INTERNATIONAL STANDARD

IEC 62270

First edition
2004-04

Hydroelectric power plant automation – Guide for computer-based control

Reference number
IEC 62270:2004(E)

Publication numbering

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE XB

For price, see current catalogue

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HYDROELECTRIC POWER PLANT AUTOMATION – GUIDE FOR COMPUTER-BASED 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 62270 has been prepared by IEC technical committee 4: Hydraulic turbines.

The text of this standard is based on the IEEE Standard 1249 (1996) *IEEE guide for computer-based control for hydroelectric power plant automation*. It was submitted to the national committees for voting under the Fast Track procedure as the following documents:

FDIS	Report on voting
4/188/FDIS	4/190/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.

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

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

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- withdrawn;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

INTRODUCTION

Automation of hydroelectric generating plants has been a known technology for many years. Due to the relative simplicity of the control logic for hydroelectric power plants, the application of computer-based control has lagged, compared to other types of generating stations, such as fossil. Now that computer-based control can be implemented for comparable costs as relay-based logic and can incorporate additional features, it is being applied in hydroelectric power stations worldwide, both in new installations and in the rehabilitation of older plants.

HYDROELECTRIC POWER PLANT AUTOMATION – GUIDE FOR COMPUTER-BASED CONTROL

1 Overview

1.1 Scope

This standard sets down guidelines for the application, design concepts, and implementation of computer-based control systems for hydroelectric plant automation. It addresses functional capabilities, performance requirements, interface requirements, hardware considerations, and operator training. It includes recommendations for system testing and acceptance. Finally, case studies of actual computer-based automatic control applications are presented.

The automation of control and data logging functions has relieved the plant operator of these tasks, allowing the operator more time to concentrate on other duties. In many cases, the plant's operating costs can be significantly reduced by automation (primarily via staff reduction) while still maintaining a high level of unit control reliability.

Automatic control systems for hydroelectric units based on electromechanical relay logic have been in general use for a number of years and, in fact, were considered standard practice for the industry. Within the last decade, microprocessor-based controllers have become available that are suitable for operation in a power plant environment. These computer-based systems have been applied for data logging, alarm monitoring, and unit and plant control. Advantages of computer-based control include use of graphical user interfaces, the incorporation of sequence of events and trending into the control system, the incorporation of artificial intelligence and expert system capabilities, and reduced plant life cycle cost.

1.2 Purpose

This standard is directed to the practicing engineer who has some familiarity with computer-based control systems and who is designing or implementing hydroelectric unit or plant control systems, either in a new project or as a retrofit to an existing one. This standard assumes that the control system logic has already been defined; therefore, its development is not covered. For information on control sequence logic, the reader is directed to the IEEE guides for control of hydroelectric power plants listed in Clause 2 of this standard.

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 61158, *Digital data communications for measurement and control - Fieldbus for use in industrial control systems*

ANSI C63.4-2001, *Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz–40 GHz* [1]

IEEE Std 100-1996, *The IEEE Standard Dictionary of Electrical and Electronics Terms* [2]

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[1] ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[2] IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

IEEE Std 485-1997, *IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications* (ANSI)

IEEE Std 610-1990, *IEEE Standard Glossary of Software Engineering Terminology* (ANSI).

IEEE Std 1010-1987 (Reaffirmed 1992), *IEEE Guide for Control of Hydroelectric Power Plants* (ANSI)

IEEE Std 1014-1987 *IEEE Standard for A Versatile Backplane Bus: VMEbus*

IEEE Std 1020-1988 (Reaffirmed 1994), *IEEE Guide for Control of Small Hydroelectric Power Plants.* (ANSI)

IEEE Std 1046-1991 (Reaffirmed 1996), *IEEE Guide for Distributed Digital Control and Monitoring for Power Plants* (ANSI)

IEEE Std 1147-1991 (Reaffirmed 1996), *IEEE Guide for the Rehabilitation of Hydroelectric Power Plants* (ANSI)

IEEE Std C37.1-1994, *IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automation Control (ANSI)*

IEEE Std C37.90.1-2002, *IEEE Standard for Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems (ANSI)*

IEEE Std C37.90.2-1995, *IEEE Trial Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers (ANSI)*

IEEE 1379: 2000, IEEE *Recommended Practice for Data Communications Between Remote Terminal Units and Intelligent Electronic Devices in a Substation (ANSI)*

ISO/IEC 8802-3:2001, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*[3] (ANSI/IEEE Std 802.3, 1996 Edition)

ISO/IEC 8802-4:1990 (Reaffirmed 1995), *Information processing systems – Local area networks – Part 4: Token-passing bus access method and physical layer specifications* (ANSI/IEEE 802.4-1990 Edition)

ISO/IEC 8802-5:1998, *Information technology –Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 5: Token ring access method and physical layer specifications* (ANSI/IEEE Std 802.5, 1995 Edition)

3 Terms and definitions

For the purposes of this document the definitions provided here reflect common industry usage as related to automation of hydroelectric power plants, and may not in all instances be in accordance with IEEE Std 100-1996, or IEEE Std 610-1990, or other applicable standards. For more rigorous definitions, or for definitions not covered herein, the reader is referred to the appropriate IEEE standards.

[3] ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

3.1
analog-to-digital (a/d) conversion
production of a digital output corresponding to the value of an analog input quantity

3.2
automatic control
arrangement of electrical controls that provides for switching or controlling, or both, of equipment in a specific sequence and under predetermined conditions without operator intervention

3.3
automatic generation control (AGC)
capability to regulate the power output of selectable units in response to total power plant output, tie-line power flow, and power system frequency

3.4
automatic voltage control (AVC)
capability to regulate a specific power system voltage, via adjustment of unit excitation within the limits of unit terminal voltage and VAR capability

3.5
automation hierarchy
design and implementation of automation functions in a multilevel structure, such as local level, group level, unit level, etc.

3.6
availability
ratio of uptime (system functional) to uptime plus downtime (system not functional)

3.7
backplane
circuit board with connectors or sockets that provides a standardized method of transferring signals between plug-in circuit cards

3.8
bridge
device that allows two networks of the same or similar technology to communicate

3.9
centralized control
control location one step removed from local control; remote from the equipment or generating unit, but still within the confines of the plant (e.g. controls located in a plant control room)

3.10
closed loop control
type of automatic control in which control actions are based on signals fed back from the controlled equipment or system. For example, a plant control system can control the power output of a multi-unit hydroelectric power plant by monitoring the total plant megawatt value and, in response, by controlling the turbine governors of each unit, change the plant power output to meet system needs

3.11
computer-based automation
use of computer components, such as logic controllers, sequence controllers, modulating controllers, and processors in order to bring plant equipment into operation, optimize operation in a steady-state condition, and shut down the equipment in the proper sequence under safe operating conditions

3.12
control hierarchy
system organization incorporating multiple levels of control responsibility

3.13
control philosophy
total concept on which a power plant control system is based

3.14
data acquisition system
centralized system that receives data from one or more remote points. Data may be transported in either analog or digital form

3.15
database
collection of stored data regarding the process variables and processing procedures

3.16
data bus
control network technology in which data stations share one single communication system medium. Messages propagate over the entire medium and are received by all data stations simultaneously

3.17
device (electrical equipment)
operating element such as a relay, contactor, circuit breaker, switch or valve, used to perform a given function in the operation of electrical equipment

3.18
digital-to-analog (d/a) conversion
production of an analog signal whose magnitude is proportional to the value of a digital input

3.19
distributed processing
design in which data is processed in multiple processors. Processing functions could be shared by the processors throughout the control system

3.20
event
discrete change of state (status) of a system or device

3.21
expert system
computer programs that embody judgmental and experimental knowledge about an application. Expert systems are able to reach decisions from new, uncertain and incomplete information with a specified degree of certainty. Expert system abilities include: making logical inferences under unforeseen conditions; using subjective and formal knowledge; explaining the procedures used to reach a conclusion; growing in effectiveness as embedded expertise is expanded and modified

3.22
firmware
hardware used for the non-volatile storage of instructions or data that can be read only by the computer. Stored information is not alterable by any computer program

3.23
gateway
device that allows two networks of differing technology to communicate

3.24
local control
for auxiliary equipment, controls that are located at the equipment itself or within sight of the equipment. For a generating station, the controls that are located on the unit switchboard/governor control station

3.25
logic:(control or relay logic)
predetermined sequence of operation of relays and other control devices

3.26
manual control
control in which the system or main device, whether direct or power-aided in operation, is directly controlled by an operator

3.27
mean-time-between-failure (MTBF)
time interval (hours) that may be expected between failures of an operating equipment

3.28
mean-time-to-repair (MTTR)
time interval (hours) that may be expected to return a failed equipment to proper operation

3.29
modem
modulator/demodulator device that converts serial binary digital data to and from the signal form appropriate for an analog communication channel

3.30
monitoring
means of providing automatic performance supervision and alarming of the status of the process to personnel and control programs

3.31
offsite control
controls that are not resident at the plant (e.g. at a switchyard, another plant, etc.)

3.32
open loop control
form of control without feedback

3.33
proportional integral derivative (PID) [control system]
control action in which the output is proportional to a linear combination of the input, the time integral of input, and the time rate of change of input. Commonly used in hydroelectric applications for the control of a generator's real power, reactive power, or flow

3.34
pixel
in image processing, the smallest element of a digital image that can be assigned a gray level

3.35
programmable logic controller (PLC)
solid state control system with programming capability that performs functions similar to a relay logic system

3.36
protocol
structured data format required to initiate and maintain communication

3.37
relay, interposing
device that enables the energy in a high-power circuit to be switched by a low-power control signal

3.38
remote control
control of a device from a distant point

3.39
reliability
characteristic of an item or system expressed by the probability that it will perform a required mission under stated conditions for a stated mission time

3.40
response time
elapsed time between the moment when a signal is originated in an input device until the moment the corresponding processed signal is made available to the output device(s), under defined system loading conditions

3.41
resistance temperature detector (RTD)
resistor for which the electrical resistivity is a known function of the temperature

3.42
scan (interrogation)
process by which a data acquisition system sequentially interrogates remote stations for data at a specific frequency

3.43
scan cycle
time in seconds required to obtain a collection of data (for example, all data from one controller, all data from all controllers, and all data of a particular type from all controllers)

3.44
serial communication
method of transmitting information between devices by sending digital data serially over a single communication channel

3.45
sequential control
mode of control in which the control actions are executed consecutively

3.46
supervisory control and data acquisition (SCADA)
system operating with coded signals over communication channels so as to provide control of remote equipment and to acquire information about the status of the remote equipment for display or for recording functions