configure BRCB when enabled	✓ Yes		
BrN5	M	A	PASSED	Exclusive use of BRCB	✓ Yes		
BrN6	C	A	PASSED	Configure unsupported BRCB options	✓ Yes		
9ab: GOOSE	**G**	**A**					
Gop1	C	A	PASSED	GetGoCBValues	✓ Yes		
Gop2	M	A	PASSED	GOOSE slow retransmit	✓ Yes		
Gop3	M	A	PASSED	Initial GOOSE stNUm=1, sqNum=1	✓ Yes		
Gop4	M	A	PASSED	GOOSE datachange - fast retransmit	✓ Yes		
Gop5	C	A	PASSED	Test mode / Test flag	✓ Yes		
Gop6	C	A	PASSED	Disable a GoCB	✓ Yes		
Gop7	M	A	PASSED	ConfRev not changed after restart	✓ Yes		
Gop10	C	A	PASSED	GOOSE with data objects (attributes are mandatory?)	✓ Yes		
GopN1	C	A	PASSED	When GoEna=TRUE, no attributes of the GoCB control block can be set except for GoEna	✓ Yes		

Test Case			KEMA Verdict	Short Test Description	Function is Integrated in PIS-10 Stack	Function in User Application	Comments
9b: GOOSE Subscribe	**G**	**A**					
Gos1	M	A	PASSED	Send single GOOSE message with new data	✓ Yes		
Gos2	M	A	PASSED	Test or NdsCom is set	✓ Yes		
Gos3	M	A	PASSED	sqNum rollover	✓ Yes		
GosN1	M	A	PASSED	Missing GOOSE	✓ Yes		
GosN2	M	A	PASSED	Double GOOSE	✓ Yes		
GosN3	M	A	PASSED	Delayed	✓ Yes		
GosN4	M	A	PASSED	Out-of-order	✓ Yes		
GosN5	M	A	PASSED	No GOOSE	✓ Yes		
GosN6	M	A	PASSED	Invalid GOOSE	✓ Yes		
12a: DOns	**G**	**A**					
Ctl2	C	A	PASSED	Test flag	✓ Yes		
CtlN3	M	A	PASSED	Operate value is the same as the actual value	✓ Yes		Current position of switch to be provided by user application, depends on hardware design
CtlN8	M	A	PASSED	Operate a direct control object twice from 2 clients		yes	User implementation according to hardware design
CtlN11	C	A	PASSED	Status remote - controls are accepted; Status local - controls are rejected		yes	User implementation according to hardware design
DOns1	M	A	PASSED	Correct Operate request		yes	User implementation according to hardware design
DOns3	M	A	PASSED	Client requests Oper resulting in Test not ok	✓ Yes		
12b: SBOns	**G**	**A**					
Ctl2	C	A	PASSED		✓ Yes		
Ctl3	M	A	PASSED		✓ Yes		User application to interact with stack internal control state machine according to hardware design via API
CtlN1	M	A	PASSED		✓ Yes		
CtlN2	M	A	PASSED		✓ Yes		
CtlN3	M	A	PASSED		✓ Yes		User application to interact with stack internal control state machine according to hardware design via API
CtlN4	M	A	PASSED			yes	User implementation according to hardware design
CtlN11	C	A	PASSED	Status remote - controls are accepted; Status local - controls are rejected		yes	User implementation according to hardware design
SBOns2	M	A	PASSED		✓ Yes		sboTimeout needs to be defined in the model and it should have a timeout value
12c: DOes	**G**	**A**					
Ctl2	C	A	PASSED	Test flag	✓ Yes		
CtlN3	M	A	PASSED	Operate value is the same as the actual value	✓ Yes		User configuration according according to functionality, executed by stack
CtlN8	M	A	PASSED	Operate a direct control object twice from 2 clients		yes	User implementation according to hardware design
CtlN11	C	A	PASSED	Status remote - controls are accepted; Status local - controls are rejected		yes	User implementation according to hardware design
DOes2	M	A	PASSED	Client requests Oper resulting in Test not ok	✓ Yes		
DOes5	M	A	PASSED	Send a correct Operate request: 1) with value change, 2) no value change, 3) intermediate value change	✓ Yes		User configuration according according to functionality, executed by stack
12d: SBOes	**G**	**A**					
Ctl2	C	A	PASSED	Test flag	✓ Yes		
Ctl3	M	A	PASSED	Select all SBO control objects and cancel them in opposite order		yes	User implementation according to hardware design
CtlN1	M	A	PASSED	Operate (without select) a SBO control object	✓ Yes		
CtlN2	M	A	PASSED	Select twice, second select should fail (or resets the select timeout)	✓ Yes		
CtlN3	M	A	PASSED	Operate value is the same as the actual value		yes	User implementation according to hardware design
CtlN4	M	A	PASSED	Select the same control object from 2 different clients		yes	User implementation according to hardware design
CtlN9	M	A	PASSED	Operate with different value then the SelectWithValue	✓ Yes		
CtlN11	C	A	PASSED	Status remote - controls are accepted; Status local - controls are rejected		yes	User implementation according to hardware design
SBOes1	M	A	PASSED	Incorrect Select	✓ Yes		
SBOes2	M	A	PASSED	SelectWithValue then 1) cancel, 2) timeout, 3) operate test not ok	✓ Yes		User configuration according according to functionality, executed by stack
SBOes3	M	A	PASSED	SelectWithValue - correct Operate request: 1) with value change, 2) no value change, 3) intermediate value change	✓ Yes		User configuration according according to functionality, executed by stack
13: Time Sync	**G**	**A**					
Tm1	M	A	PASSED	Verify the DUT supports the SCSM time synchronisation	✓ Yes		Time synchronization to be linked with time management of system firmware
Tm2	M	A	PASSED	Check report/logging timestamp accuracy matches the documented timestamp quality of the server	✓ Yes		
TmN1	M	A	PASSED	Verify that when time synchronisation communication lost is detected after a specified period	✓ Yes		

M: Mandotary
A: Applicable
C: Conditional
n/a: Not Applicable

IEC 61850 Certificate Level A[1]

International Usersgroup

No. 74100344-NMEA 11-0597

Issued to:
SystemCORP Embedded Technology Pty Ltd
Suite 4/12 Brodie Hall Drive
Technology Park
Bentley WA 6102
Australia

For the product:
WebCAN Substation Control and Monitoring System PIS-10
Firmware V1.36.00

Software runs on the Beck IPC SC143

Issued by: KEMA

The product has not shown to be non-conforming to:

IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems in substations

The conformance test has been performed according to IEC 61850-10 with product's protocol, model and technical issue implementation conformance statements: "IEC 61850 SET Protocol Implementation Conformance Statement (PICS) WebCAN, version 4.01", "IEC 61850 SET Model Implementation Conformance Statement (MICS) WebCAN, version 1.02", "IEC 61850 SET TISSUES Implementation Conformance Statement (TICS) WebCAN, version 1.02" and product's extra information for testing: "IEC 61850 SET Protocol implementation eXtra Information for testing (PIXIT) WebCAN, version 1.05".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases as defined in the UCA International Users Group Device Test procedures v2.2):

1	Basic Exchange (19/24)	12a	Direct Control (6/11)
2	Data Sets (3/6)	12b	SBO Control (8/14)
5	Unbuffered Reporting (14/18)	12c	Enhanced Direct Control (6/13)
6	Buffered Reporting (16/20)	12d	Enhanced SBO Control (11/19)
9a	GOOSE Publish (9/12)	13	Time Synchronization (3/4)
9b	GOOSE Subscribe (9/10)		

This Certificate includes a summary of the test results as carried out at KEMA in the Netherlands with UniCAsim 61850 version 3.21.02 with test suite 3.21.02 and UniCA 61850 analyzer 4.22.02. The test is based on the UCA International Users Group Device Test Procedures version 2.2. This document has been issued for information purposes only, and the original paper copy of the KEMA report: No. 74100344-NMEA 11-0596 will prevail.

The test has been carried out on one single specimen of the product as referred above and submitted to KEMA by SystemCORP. The manufacturer's production process has not been assessed. This Certificate does not imply that KEMA has certified or approved any product other than the specimen tested.

Arnhem, 15 Maart 2011

M. Adriaensen
Regional Director Management & Operations Consulting

Robin Massink
Test Engineer

1 Level A - Independent Test lab with certified ISO 9000 or ISO 17025 Quality System