THE USE OF IEC 61400-25 STANDARD TO INTEGRATE WIND POWER PLANTS INTO THE CONTROL OF POWER SYSTEM STABILITY

E. SAN TELMO, I. CANALES, J. L. VILLATE, E. ROBLES, S. APIÑANIZ

ROBOTIKER , Parque Tecnológico Edif. 202 48170 Zamudio (Bizkaia), Spain.
esantelmo@robotiker.es
Tél : + 34 94 600 22 66, Fax : + 34 94 600 22 99

ABSTRACT:.

The main purpose of the standard IEC 61400-25 is the unification of communication systems in wind power plants, both for internal exchange of information and for remote control. Most of the current control and monitoring systems used in wind farms are vendor-specific and the protocols and data provided by these systems are therefore dependent on their manufacturer. This paper explains the main features of IEC 61400-25 standard, and it also highlights its advantages for the integration of wind farms into the electric system.

Keywords:
IEC 61400-25, communication, wind power plants, interoperability, integration.

1 Introduction

The growing interest in using renewable energy sources and a favourable legal framework in many countries have originated a growth of wind power plants and wind electricity. Traditionally, wind turbines have been designed to work as independent machines, which are able to fulfill their main aim as energy producers without a continuous control or monitoring. Due to the fact that the energy produced by wind turbines depends on external factors (i.e. wind speed) and taking into account that in some national regulations all the electricity produced by wind farms can be directly injected into the power system, these generation units can contribute to the instability of the electricity system if they do not include appropriate control systems.

The integration of wind farms into the electricity systems, contributing to the active and reactive power control, implies new requirements [1] in communication capabilities of wind turbines and control centres. The use of standard information models and communication systems can simplify and unify the integration of wind power plants into the whole power system.

2 IEC 61400-25 features

Before explaining how wind farms can be integrated seamless into the electricity system, the main features of IEC 61400-25 standard [2] are outlined. IEC 61400-25 is based on the principles described in the IEC 61850 standard [3] defined for integrating different intelligent electronic devices inside substation automated systems (SAS).

IEC 61850 standard is based on two principles:

- definition of an scalable and hierarchical information model that can hold the different parameters and data interchanged between the actors in the system. In this information model all the information is fully tagged and each vendor is required to name the information using the standard references.
- separation of applications from communication stacks. Communication protocols and technologies evolve quite faster than the applications using them. The standard defines an abstraction layer with a set of services, which allows an easy replacement of communication technologies or protocols, requiring no change in the application on the top of them.

2.1 Information model

The basic information of a wind turbine has been standardized. Each component member of the system devices (wind turbine, control centre, meteorological system,…) has been modelled in a data structure called “logical node”. A logical node is a data holder that can hold different types of information related to that component. The different data types include status, measurements, control information and settings.

For instance, the general information of a wind turbine is stored in a logical node called “WTUR”. This logical node is an information holder which shows the status, the active and reactive energy production, and which allows the modification of the most important settings as the power factor or the demanded active and reactive power.

The detailed information of the components of a wind turbine can be accessed using the different logical nodes of the system. The components of a wind turbine, that have been modelled, include elements as the rotor, transmission, generator, converter, nacelle, yawing and tower.

This information model does not limits itself to the wind turbine. Basic information from meteorological stations has also been modelled, so it can be communicated using this standard. In the future, if more systems are included in wind power plants, the model can also be extended to include as many of them as needed.

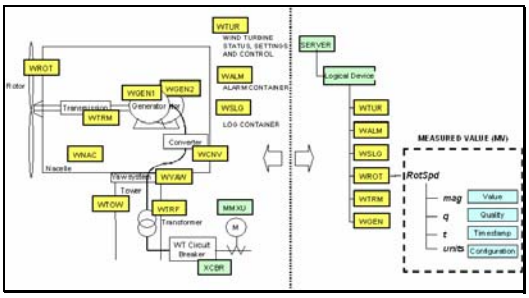

fig. 1. Wind power plant information model

The information model also defines the structure for supporting information of alarms of the system. These alarms can be interchanged between different actors in a standard format understandable by all of them.

2.2 Abstract communication services

IEC 61400-25 has defined the subset of abstract communication services needed to perform all the interchanges of information within the wind power plant [4]. This set of services allows the establishment of a communication link, called association, and the interchange of services to read or write variables, to modify set-points or to send different commands to wind turbines. Also an event-driven mechanism is available to avoid the necessity of "polling" the desired information. The more intelligent devices could also include the logging model. These devices shall monitor and store the changes of some critical status or measured information of the system. The device log will be accessed using the standard logging query services.

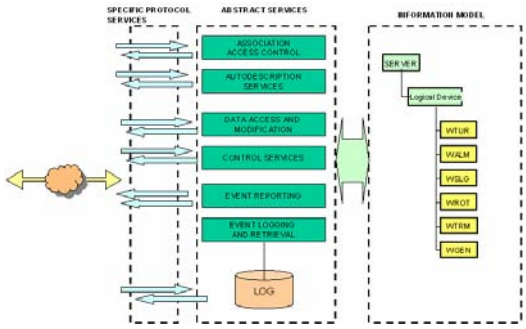

fig. 2. Abstract communication services

2.3 Communication protocols

The communication inside-outside wind power plants implies different requirements in communication protocols and technologies.

A continuous monitoring and control of all the wind turbines inside a wind farm may require to exchange a huge amount of data and therefore the use of high bandwidth network and protocols which minimize the size of the packets sent to the network.

The control of the whole system from outside may require to monitor only a few set of parameters periodically and to request changes in some settings, if the system stability requires it. In this case, the amount of data decreases and the bandwidth limitation may disappear.

Having in mind different set of actors and cases of use, IEC 61400-25 working group is working hard trying to provide a set of communication protocols able to fulfil the different requirements of the system and using the best set of available communication protocols. These protocols include the following mapping methods:

- MMS
- Web Services
- OPC-XML-DA
- IEC 60870-5-104
- DNP3

Depending on the mapping used, the data interchanged in the network will have a different format, but the information exchanged by the same services in all mappings methods shall contain the same meaning and content.

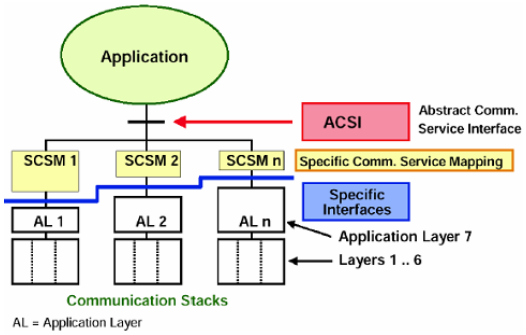

fig. 3. Mapping to specific communication protocols

An important drawback to be considered in the design of multi-vendor wind power plants, is the necessity of including in the system requirements the use of either:

- the same mapping method for all the devices in the system, or
- a SCADA system able to communicate with the different mappings used by the devices in the wind farm.

2.4 Comparison of available communication protocols (mapping methods)

2.4.1 ISO 9506 – MMS (Manufacturing Message Specification)

Its use is defined in ISO-9506. The standard IEC 61850-8-1 describes how the abstract service interface has to be mapped into MMS available service primitives.

The main positive arguments of MMS are the reduction of bandwidth needs due to its binary data encoding, the fact that it is, up to date, the only tested protocol in real systems and the possibility of making use of the full set of abstract communication services.

As a drawback, MMS uses the full OSI stack, so the processing requirements are quite high and software complexity of libraries makes the development of a full stack further than difficult.

2.4.2 Web Services

Web services technology has been used to create an XML (eXtensible Markup Language) oriented interchange of data that has been customized to provide the interfaces requested by the abstract services layer. Messages coding involves the translation of the application interface to XML format but, as a drawback, the size of the information increases and the limitation in bandwidth can be a problem if big amounts of information have to be interchanged.

This mapping allows the full set of services defined in the abstract service interface.

2.4.3 OPC XML DA

OPC XML DA is a technology defined by OPC foundation to provide data access independently of the operative systems and platforms interchanging the information using XML messages.

An advantage of OPC XML DA, regarding its "brother" using XML services, is that currently there are solutions in the market using this technology, so it can be consider a well proven technology.

As a drawback, the set of services defined in OPC XML DA is not designed to perform the logging mechanism so this subset of services is not available using this mapping.

2.4.4 IEC 60870-5-104

IEC 60870-5-104 protocol is currently the most used technology to control remote stations from control centres.

As a first step to integrate IEC 61400-25 wind farms into the control system, a "gateway" solution has been defined in order to send the wind farm standard data using the IEC-60870-5-101/104 service data units.

2.4.5 DNP3

Distributed Network Protocol 3 appears as a branch in the development of IEC 60860-5-101 protocol. The same principles, applied to IEC 60870-5-104 , applies here. As a main difference, its specification is defined by DNP3 users group, so IEC can only describes how the mapping could be executed using the current definition of DNP specification.

3 Use of the standard to improve power system stability

The definition of the data information model of a wind turbine details how the behaviour of this element can be monitored and controlled independently from the manufacturer and the technology used. The use of this information model allows a uniform control of operation: increasing or reducing energy production, ramping of active or reactive power and even, connecting or disconnecting the wind turbine from the system.

In order to provide a control of the whole wind power plant, two logical nodes (data holders) have been defined inside IEC 61400-25 information model. The information hold in these data structures has been standardized, so any control system can make use of them independently from the topology of the plant, the number and kind of the wind turbines used, etc.

These data structures allow adjusting the value of the following parameter of the wind power plant:

- active/reactive power output,
- gradient ramping down,
- gradient ramping up,
- active power reserve (spinning reserve)
- voltage output
- voltage ramping down,
- voltage ramping up,
- slope of voltage control droop,
- power factor (producer or consumer of reactive power)

The use of these data structures does not constraint neither the topology of the system nor the control algorithm used to modify the behaviour of the plant to reach the desired energy production.

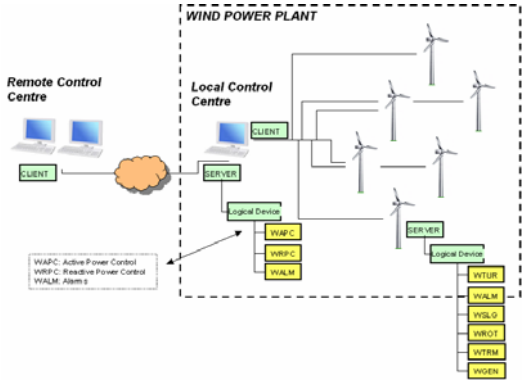

fig. 4. IEC 61400-25 wind power plant active and reactive power control

The main advantage of requesting the use of IEC 61400-25 and this type of power control is the possibility of communication with different power plants using the same control systems due to the fact that all of them expose the same interface to the outside, regardless of the protocol and technologies used inside the wind farm

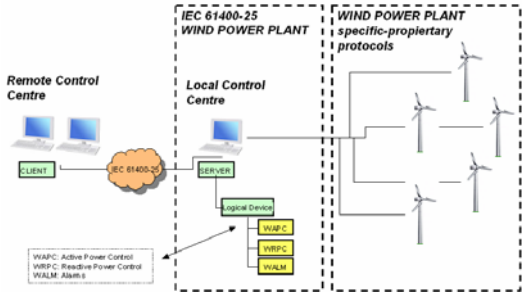

fig. 5. Seamless control independent from the wind power plant internal protocol or topology

If a more specific control is required, the local control centre can behave as a data concentrator that exposes to the remote system users only a subset of the information available in each wind turbine.

4 Conclusions

IEC 61400-25 standard opens a possibility in the reusability of control and monitoring applications and a better integration of wind farms into the power system. IEC 61400-25 standard uses the most innovative principles to simplify the interoperability and integration of different manufacturer devices. These principles have been already tested in order to provide interoperability inside substations (IEC 61850) and they are being extended to be applied into the integration of distributed energy resources (IEC 61850-7-420) [5] and hydropower plants (IEC 61850-7-410) [6].

5 Acknowledgements

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6 References

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[3] IEC 61850 - Communication systems and networks in substations

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[5] IEC 61850-7-420 – Hydroelectric power plants: Communication for monitoring and control (Committee Draft for Vote).

[6] IEC 61850-7-410 – Distributed energy resources power plants: Communication for monitoring and control (Committee Draft for Vote).

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[1] ROBOTIKER ENERGY BUSINESS UNIT

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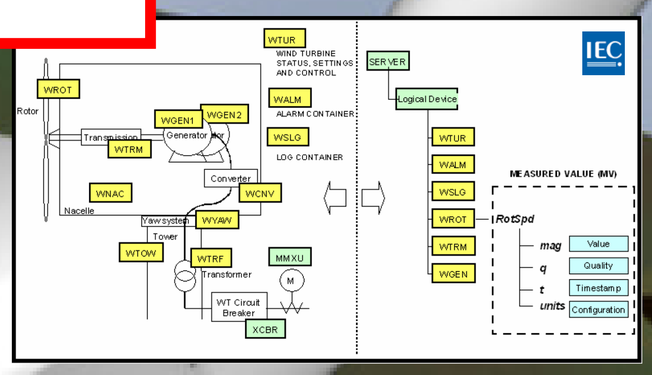
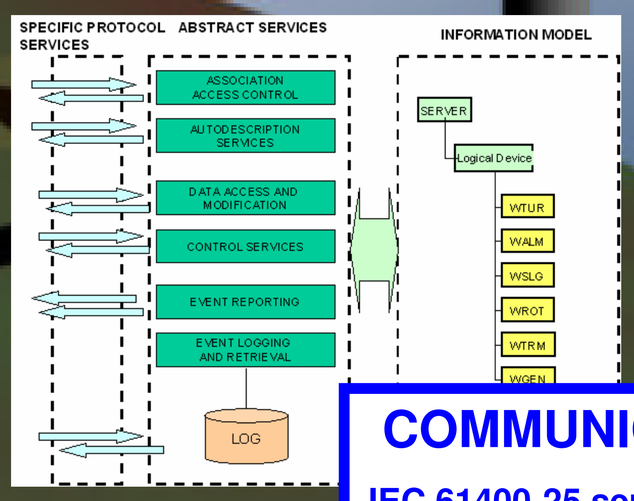
INFORMATION MODEL

IEC 61400-25 have modelled the main components inside the wind power plants using a hierarchical data structure.



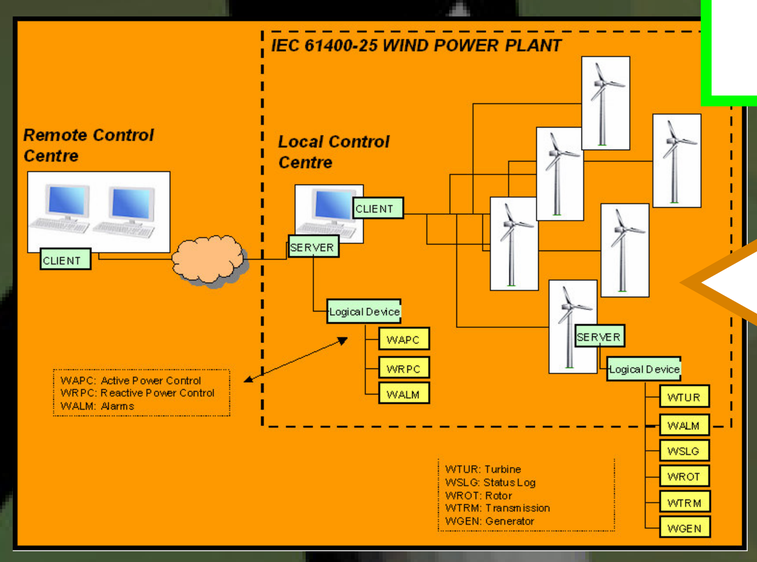


COMMUNICATION SERVICES

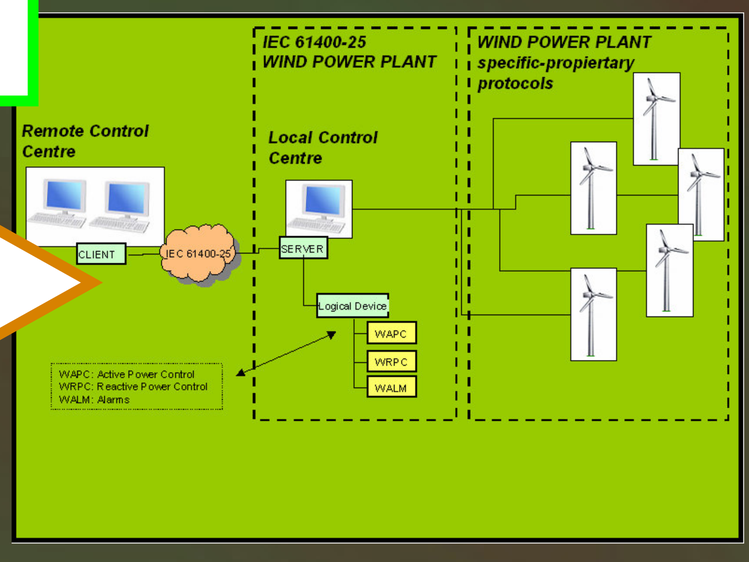
IEC 61400-25 separates the applications from the application protocols defining an abstraction layer called ACSI (Abstract Communication Service Interface).

ACTIVE AND REACTIVE POWER STANDARD CONTROL

IEC 61400-25 specifies and standard mechanism to control de active or reactive power of either existent or new wind power plants.



APPLICABLE TO NEW AND EXISTENT WIND POWER PLANTS



CONCLUSIONS

IEC 61400-25 standard opens a possibility in the reusability of control and monitoring applications and a better integration of wind farms into the power system. It uses the most innovative principles to simplify the interoperability and integration of different manufacturer devices. These principles have been already tested in order to provide interoperability inside substations (IEC 61850) and they are being extended to be applied into the integration of distributed energy resources and hydropower plants.