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TECHNICAL REPORT

colour inside

Communication networks and systems for power utility automation – Part 7-510: Basic communication structure – Hydroelectric power plants – Modelling concepts and guidelines

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

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FOREWORD

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IEC 61850-7-510, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
57/1143/DTR	57/1203/RVC

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

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 stability 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- withdrawn,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.

A bilingual version of this technical report may be issued at a later date.

INTRODUCTION

This Technical Report is connected with IEC 61850-7-410, as well as IEC 61850-7-4:2010, explaining how the control system and other functions in a hydropower plant can use logical nodes and information exchange services within the complete IEC 61850 package to specify the information needed and generated by, and exchanged between functions.

The dynamic exchange of values by using polling, GOOSE, Reporting or Sampled Values is beyond the scope of this report. This data flow is specified in the engineering work flow defined in IEC 61850-5; this part of IEC 61850 applies also to applications in hydro power plants.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 7-510: Basic communication structure – Hydroelectric power plants – Modelling concepts and guidelines

1 Scope

This part of IEC 61850 is intended to provide explanations on how to use the Logical Nodes defined in IEC 61850-7-410 as well as other documents in the IEC 61850 series to model complex control functions in power plants, including variable speed pumped storage power plants.

IEC 61850-7-410 introduced the general modelling concepts of IEC 61850 to hydroelectric power plants. It is however not obvious from the standard how the modelling concepts can be implemented in actual power plants.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60870-5-104, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles*

IEC 61850-5:2003, *Communication networks and systems in substations – Part 5: Communication requirements for functions and device models*

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

IEC 61850-7-2, *Communication networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract communication service interface (ACSI)*

IEC 61850-7-3, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes*

IEC 61850-7-4:2010, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC 61850-7-410, *Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control*

IEC 61850-8-1, *Communication networks and systems for power utility automation – Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*

IEC 61850-9-2, *Communication networks and systems for power utility automation – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

ISO/TS 16952-10, *Technical product documentation – Reference designation system – Part 10: Power plants*

3 Overall communication structure in a hydropower plant

3.1 Abstract communication structure

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 consists 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 at least one dam associated with a hydropower plant. There are however reservoirs that are not related to any specific power plant, equally there are power plants from which more than one dam is being controlled. There can also be dams with more than one hydropower plant. While all other objects can be addressed through a specific power plant, dams might have to be addressed directly.

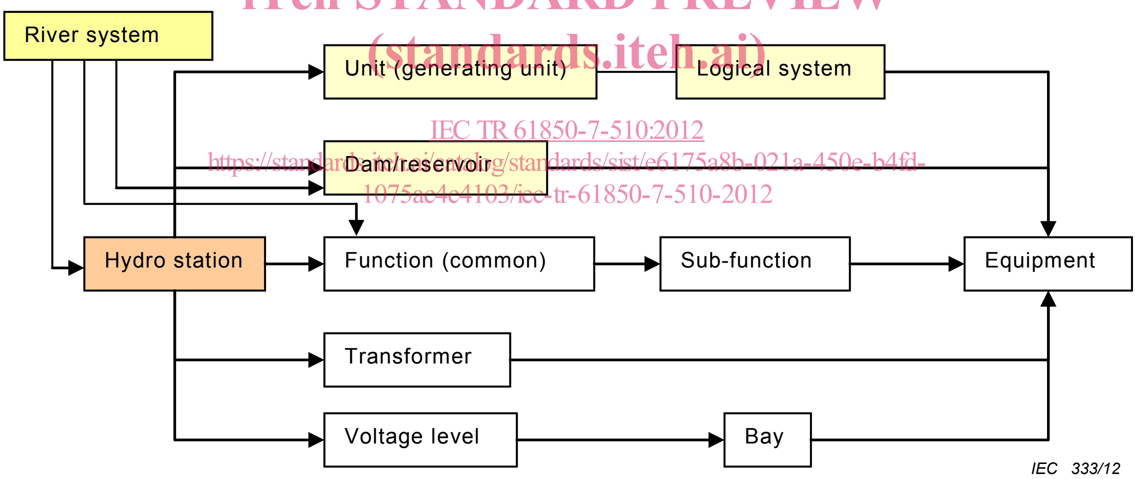

Figure 1 – Structure of a hydropower plant

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 document are more or less overlapping. This will allow the user to arrange Logical Devices by selecting the most appropriate Logical Nodes that suits 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.

3.2 Communication network

Defining a station communication network is one of the primary steps for defining how the logical devices will be distributed among IEDs. The decision of where to nest the logical device is relative to the physical connection of an IED and the field instrumentation. Table 1 lists an example of physical devices used for control of a small hydropower plant.

Table 1 – IED within a simplified single unit power plant

Intelligent electronic device	Description	Example of types of logical Devices nested in an IED
IED1	Intake valve controller	Valve {A, B}
IED2	Turbine controller and speed governor	Actuators, Controllers, Turbine information
IED3	High pressure oil system controller	Tank, Pump A, Pump B
IED4	Generator monitoring system	Phase Windings{A,B,C}, Eccentricity
IED5	Excitation system	Logical device group reference: Regulation, Controls, Field Breaker, Protection
IED6	Bearing monitoring system	Thrust bearing, guide bearing, and generator bearing
IED7	Dam monitoring system	Spillway gate{1,2} and dam
Unit IED	Unit acquisition and control	Logical device group reference: sequences and Alarm grouping
Common IED	Remote terminal unit	Nil
Merging unit 1	Current- and voltage measurements at generator	Merging Unit
Merging unit 2	Current- and voltage measurements in MV	Merging Unit
Merging unit 3	Current- and voltage measurements in HV	Merging Unit
PROT1 T	Primary transformer protection	Protection, measurement
PROT2 T	Secondary transformer protection	Protection, measurement
PROT1 G	Primary generator protection	Protection, measurement
PROT2 G	Secondary generator protection	Protection, measurement

The following example in Figure 2 shows a simplified network of a single unit power plant. The IEDs exchange information and control commands using MMS (IEC 61850-8-1), send trip commands via GOOSE messaging (IEC 61850-9-2) and get information instantaneous current and voltage reading via sample value (IEC 61850-9-2). The logical devices are distributed among IEDs along functional groupings. The information is pushed to the dispatch centre via a data concentrator which is the remote terminal unit using IEC 60870-5-104.

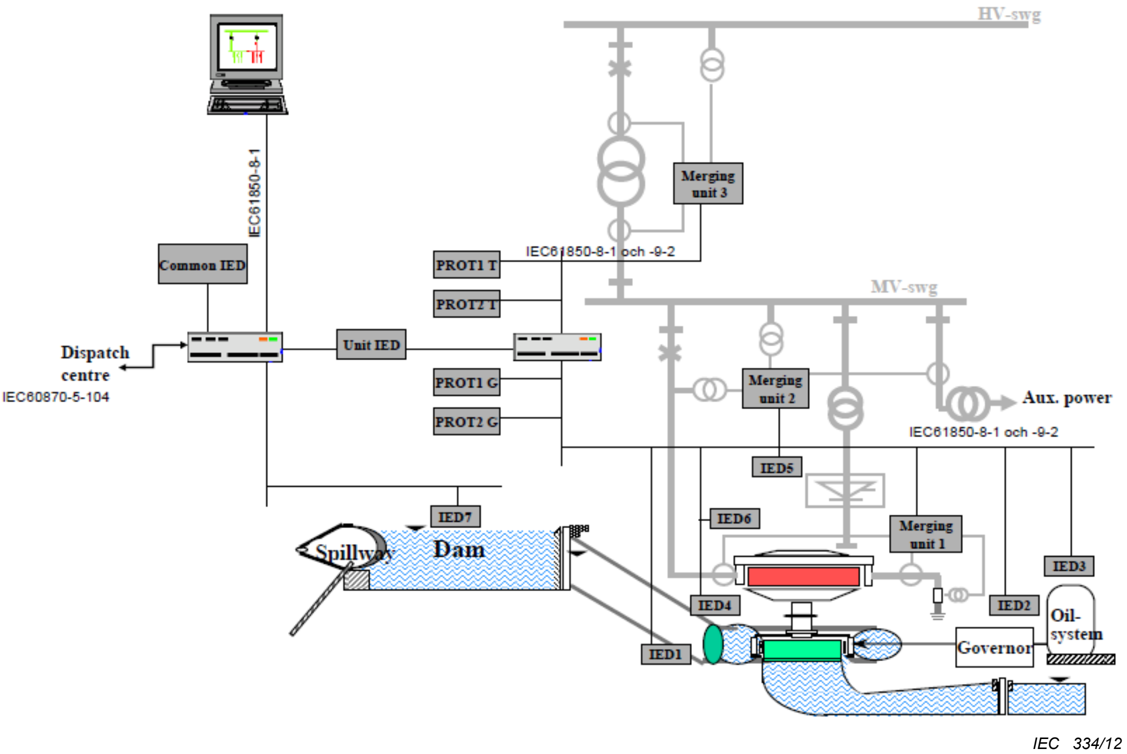

Figure 2 – Simplified network of a hydropower plant

3.3 Operational modes

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:

Stopped – Unit is at standstill

Speed no load, not excited – No field current is applied, no voltage is generated; the generator is running at rated speed but not connected to any external load.

Speed no load, excited – Field current is applied and a voltage is generated, the generator is however not connected to any external load, there is no significant stator current.

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

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.

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

Local supply mode – In 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.

3.4 Fundamental control strategies

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

Speed control in isolated mode:

The purpose of the speed control basically is to maintain constant frequency. For more detailed description, see IEC 61362.

Active power control:

The active power output control with a separate power controller is applied with the unit connected to the grid. For more detailed description, see IEC 61362.

Reactive power control:

Reactive power control includes voltage and power factor control. This can include synchronous condenser mode without active power output, but also added to active power production.

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 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.).

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.

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 automatically will 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.