IEC 61850-7-410

Edition 1.0 2007-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control

Réseaux et systèmes de communication pour l'automatisation des systèmes électriques – Partie 7-410: Centrales hydroélectriques – Communication pour contrôle et commande

IEC 61850-7-410:2007

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX XC

ICS 33.200

ISBN 978-2-88912-589-0

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 7-410: Hydroelectric power plants – Communication for monitoring and control

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61850-7-410 has been prepared by IEC technical committee 57: *Power systems management and associated information exchange*.

It has been decided to amend the general title of the IEC 61850 series to *Communication networks and systems for power utility automation.* Henceforth, new editions within the IEC 61850 series will adopt this new general title.

This bilingual version (2013-01) corresponds to the English version, published in 2007-08.

The text of this standard is based on the following documents:

FDIS	Report on voting
57/886/FDIS	57/905/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61850 series, under the general title *Communication networks and systems for power utility automation*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The present standard includes all additional logical nodes, not included in IEC 61850-7-4:2003, required to represent the complete control and monitoring system of a hydropower plant.

Most of the Logical Nodes in IEC 61850-7-410 that are of general use, Logical Nodes the names of which do not start with the letter "H", will be transferred to the future Edition 2 of IEC 61850-7-4. In the same manner, all Common Data Classes specified in IEC 61850-7-410 will be transferred to future Edition 2 of IEC 61850-7-3.

Once future Editions 2 of IEC 61850-7-3 and IEC 61850-7-4 are published, IEC 61850-7-410 will be revised to include only those Logical Nodes that are specific to hydropower use.

Before Edition 2 of IEC 61850-7-410 is published, there will be a period where the Common Data Class (CDC) and Logical Node (LN) specifications will overlap with IEC 61850-7-3 (future Edition 2) and IEC 61850-7-4 (future Edition 2). During this time, the specifications in IEC 61850-7-3 (future Edition 2) and IEC 61850-7-4 (future Edition 2) will apply.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 7-410: Hydroelectric power plants – Communication for monitoring and control

1 Scope

IEC 61850-7-410 is part of the IEC 61850 series. This part of IEC 61850 specifies the additional common data classes, logical nodes and data objects required for the use of IEC 61850 in a hydropower plant.

The Logical Nodes and Data Objects (DO) defined in this part of IEC 61850 belong to the following fields of use:

- **Electrical functions**. This group includes LN and DO used for various control functions, essentially related to the excitation of the generator. New LN and DO defined within this group are not specific to hydropower plants; they are more or less general for all types of larger power plants.
- **Mechanical functions**. This group includes functions related to the turbine and associated equipment. The specifications of this document are intended for hydropower plants, modifications might be required for application to other types of generating plants. Some more generic functions are though defined under Logical Node group K.
- **Hydrological functions**. This group of functions includes objects related to water flow, control and management of reservoirs and dams. Although specific for hydropower plants, the LN and DO defined here can also be used for other types of utility water management systems.
- **Sensors**. A power plant will need sensors providing measurements of other than electrical data. With a few exceptions, such sensors are of general nature and not specific for hydropower plants.

NOTE All Logical Nodes with names not starting with the letter "H" will be included in a future edition 2 of IEC 61850-7-4. When that document is published, the Logical Nodes in IEC 61850-7-4 (Edition 2) will take precedence over Logical Nodes with the same name in this part IEC 61850-7-410.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies:

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

IEC 61850-5, *Communication networks and systems in substations – Part 5: Communication requirements for functions and device models*

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

IEC 61850-7-2:2003, *Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication services interface (ACSI)*

IEC 61850-7-3:2003, *Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes*

IEC 61850-7-4:2003, *Communication networks and systems in substations – Part 7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61850-2 apply.

4 Abbreviations

In general, the abbreviations defined in IEC 61850-2 apply. The following abbreviations are repeated here for convenience.

ASG	Analogue setting
BSC	Binary controlled step position information
CDC	Common data class
CIM	Common information model (reference to IEC 61970-301)
CMV	Complex measured value
DO	Data object
DPC	Double point control
DPL	Device name-plate
DPS	Double point status information
HMI	Human machine interface
IED	Intelligent electronic device
INC	Controllable integer status
ING	Integer status setting
INS	Integer status
LD	Logical device
LN	Logical node
MV	Measured value
PD	Physical device
PID	Proportional – Integrating – Derivative regulator
SAV	Sampled analogue value
SMV	Sampled measured value
SPC	Single point control
SPS	Single point status

WYE Phase to ground related measured values of a three-phase system

5 Basic concepts for hydropower plant control and supervision

5.1 Functionality of a hydropower plant

Figure 1 is based on the substation structure described in IEC 61850-6. A typical power plant will include a "substation" part that will be identical to what is described in the IEC 61850 series. The generating units with their related equipment are added to the basic structure.

A generating unit does consist of a turbine-generator set with auxiliary equipment and supporting functions. Generator transformers can be referenced as normal substation transformers; there is not always any one-to-one connection between generating units and transformers.

The dam is a different case. There is always one dam associated with a hydropower plant. There are however reservoirs that are not related to any specific power plant as well as there are power plants from which more than one dam are being controlled. While all other objects can be addressed through the power plant, dams might have to be addressed directly.

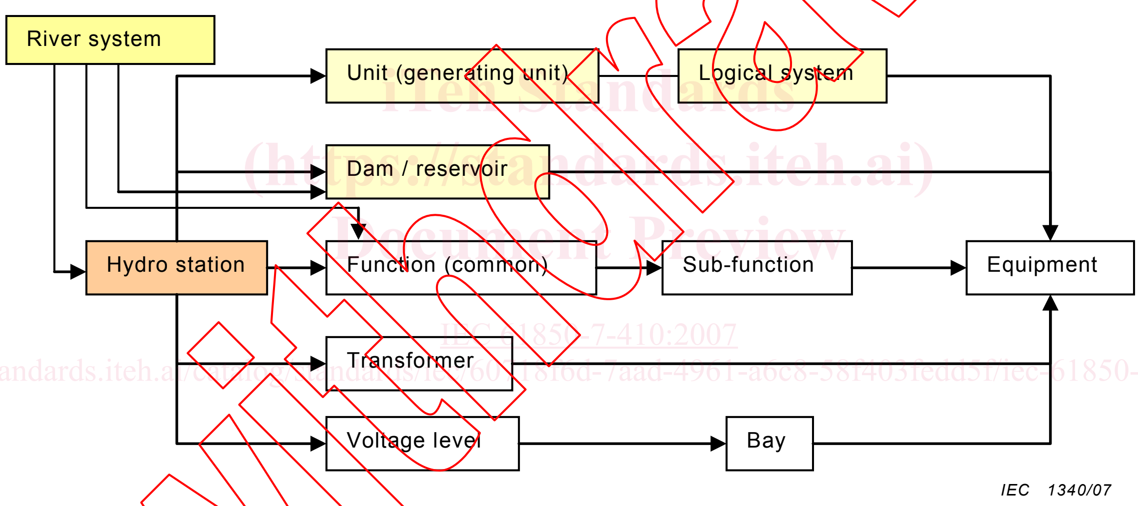

Figure 1 – Structure of a hydropower plant

There is, however, no standardised way of arranging overall control functions. The structure will depend on whether the plant is manned or remote operated, as well as traditions within the utility that owns the plant. In order to cover most arrangements, some of the Logical Nodes defined in this part of IEC 61850 more or less overlap. This will allow the user to arrange Logical Devices by selecting the most appropriate Logical Nodes that suit the actual design and methods of operation of the plant. Other Logical Nodes are very small, in order to provide simple building blocks that will allow as much freedom as possible in arranging the control system.

Some control functions do work more or less autonomously after being started and stopped by the start/stop sequencer. Such functions include the cooling system for the generator and the lubrication oil system for the bearings.

5.2 Principles for water control in a river system

5.2.1 General

The water control of river systems and hydropower plants can follow different strategies, depending on the external requirements put on the operation of the system.

a) Water flow control

In this type of control, the power production is roughly adapted to the water flow that is available at the moment. The rate of flow is the controlled while the water level is allowed to vary between high and low alarm levels in the dams. The dams are classified after the time over which the inflow and outflow shall add up (daily, weekly etc.).

b) Water level control

In some locations, there are strict limits imposed on the allowed variation of the water level of the dam. This might be due to maritime shipping or by other environmental requirements. In this case, the upper water level of the dam is the overriding concern, power production is adjusted by the water level control function to provide correct flow to maintain the water level.

c) Cascade control

In rivers with more than one power plant, the overall water flow in the river is coordinated between plants to ensure an optimal use of the water. Each individual plant can be operated according to the water level model or the water flow model as best suited, depending on the capacity of the local dam and allowed variation in water levels. The coordination is normally done at dispatch centre level, but power plants often have feed-forward functions that will automatically notify the next plant downstream if there is a sudden change of water flow.

Power plants with more than one generating unit and/or more than one dam gate, can be provided with a joint control function that controls the total water flow through the plant as well as the water level control.

5.2.2 Principles for electrical control of a hydropower plant

A power plant can be operated in different modes: active power production mode or condenser mode. The generator can be used as a pure synchronous condenser, without any active power production and with the runner spinning in air.

In a pumped storage plant, there is a motor mode for the generator. A generator in a pumped storage plant can also be used for voltage control in a synchronous condenser mode, in this case, normally with an empty turbine chamber.

The following steady states are defined for the unit:

a) *Excited, not connected* – Field current is applied and a voltage is generated, the generator is however not connected to any load, there is no significant stator current.

b) *Synchronised* – The generator is synchronised to an external network. This is the normal status of an operating generator.

c) *Synchronised in condenser mode* – The generator is synchronised. However it does not primarily produce active power. In condenser mode, it will produce or consume reactive power, in generation- or pump-direction (for pumped storage), it consumes active power.

d) *Island operation mode* – The external network has been separated and the power plant shall control the frequency.

e) *Local supply mode* – In the case of a larger disturbance of the external network, one or more generators in a power plant can be set at a minimum production to provide power for local supply only. This type of operation is common in thermal power plants to shorten the start-up time once the network is restored, but can also be used in hydropower plants for practical reasons.