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Kommunikationsnetze und -systeme für die Automatisierung in der elektrischen Energieversorgung – Teil 7-410: Wasserkraftwerke – Kommunikation für Überwachung, Regelung und Steuerung (IEC 61850-7-410:2007); Englische Fassung EN 61850-7-410:2007

Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control (IEC 61850-7-410:2007); English version EN 61850-7-410:2007

Réseaux et systèmes de communication pour l`automatisation des services de distribution d`énergie – Partie 7-410: Centrales hydroélectriques – Communication pour la surveillance et le contrôle-commande (CEI 61850-7-410:2007); Version anglais EN 61850-7-410:2007

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Beginn der Gültigkeit

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Nationales Vorwort

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Für diese Norm ist das nationale Arbeitsgremium K 952 „Netzleittechnik“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE (www.dke.de) zuständig.

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Vorwort

Der Text des Schriftstücks 57/886/FDIS, zukünftige 1. Ausgabe von IEC 61850-7-410, ausgearbeitet von dem IEC/TC 57 „Power systems management and associated information exchange“, wurde der IEC-CENELEC Parallelen Abstimmung unterworfen und von CENELEC am 2007-10-01 als EN 61850-7-410 angenommen.

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Der Text der Internationalen Norm IEC 61850-7-410:2007 wurde von CENELEC ohne irgendeine Abänderung als Europäische Norm angenommen.

In der offiziellen Fassung sind unter „Literaturhinweise“ zu den aufgelisteten Normen die nachstehenden Anmerkungen einzutragen:

IEC 61362	ANMERKUNG	Harmonisiert als EN 61362:1998 (nicht modifiziert).
IEC 61400-25-2	ANMERKUNG	Harmonisiert als EN 61400-25-2:2007 (nicht modifiziert).
IEC 61850-7-1	ANMERKUNG	Harmonisiert als EN 61850-7-1:2003 (nicht modifiziert).
IEC 61850-10	ANMERKUNG	Harmonisiert als EN 61850-10:2005 (nicht modifiziert).
IEC 61970-301	ANMERKUNG	Harmonisiert als EN 61970-301:2004 (nicht modifiziert).
IEC 62270	ANMERKUNG	Harmonisiert als EN 62270:2004 (nicht modifiziert).

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Full document details: DIN EN 61850-7-410:2008-04

CONTENTS

INTRODUCTION 7

1 Scope 8
2 Normative references 8
3 Terms and definitions 9
4 Abbreviations 9
5 Basic concepts for hydropower plant control and supervision 10
5.1 Functionality of a hydropower plant 10
5.2 Principles for water control in a river system 10
5.2.1 General 10
5.2.2 Principles for electrical control of a hydropower plant 11
5.3 Logical structure of a hydropower plant 12
6 Modelling concepts and examples 18
6.1 The concept of Logical Devices 18
6.2 Logical nodes for sensors, transmitters, supervising and monitoring functions 18
6.3 Address strings 19
6.4 Naming of logical nodes 20
6.5 Recommended naming structure for automatic control functions 20
6.6 Summary of logical nodes to be used in hydropower plants 21
6.6.1 General 21
6.6.2 Group C – Control functions 22
6.6.3 Group F – Functional blocks 22
6.6.4 Group H – Hydropower specific logical nodes 22
6.6.5 Group I – Interface and archiving 23
6.6.6 Group K – Mechanical and non-electrical primary equipment 24
6.6.7 Group L – Physical devices and common logical nodes 24
6.6.8 Group M – Metering and measurement 24
6.6.9 Group P – Protection functions 24
6.6.10 Group R – Protection related functions 25
6.6.11 Group S – Supervision and monitoring 25
6.6.12 Group T – Transducers and instrument transformers 26
6.6.13 Group X – Switchgear 26
6.6.14 Group Y – Power transformers 26
6.6.15 Group Z – Power system equipment 27
7 Logical Node Classes 27
7.1 Abbreviations and definitions used in Logical Node tables 27
7.1.1 Interpretation of Logical Node tables 27
7.1.2 Abbreviated terms used in Attribute Names 28
7.2 Logical Nodes representing functional blocks LN group F 29
7.2.1 Modelling remarks 29
7.2.2 LN: Counter Name: FCNT 29
7.2.3 LN: Curve shape description Name: FCSD 29
7.2.4 LN: Generic Filter Name: FFIL 30
7.2.5 LN: Control function output limitation Name: FLIM 30

Documents
Document Sharing Hub

Full document details: DIN EN 61850-7-410:2008-04

7.2.6 LN: PID regulator Name: FPID 31
7.2.7 LN: Ramp function Name: FRMP 32
7.2.8 LN: Set-point control function Name: FSPT 33
7.2.9 LN: Action at over threshold Name: FXOT 34
7.2.10 LN: Action at under threshold Name: FXUT 34
7.3 Hydropower specific Logical Nodes LN group H 35
7.3.1 Modelling remarks 35
7.3.2 LN: Turbine – generator shaft bearing Name: HBRG 35
7.3.3 LN: Combinator Name: HCOM 35
7.3.4 LN: Hydropower dam Name: HDAM 36
7.3.5 LN: Dam leakage supervision Name: HDLS 36
7.3.6 LN: Gate position indicator Name: HGPI 36
7.3.7 LN: Dam gate Name: HGTE 37
7.3.8 LN: Intake gate Name: HITG 37
7.3.9 LN: Joint control Name: HJCL 38
7.3.10 LN: Leakage supervision Name: HLKG 39
7.3.11 LN: Water level indicator Name: HLVL 39
7.3.12 LN: Mechanical brake Name: HMBR 40
7.3.13 LN: Needle control Name: HNDL 40
7.3.14 LN: Water net head data Name: HNHD 40
7.3.15 LN: Dam over-topping protection Name: HOTP 41
7.3.16 LN: Hydropower/water reservoir Name: HRES 41
7.3.17 LN: Hydropower unit sequencer Name: HSEQ 42
7.3.18 LN: Speed monitoring Name: HSPD 42
7.3.19 LN: Hydropower unit Name: HUNT 43
7.3.20 LN: Water control Name: HWCL 44
7.4 Logical Nodes for interface and archiving LN group I 44
7.4.1 Modelling remarks 44
7.4.2 LN: Safety alarm function Name: ISAF 45
7.5 Logical Nodes for mechanical and non-electric primary equipment LN group K 45
7.5.1 Modelling remarks 45
7.5.2 LN: Fan Name: KFAN 45
7.5.3 LN: Filter Name: KFIL 46
7.5.4 LN: Pump Name: KPMP 46
7.5.5 LN: Tank Name: KTNK 47
7.5.6 LN: Valve control Name: KVLV 47
7.6 Logical Nodes for metering and measurement LN group M 48
7.6.1 Modelling remarks 48
7.6.2 LN: Environmental information Name: MENV 48
7.6.3 LN: Hydrological information Name: MHYD 48
7.6.4 LN: DC measurement Name: MMDC 49
7.6.5 LN: Meteorological information Name: MMET 49
7.7 Logical Nodes for protection functions LN group P 50
7.7.1 Modelling remarks 50
7.7.2 LN: Rotor protection Name: PRTR 51
7.7.3 LN: Thyristor protection Name: PTHF 51
7.8 Logical nodes for protection related functions LN Group R 51
7.8.1 Modelling remarks 51
7.8.2 LN: synchronising or synchro-check device Name: RSYN 51

Documents
Document Sharing Hub
Full document details: DIN EN 61850-7-410:2008-04

7.9 Logical Nodes for supervision and monitoring LN group S 53
7.9.1 Modelling remarks 53
7.9.2 LN: temperature supervision Name: STMP 53
7.9.3 LN: vibration supervision Name: SVBR 53
7.10 Logical Nodes for instrument transformers and sensors LN group T 54
7.10.1 Modelling remarks 54
7.10.2 LN: Angle sensor Name: TANG 54
7.10.3 LN: Axial displacement sensor Name: TAXD 54
7.10.4 LN: Distance sensor Name: TDST 55
7.10.5 LN: Flow sensor Name: TFLW 55
7.10.6 LN: Frequency sensor Name: TFRQ 55
7.10.7 LN: Humidity sensor Name: THUM 56
7.10.8 LN: Level sensor Name: TLEV 56
7.10.9 LN: Magnetic field sensor Name: TMGF 56
7.10.10 LN: Movement sensor Name: TMVM 56
7.10.11 LN: Position indicator Name: TPOS 57
7.10.12 LN: Pressure sensor Name: TPRS 57
7.10.13 LN: Rotation transmitter Name: TRTN 57
7.10.14 LN: Sound pressure sensor Name: TSND 58
7.10.15 LN: Temperature sensor Name: TTMP 58
7.10.16 LN: Mechanical tension /stress sensor Name: TTNS 58
7.10.17 LN: Vibration sensor Name: TVBR 59
7.10.18 LN: Water pH sensor Name: TWPH 59
7.11 Logical Nodes for power system equipment LN group Z 59
7.11.1 Modelling remarks 59
7.11.2 LN: Neutral resistor Name: ZRES 59
7.11.3 LN: Semiconductor rectifier controller Name: ZSCR 60
7.11.4 LN: Synchronous machine Name: ZSMC 60
8 Data name semantics 62
9 Common data classes 75
9.1 General 75
9.2 Device ownership and operator (DOO) 75
9.3 Maintenance and operational tag (TAG) 75
9.4 Operational restriction (RST) 76
10 Data attribute semantics 76

Annex A (informative) Algorithms used in logical nodes for automatic control 79
Annex ZA (normative) Normative references to international publications with their corresponding European publications 86

Bibliography 85

Figure 1 – Structure of a hydropower plant 10
Figure 2 – Principles for the joint control function 12
Figure 3 – Water control functions 13
Figure 4 – Water flow control of a turbine 14
Figure 5 – Typical turbine control system 15

AVA Documents
Document Sharing Hub

Full document details: DIN EN 61850-7-410:2008-04

Figure 6 – Excitation system 16
Figure 7 – Electrical protections of a generating unit 17
Figure 8 – Conceptual use of transmitters 18
Figure 9 – Logical Device Name 19
Figure 10 – Example of naming structure, in a pumped storage plant, based on IEC 61346-119
Figure A.1 – Example of curve based on an indexed gate position providing water flow 79
Figure A.2 – Example of curve based on an indexed guide vane position (x axis) vs net head (y axis) giving an interpolated Runner Blade position (Z axis) 80
Figure A.3 – Example of a proportional-integral-derivate controller 81
Figure A.4 – Example of a Power stabilisation system 82
Figure A.5 – Example of a ramp generator 82
Figure A.6 – Example of an interface with a set-point algorithm 83
Figure A.7 – Example of a physical connection to a set-point device 84

Table 1 – Example of Logical Device over-current protection 18
Table 2 – recommended LN prefixes 21
Table 3 – Logical nodes for control functions 22
Table 4 – Logical nodes representing functional blocks 22
Table 5 – Hydropower specific logical nodes 22
Table 6 – Logical nodes for interface and archiving 23
Table 7 – Logical nodes for mechanical and non-electric primary equipment 24
Table 8 – Logical nodes for physical devices and common LN 24
Table 9 – Logical nodes for metering and measurement 24
Table 10 – Logical nodes for protections 25
Table 11 – Logical nodes for protection related functions 25
Table 12 – Logical nodes for supervision and monitoring 25
Table 13 – Logical nodes for sensors 26
Table 14 – Logical nodes for switchgear 26
Table 15 – Logical nodes for power transformers 26
Table 16 – Logical nodes for power system equipment 27
Table 17 – Interpretation of Logical Node tables 27
Table 18 – Conditional attributes in FPID 31
Table 19 – Description of data 62
Table 20 – Semantics of data attributes 77

Documents
Document Sharing Hub
Full document details: DIN EN 61850-7-410:2008-04

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.

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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 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)*

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Full document details: DIN EN 61850-7-410:2008-04

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

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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 below 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.

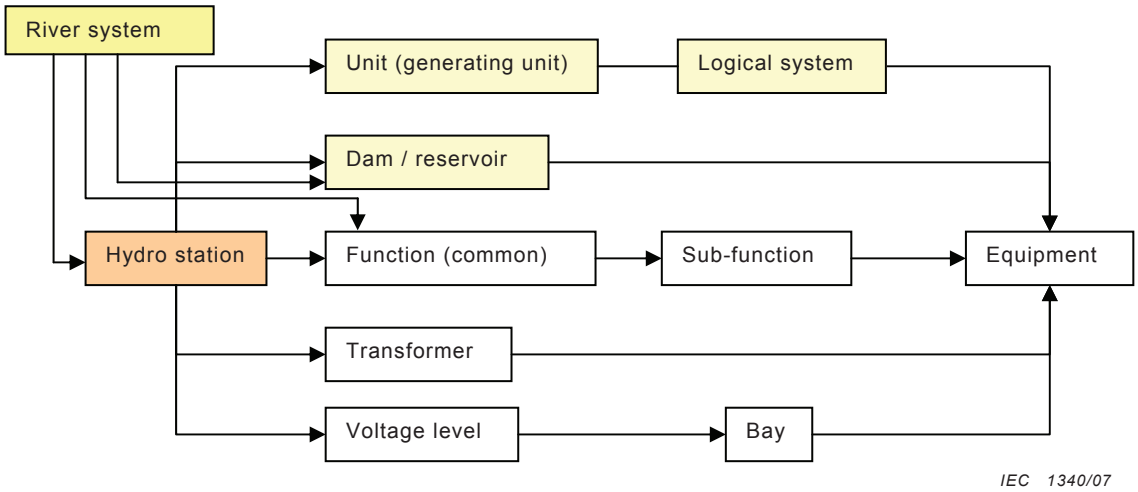

Figure 1 – Structure of a hydropower plant

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 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.

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

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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.

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5.3 Logical structure of a hydropower plant

Different devices handle active and reactive power control. The turbine governor provides the active power control by regulating the water flow through the turbine and thus the pole angle between the rotating magnetic flux and the rotor. The excitation system provides the reactive power control by regulating the voltage of the generator. The magnetic flux shall correspond to the shaft torque to keep the generator synchronised to the grid.

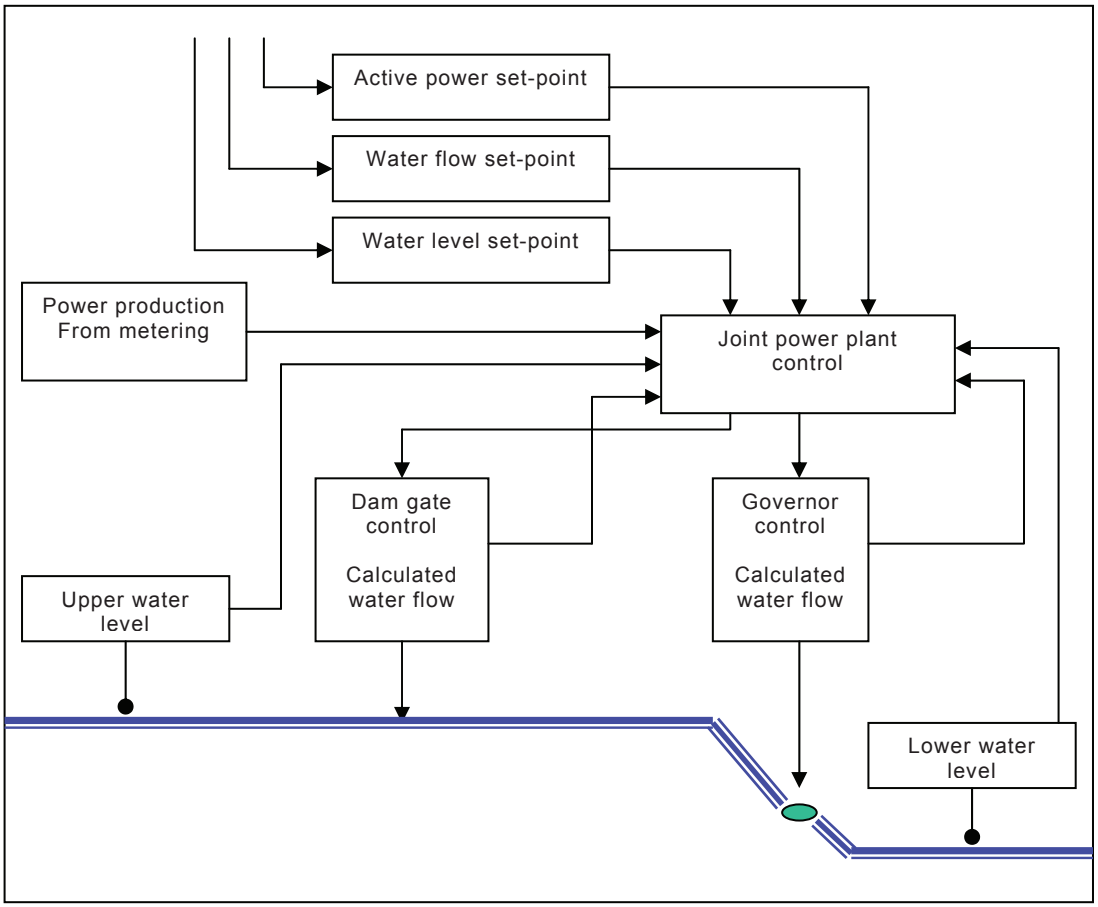

Figure 2 – Principles for the joint control function

Figure 2 shows an example of an arrangement including a joint control function. The set-points will be issued from a dispatch centre and could be one of three optional values. Therefore, the type of set-point that will be used depends on the water control mode that is used for the plant.

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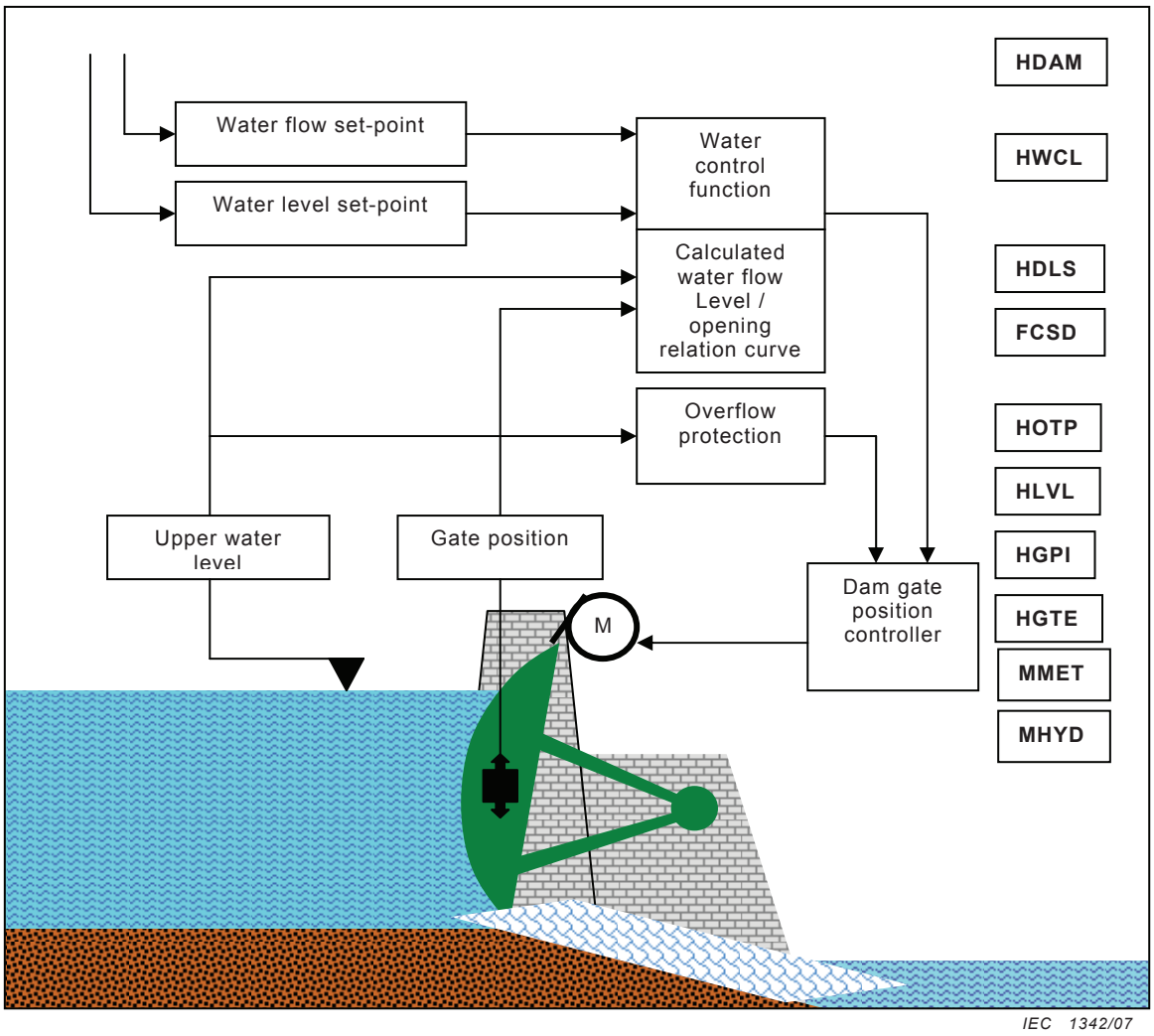

Figure 3 – Water control functions

Figure 3 is a typical example of water control functions of a dam. The overall water control of a hydropower plant will also include the water running through turbines. The overtopping protection (HOTP) is a safety function, acting independent of other control functions that will override normal spillway gate controls.

In the case of a reservoir without any power production, this water control function will get the set-points from a dispatch centre; in the case of a power plant it will be normally the joint control function that sets the values. The set-point will be either water level or water flow set-points.

The total water flow is the sum of flows through turbines and gates. The overall flow control shall also consider the flow through turbines. The turbine control system can, due to this, be provided with different set-points for the control:

- Water flow set-point. The control system will base the regulation on the given water flow level and try to optimise the production.
- Active power set-point. The control system will try to meet the active power, the water flow will be reported back to the overall water control system.

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- Active power control with speed droop. This is the mode when the unit is contributing to the network frequency control. The active power set-point is balanced over the speed droop setting to obtain the desired power/frequency amplification.
- Frequency set-point. in the case of an islanded system or a power plant in peak load duty, the active power will be controlled to exactly meet the demand. This control mode is also used during start-up of the unit, up to the point when the generator is synchronised. Water flow will be reported.

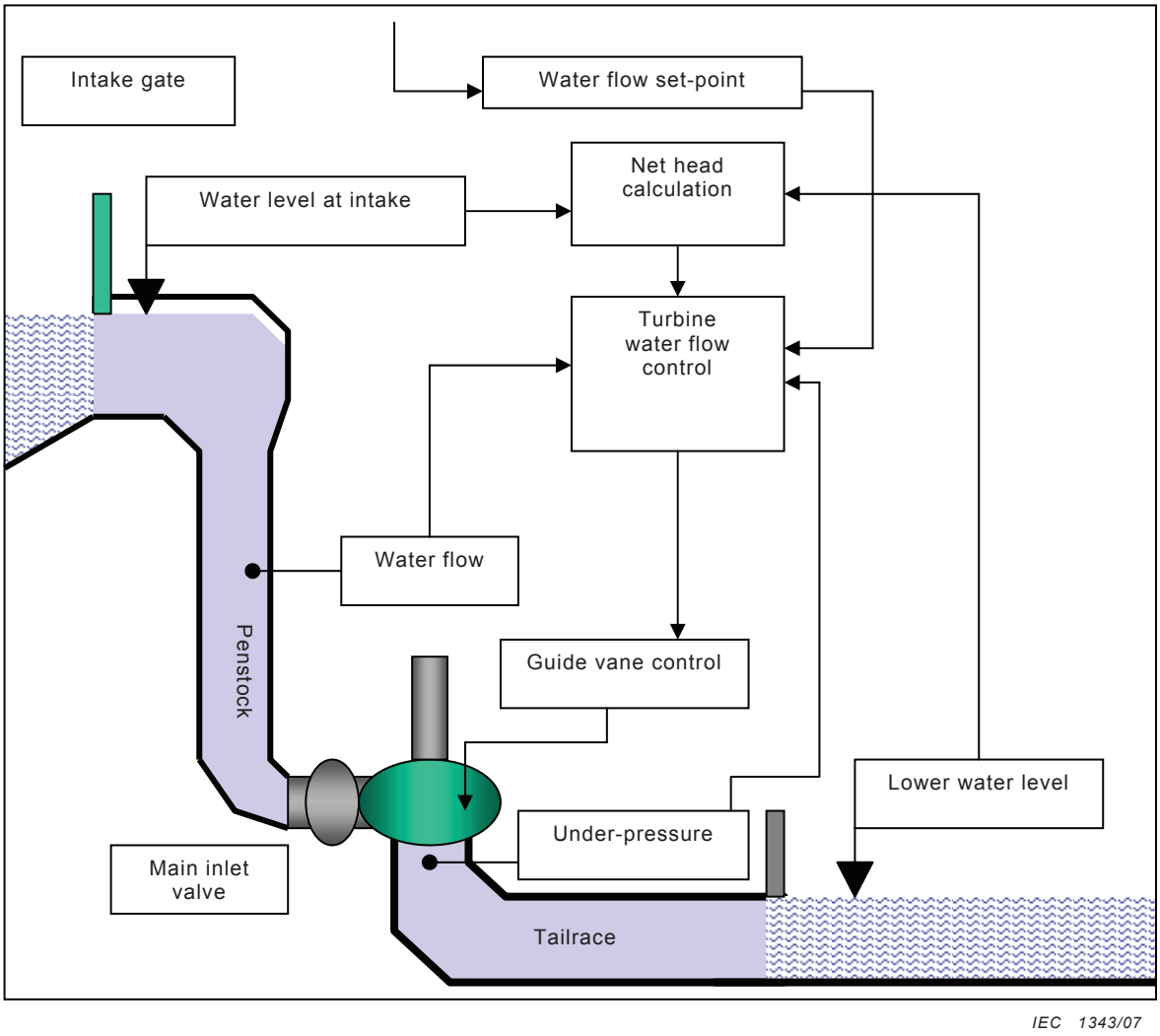

Figure 4 – Water flow control of a turbine

Figure 4 shows an example of water flow control of a turbine. Direct measurement of the water flow, as indicated in the figure, is less common. The flow is normally calculated, using the net head, the opening angle of the guide vanes and a correlation curve.

Main inlet valves to shut off the turbine chamber are used for pumped storage plants and power plants with high penstocks.

It is important to differentiate between the water levels of the dam and at the intake. Due to the intake design or if the turbine is running close to rated power, the water level at the intake might be considerably lower than the average for the dam.

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The measurement of under-pressure below the turbine chamber is a safety measure, to ensure that the operation of the guide vanes does not cause any dangerous conditions in the tail-race part.

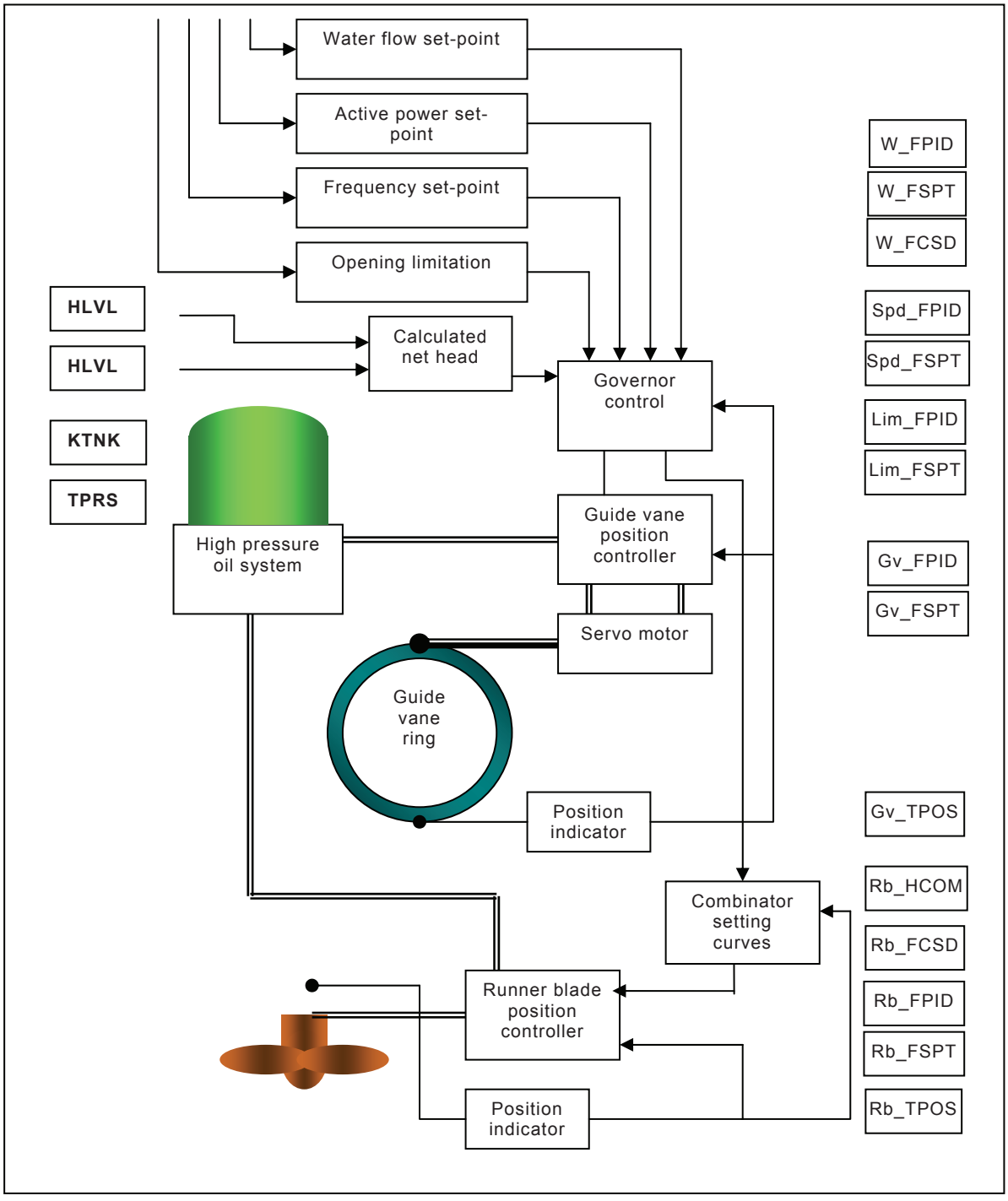

Figure 5 – Typical turbine control system

Figure 5 above shows an example of a turbine control system for a Kaplan turbine with moveable runner blades.

The frequency set-point and any opening (maximum power) limitation set-point are most likely to be given by dispatch centre (or locally).

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The active power set-point can be given by dispatch centre, but in the case of overriding water control functions, it is given by the joint control function (HJCL). The water control set-point is almost always provided by the joint control function.

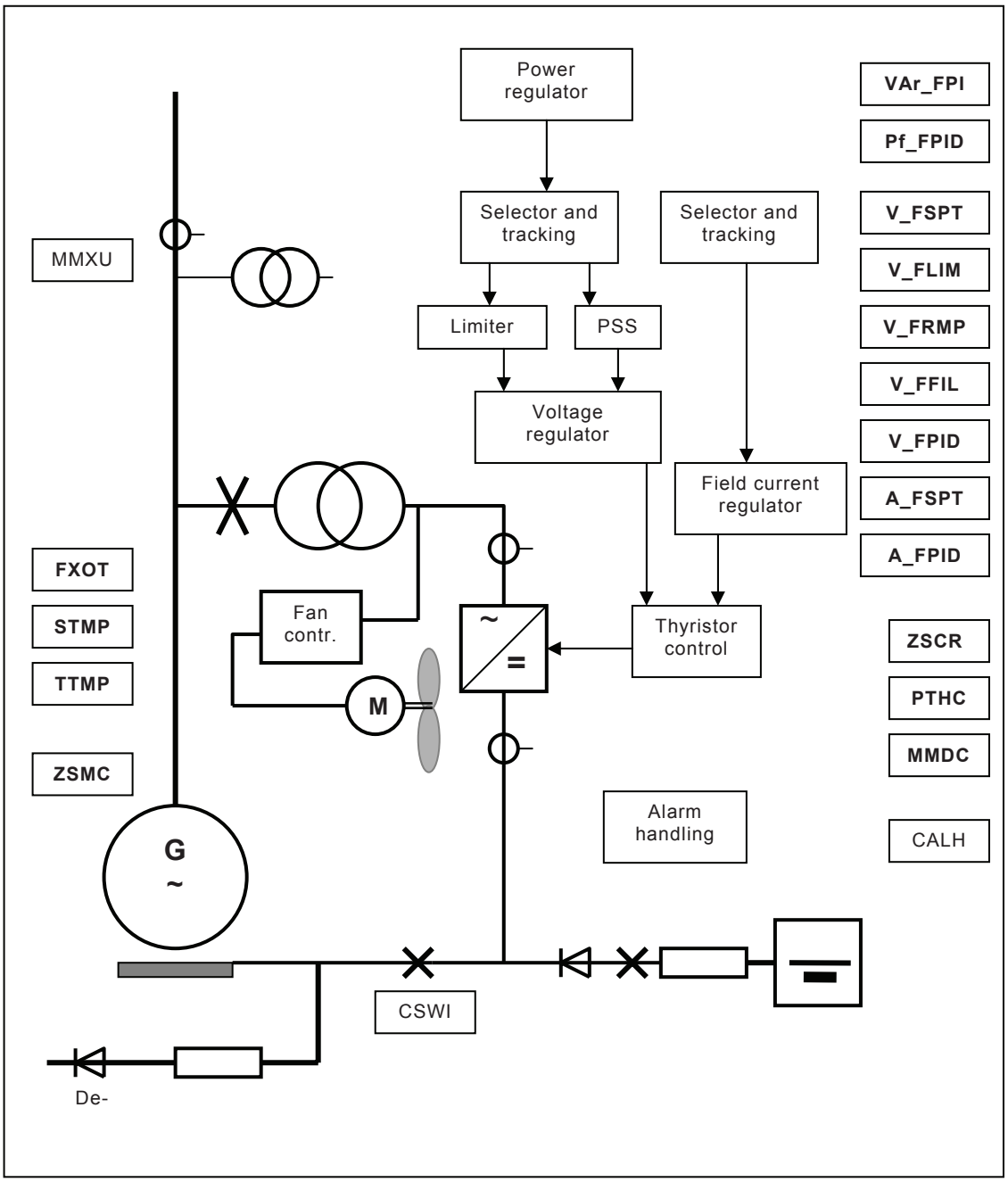

Figure 6 – Excitation system

Figure 6 shows an example of the excitation system for a generator. There are a number of different design principles for excitation systems; the figure does, however, include the most common functions. The synchronisation device can be included in the excitation system, in the turbine governor system, or it can be a separate device not being part of either.

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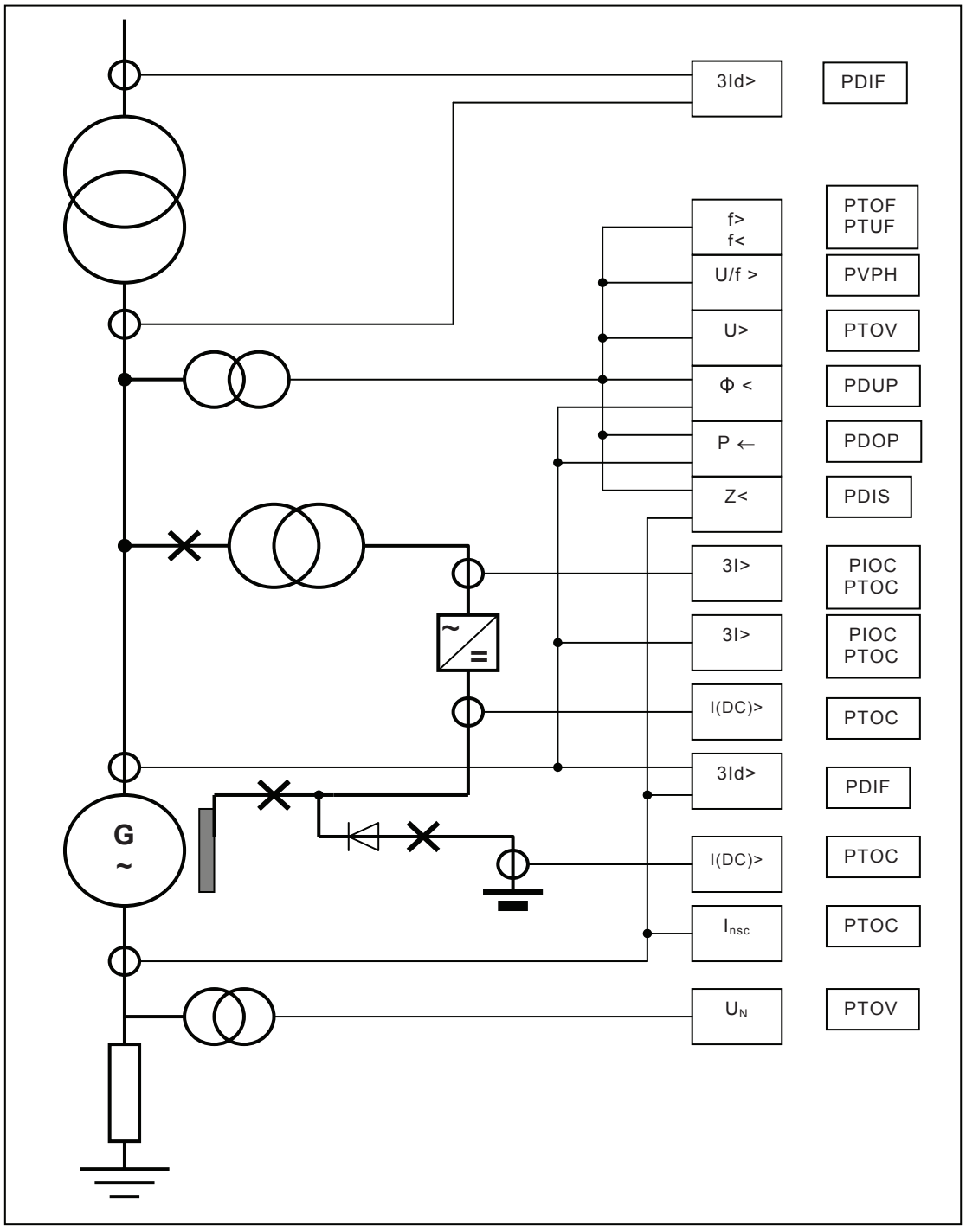

Figure 7 – Electrical protections of a generating unit

Figure 7 shows examples of electrical protections that are commonly used in hydropower applications. There might be other protections beside the ones shown here, such as shaft current protection. Another protection not included in the figure is a protection against unintentional energisation at stand-still; logical node name PZSU.

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6 Modelling concepts and examples

6.1 The concept of Logical Devices

A Logical Device is a local definition of an entity that may contain an arbitrary number of Logical Nodes. Logical Devices are used to provide a common address for Logical Nodes that would normally be grouped together. The principle of how Logical Devices are used is described in IEC 61850-7-1. For the formal specification of Logical Devices, see IEC 61850-7-2, Clause 8. As an example, we can look at a simple over-current protection, a standard distribution type protection device. Even if being part of for example an excitation system, this protection will be a separate device, with a possible set-up according to Table 1. All logical nodes in this example are found in IEC 61850-7-4.

Table 1 – Example of Logical Device over-current protection

LOGICAL-DEVICE class		
Attribute name	**Attribute type**	**Value/value range/explanation**
SupplyOC	ObjectName	Incoming supply over-current protection
G1ExOCin	ObjectReference	Excitation system for G1, incoming over-current
LPHD	LOGICAL-NODE	Physical device data
LLN0	LOGICAL-NODE	Logical node zero
MMXU	LOGICAL-NODE	Three-phase measurement data
PIOC1	LOGICAL-NODE	First step, instantaneous
PTOC2	LOGICAL-NODE	Second step, time delayed
PTOC3	LOGICAL-NODE	Second step, time delayed *
RDIR1	LOGICAL-NODE	Directional element, linked to first step *
RBRF	LOGICAL-NODE	Breaker-failure function *
* Functions not required in the specific application can be disabled, in which case the corresponding logical nodes will not show in the Logical Device Directory.		

A real world excitation system would most likely be built up of a number of smaller logical (and physical) devices. The excitation system as such will then only be a part of the name reference string that identifies the various logical devices that together constitutes the overall function.

6.2 Logical nodes for sensors, transmitters, supervising and monitoring functions

This group of logical nodes are divided in two groups. Sensors and transmitters are listed within logical node group T. These devices will output a single sampled analogue value at a given sampling rate. Supervising and monitoring functions are grouped under S, these functions may convert the sampled values to measured values and perform checks against limits. Figure 8 shows the concept of how different data classes are used.

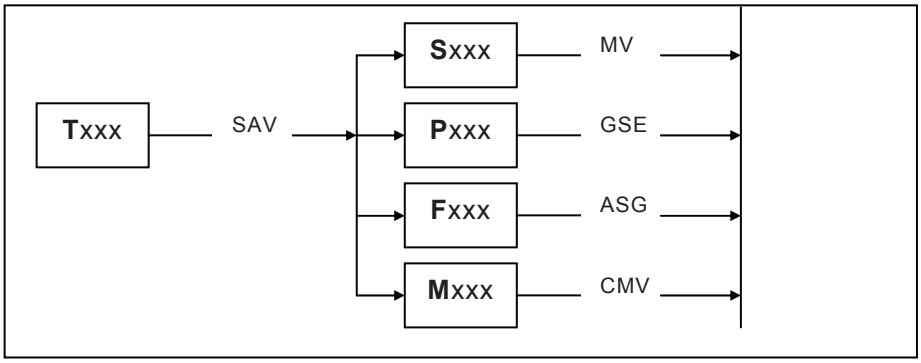

Figure 8 – Conceptual use of transmitters *IEC 1347/07*

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6.3 Address strings

The utility is expected to provide the address, from top level and down to the Logical Device level. The naming conventions and format shall be as specified in IEC 61850-7-2, Clause 19.

The allowed format is basically as shown in Figure 9.

LD Name	LN Name			Data Name	Data Attribute Name
	LN Prefix	LN Class	LN Instance no		

IEC 1348/07

Figure 9 – Logical Device Name

The Logical Device name (**LDName**) may consist of up to 32 alphanumeric characters.

The Logical Node name (**LNName**) may consist of up to 11 alphanumeric characters, arranged as follows:

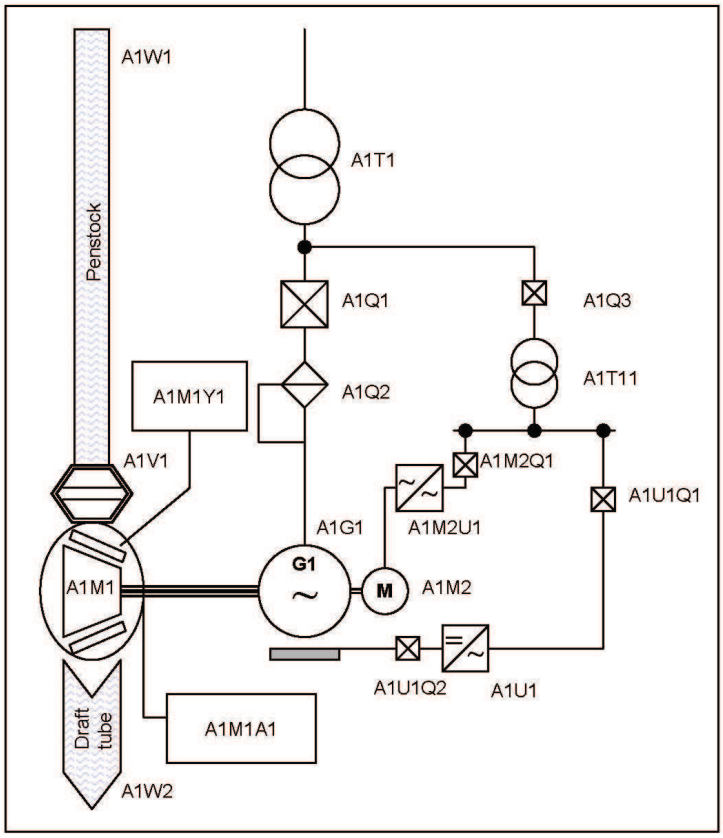
Logical Node prefix: m characters

Logical Node Class name: 4 characters (e.g. as specified in IEC 61850-7-4)

Logical Node instance number: n numeric characters

m + n may be up to 7 characters

A Data Name (DataName) may consist of 10 characters (e.g. as specified in IEC 61850-7-4). Figure 10 shows an example of possible LD name strings, using IEC 61346-1.



IEC 1349/07

A1	Generating unit 1
A1G1	Generator 1
A1M1	Turbine
A1M1Y1	Turbine governor
A1M1A1	Compressed air system for turbine chamber
A1M2	Start motor (pony motor)
A1M2U1	Motor start system
A1M2Q1	Start motor supply circuit-breaker
A1T1	Generator transformer
A1T11	Local services transformer
A1Q1	Generator circuit-breaker
A1Q2	Phase-shift switch
A1Q3	Local services switch
A1U1	Excitation system
A1U1Q1	Excitation supply switch
A1U1Q2	Field circuit-breaker
A1V1	Ball valve

Figure 10 – Example of naming structure, in a pumped storage plant, based on IEC 61346-1

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6.4 Naming of logical nodes

Logical Nodes are grouped together with nodes of similar or related functions having the same first letter. The following letters are at present assigned to such groups of functions:

A Automatic control functions

C Control functions

D Functions specific to distributed energy resources (DER)

F Logical nodes representing functional blocks

G Generic references

H Functions specific to hydropower plants

I Interface and archiving functions

K Kinetic energy, mechanical devices and equipment

L Physical devices and common logical nodes

M Metering and measurement

P Electrical protections

R Protection related functions

S Supervision and monitoring

T Sensors and transmitters (including instrument transformers)

W Functions specific to wind power plants

X Switchgear

Y Power transformers

Z Power system equipment

6.5 Recommended naming structure for automatic control functions

In substations, the logical nodes representing functions are named after the purpose of the functions. In most cases, the algorithms used are hidden from the user and there is little point in indicating the type of algorithm of the function.

The design of control functions in power plants is, however, different. Most control structures are assembled from generic control blocks. The logical nodes for automatic control functions included in this document are named on a principle based on the algorithm used within the function, for example PID regulator, ramping control etc.

In order to indicate which logical nodes are used in the same overall control function, or what type of equipment is being controlled, prefixes can be used in a formalised manner. This is recommended for situations where one logical device might include more than one group of control functions. For example, a turbine governor control that includes both frequency and active power control functions, functions for correlating guide vane and runner blade settings as well as position control of operated devices.

As an example, a runner blade control function within the turbine governor, based on a PID regulator algorithm, may be identified as Rb_FPID. If there is more than one logical node of the same type, the instances shall be differentiated by suffix numbers.

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Recommended logical node prefixes are listed in Table 2 below:

Table 2 – recommended LN prefixes

Name/description of function	Recommended LN prefix
Active power	W_
Actuator	Act_
Current	A_
Deflector	Dfl_
Droop	Drp_
Flow	Flw_
Frequency	Hz_
Guide vane	Gv_
Level	Lvl_
Limiter	Lim_
Needle	Ndl_
Position	Pos_
Power factor	Pf_
Pressure	Pa_
Reactive power	VAr_
Runner blade	Rb_
Speed	Spd_
Temperature	Tmp_
Voltage	V_

The prefixes in Table 2 are only recommendations, the user may decide on another method to identify the purpose of logical nodes for control functions. If a more specific definition is required, for example if a flow control function is intended for water flow or oil flow, this should be identified by the logical device namestring.

6.6 Summary of logical nodes to be used in hydropower plants

6.6.1 General

This part of IEC 61850 specifies the compatible Logical Node classes to be used in hydropower plants listed in the following Tables 3 to 16. Logical Node names shown in bold are the LN classes defined in this document. Logical Node names shown in plain text are defined in IEC 61850-7-4:2003, they are included in this list for easier reference.

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Full document details: DIN EN 61850-7-410:2008-04

6.6.2 Group C – Control functions

Table 3 – Logical nodes for control functions

LN Class	Description
CALH	Alarm handling. See IEC 61850-5 for a description of this LN.
CSWI	Switch controller. See IEC 61850-5 for a description of this LN.

6.6.3 Group F – Functional blocks

Table 4 – Logical nodes representing functional blocks

LN Class	Description
FCNT	**Counter function**. This LN represents a generic counter. It can be a separate physical device or be embedded in a more complex logical device. It basically counts incoming pulses that might represent anything that can be counted.
FCSD	**Curve shape description**. A logical node to hold a curve shape description used for correlation between measured values and metered values.
FFIL	**Filter function.** Basic filter function to modify a measured value.
FLIM	**Limiter function.** The function is used to set restrictions to output signals of other control functions.
FPID	**Proportional, integral and derivative regulator function.** Basic regulator function used in most controllers.
FRMP	**Ramp control function.** Ramp function to be used to modify e.g. a set-point value.
FSPT	**Setpoint control function.** Basic function used to modify inputs to regulators or other control functions.
FXOT	**Action at over threshold.** This logical node represents a function acting when the measured value increases above a given set value. It can typically be used whenever a protection, control or alarm function is based on other physical measurements than primary electric data.
FXUT	**Action at under threshold.** This logical node represents a function acting when the measured value decreases below a given set value. It can typically be used whenever a protection, control or alarm function is based on other physical measurements than primary electric data.

6.6.4 Group H – Hydropower specific logical nodes

Table 5 – Hydropower specific logical nodes

LN Class	Description
HBRG	**Turbine – generator shaft bearing**. This LN holds data pertaining to bearings, such as temperatures and lubrication oil flows.
HCOM	**Combinator (3D-CAM or 2D-CAM)**, optimises the relation between net head, guide vanes and runner blades. It is used in power plants with Kaplan turbines with moveable runner blades. The combinatory function will also use the FCSD LN to hold the relation curves for different net heads.
HDAM	**Hydropower dam**. A logical node that is used to represent the physical aspects of the dam.
HDLS	**Dam leakage supervision**. Represents a device that will supervise and give alarm in the case of dam leakage. The actual measurement can be based on water flow.
HGPI	**Gate position indicator**. A device that provides the position of a dam gate. The position is given either as an angular displacement in the case of sector gates or as distance from fully closed position in the case of straight gates. For aperture gates and valves where the position is given as percent of full opening, either the HVLV or the SPOS logical nodes are recommended.

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Full document details: DIN EN 61850-7-410:2008-04

Table 5 *(continued)*

LN Class	Description
HGTE	**Dam gate**. This LN is intended to hold information about the gate. It can also present a calculated water flow through the gate, in which case the FCSD LN shall be included in the same logical device, to provide the relations. Note that in this LN the position set-point is listed under *Controls* instead of *Settings*. The normal way to control a gate is to send a position set-point.
HITG	**Intake gate**. This LN can be used to represent intake gates. The gates will almost never be placed in any other position than fully closed or fully open. However to cater for step-wise or other controls, the gate is normally provided with a number of position switches.
HJCL	**Power plant joint control function**. In plants with more than one gate or several turbines, this LN will represent the joint control function that is used to supervise the total water flow or to maintain a constant water level. The LN shall be instantiated to provide one instance for each gate and each turbine to be supervised.
HLKG	**Leakage supervision**. This LN can be used to measure any leakage in the plant, it is more generic than HDLS.
HLVL	**Dam water level indicator**. The LN represents the water level sensing device. The output is a distance including an offset from a base level (commonly the distance above sea).
HMBR	**Mechanical brake for the generator shaft**. This is a LN for the brake control. The brake is used for stopping the unit during shut-down and to hold the shaft still, once the unit is stopped.
HNDL	**Needle control**. A specialised LN that represents the control of Pelton turbines.
HNHD	**Net head data**. A LN that can be used to present the calculated net head data (difference between upper and lower water levels) in a hydropower plant.
HOTP	**Dam overtopping protection**. A protection function that will act by opening one or more gates in the case of a risk for overflow. The protection will sometimes include its own water measurement device; hence an optional measured value for water level. Whether the protection shall trip a unit or not depends on the layout of the plant, if there is a risk of flooding if the dam overflows.
HRES	**Water reservoir.** A logical node that is used to represent the logical function of a reservoir. If the content is to be calculated, the FSCD LN shall be used to provide the relation between water level and content.
HSEQ	**Start/stop sequencer**. A simple LN that only presents what the sequencer is doing (inactive – starting – stopping) and in case it is active, what step it is presently working on.
HSPD	**Speed monitoring**. This LN is normally located in a stand-alone logical device, separated from but monitoring the turbine governor. It will also act as a placeholder for various speed limits and set-points used by the start sequencer and other control functions.
HUNT	**Hydropower production unit**. This LN represents the physical device of the turbine and generator combination in a hydropower plant. It is intended as an extended rating plate that allows temporary settings of data. It also acts as a placeholder for the current operating conditions of the unit.
HWCL	**Water control function**. This LN will represent one physical device that can modify the water flow though the plant, either a gate or a turbine. In the case of a plant with a joint control function, the HJCL LN will provide the flow set-point to be used by HWCL.

6.6.5 Group I – Interface and archiving

Table 6 – Logical nodes for interface and archiving

LN Class	Description
IARC	Generic archiving function. See IEC 61850-5 for a description of this LN.
IHMI	Generic human – machine interface. See IEC 61850-5 for a description of this LN.
ISAF	Generic safety device. This logical node represents an alarm push-button or other device that will provide an alarm in the case of danger to persons or property.

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6.6.6 Group K – Mechanical and non-electrical primary equipment

Table 7 – Logical nodes for mechanical and non-electric primary equipment

LN Class	Description
KFAN	**Fan.** The LN represents the physical device of a fan.
KFIL	**Filter.** The LN represents a filter for air, liquid or other media.
KPMP	**Pump.** The LN represents the physical device of a pump for gaseous or liquid media.
KTNK	**Tank**. This LN represents tanks of various types used in the plant, e.g. for water, hydraulic oil or pressurised air. It can be used for tanks that are pressurised.
KVLV	**Valve or aperture gate**. A valve or gate that can be operated between two end positions that can be given as a percentage of full open position. It would normally be assumed that the measured flow can be calculated directly based on the percent of opening.

6.6.7 Group L – Physical devices and common logical nodes

Table 8 – Logical nodes for physical devices and common LN

LN Class	Description
LLN0	Logical Node zero. Shall always be present in a logical device. See IEC 61850-7-4 for a description of this LN.
LPHD	Physical device information. Shall always be present in a physical device. See IEC 61850-7-4 for a description of this LN.

6.6.8 Group M – Metering and measurement

Table 9 – Logical nodes for metering and measurement

LN Class	Description
MDIF	Differential current measurement. See IEC 61850-5 for a description of this LN.
MENV	**Environmental data**. This LN is used to present various measurements of environmental data, outside what is provided by MHYD and MMET.
MHAI	Harmonics measurement. See IEC 61850-5 for a description of this LN.
MHYD	**Hydrological measurement.** This LN is used for measurements of hydrological data that is used to supply water level and flow data to various systems such as the power plant controller or to other agencies.
MMDC	**DC current and voltage measurement**. This LN is used for measurements in DC systems. It provides current (I), voltage (V), active power (P) and resistance (Ω). Since most DC systems in power plants are not connected to earth, the measurements of voltage and resistance is optionally provided between poles as well between each pole and earth.
MMET	**Meteorological measurement.** This LN is used for measurements of meteorological data elements that contribute to predict level and flow fluctuations in the river system.
MMXN	Single-phase measurement. See IEC 61850-5 for a description of this LN.
MMXU	Three-phase measurement. See IEC 61850-5 for a description of this LN.

6.6.9 Group P – Protection functions

NOTE Most of the logical nodes that represent protective functions are defined in the substation part of the IEC 61850 series.

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Table 10 – Logical nodes for protections

LN Class	Description
PDIF	Generator differential, restricted earth-fault. See IEC 61850-5 for a description of this LN.
PDOP	Reverse power. See IEC 61850-5 for a description of this LN.
PDUP	Loss of field (excitation system failure). See IEC 61850-5 for a description of this LN.
PHIZ	Residual over-voltage. See IEC 61850-5 for a description of this LN.
PIOC	Phase over-current. See IEC 61850-5 for a description of this LN.
PPAM	Phase angle, out-of-step. See IEC 61850-5 for a description of this LN.
PRTR	**Rotor protection**. Field short-circuit protection using the 6th harmonic (300Hz).
PSDE	Directional earth-fault. See IEC 61850-5 for a description of this LN.
PTHF	**Thyristor failure protection**. Will provide alarm and tripping in the case of one or more thyristors fails.
PTOC	Time over-current, rotor earth-fault, bearing current, stator earth-fault.
PTOF	Over-frequency. See IEC 61850-5 for a description of this LN.
PTOV	Over-/under-voltage. See IEC 61850-5 for a description of this LN.
PTUF	Under-frequency. See IEC 61850-5 for a description of this LN.
PTTR	Overload. See IEC 61850-5 for a description of this LN.
PVOC	Under impedance. See IEC 61850-5 for a description of this LN.
PVPH	Over-fluxing. See IEC 61850-5 for a description of this LN.
PZSU	Energising at stand-still. See IEC 61850-5 for a description of this LN.

6.6.10 Group R – Protection related functions

Table 11 – Logical nodes for protection related functions

LN Class	Description
RBRF	Breaker-fail protection. See IEC 61850-5 for a description of this LN.
RPSB	Power swing detection. See IEC 61850-5 for a description of this LN.
RSYN	**Synchronizing**. Replacement specification of the LN of IEC 61850-7-4:2003. The existing specification in IEC 61850-7-4:2003 is incorrect for use in power generation.

6.6.11 Group S – Supervision and monitoring

Table 12 – Logical nodes for supervision and monitoring

LN Class	Description
SPDC	Partial discharge sensor. See IEC 61850-5 for a description of this LN.
STMP	**Temperature supervision**. This logical node represents a generic temperature supervision system that can provide alarm and trip signals. In an application, the LN shall be instantiated with one instance per temperature being measured.
SVBR	**Vibration supervision**. This logical node represents a generic vibration supervision system that can provide alarm and trip signals. In an application, the LN shall be instantiated with one instance per point being measured. The LN can be used to supervise either vibration or axial displacement or both values.

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