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Telecontrol equipment and systems

Part 1: General considerations

Section One – General principles

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

TELECONTROL EQUIPMENT AND SYSTEMS

Part 1: General considerations

Section One: General principles

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This report has been prepared by IEC Technical Committee No. 57: Telecontrol, teleprotection and associated telecommunications for electric power systems.

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

Six Months' Rule	Report on Voting	Two Months' Procedure	Report on Voting
57(CO)21	57(CO)25	57(CO)30	57(CO)34

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

The following IEC publication is quoted in this report:

Publication No. 50(371) (1984): International Electrotechnical Vocabulary, Chapter 371: Telecontrol.

TELECONTROL EQUIPMENT AND SYSTEMS

Part 1: General considerations

Section One - General principles

INTRODUCTION

Telecontrol systems serve for monitoring and control of processes which are geographically widespread. They include all equipment and functions for acquisition, processing, transmission and display of the necessary process information. The performance of a telecontrol system is determined basically by:

1) the data integrity of information transfer, from a source to its destination, and

2) the speed with which information is transferred to its destination.

The data integrity is defined as the unchangeability of an information content from a source to its destination, while the speed of information transfer is measured by the overall transfer time.

The high responsibility which is associated with the transmission of information such as commands and the occurrence of adverse environmental conditions necessitate standards for data acquisition and of data transmission which fulfil stringent requirements of data integrity and transmission efficiency.

It should be noted that although this series of standards has been produced specifically for telecontrol systems used in electrical power systems, they may also be applied to other fields of application, e.g. gas and water supply and distribution, etc.

The aim of these standards is to provide adequate information for correct planning and reliable operation of telecontrol systems. The standards are divided into different parts, listed in Clause 2 of this report.

This part of this series of telecontrol standards is intended to give the user a general survey of the systems and their elements, thus presenting the necessary basic information for a thorough understanding of the following parts of these standards.

1. Scope

This series of standards applies to telecontrol equipment and systems with coded bit serial data transmission for monitoring and control of geographically widespread processes.

2. Object

This series of standards describes configurations and functions of telecontrol systems and of related elements. It defines the functional requirements, logical characteristics and interface conditions of the basic elements and the rules those elements shall follow in co-existing with other elements.

These standards do not define the internal physical characteristics of such elements nor the layout, construction or material used.

The following subjects are outside the scope of these standards:

- ripple control systems;
- properties of transmission channels and local bus (highway) systems for communication between process input/output elements;
- teleprotection and locally automated functions even though they may sometimes be implemented within a telecontrol system.

These standards are subdivided into several parts, which are subdivided into several sections and issued as separate publications bearing the following titles and scopes:

IEC Publication 870-1-1: Part 1: General considerations, Section One - General principles (which constitutes this report)

This report explains the structural elements, configurations and basic functions of telecontrol systems.

It gives an overview of functional elements which contribute to basic structures and possible choice of telecontrol systems configurations.

It deals with functions which are typical for any process to be monitored and controlled but emphasizes the specific problems which characterize geographically widespread processes, such as the dominant influence of telecommunication links with restricted bandwidth and often low signal-to-noise ratio.

However, this report shall only serve as an introduction to the detailed standards and recommendations laid down in Parts 2-5 quoted below.

IEC Publication 870-1-2: Part 1: General considerations, Section Two - Guide for specifications (under consideration)

This Section Two of Part 1 will describe guidelines for planning and defining specifications of telecontrol systems and equipment in order to accommodate individual application demands.

IEC Publication 870-1-3: Part 1: General considerations, Section Three - Glossary (under consideration)

This Section Three of Part 1 will present the specific terms of telecontrol techniques as defined in the International Electrotechnical Vocabulary [IEV] [IEC Publication 50 (371)] as well as other terms which are necessary for the understanding of this series of standards.

IEC Publication 870-2-1: Part 2: Operating conditions, Section One - Environmental conditions and power supplies

This Section One of Part 2 defines the environmental and power supply conditions to which the telecontrol equipment should be designed in order to fulfil its specifications. It establishes classes for different conditions and also defines test procedures.

IEC Publication 870-2-2 will constitute Section Two and it will deal with electromagnetic compatibility as well as corrosive and erosive influences.

IEC Publication 870-3: Part 3: Interfaces (in preparation)

This part will define the interface conditions that have to be met in order to correlate the different pieces of equipment needed to form a telecontrol system and to allow the user to manage such a system.

IEC Publication 870-4: Part 4: Performance requirements (in preparation)

This part will deal with those characteristics that have to be met by telecontrol equipment and systems to accomplish the functions for which they are intended in a continuous, secure and precise manner, and in addition to be flexible enough to accommodate future demands.

IEC Publication 870-5: Part 5: Transmission protocols (in preparation)

This part will describe the functional characteristics of data transmission that shall be met in order to implement a telecontrol system by means of links or networks. Data integrity requirements for information transmission, distinct data formats and transmission methods, which fulfil these requirements, will be defined.

This part will include several sections.

The standards listed above will be completed by additional parts and sections as appropriate.

3. General aspects related to telecontrol systems

The fundamental aspects relating to the operation of geographically widespread processes including the generation and optimum transportation and distribution of a product are very similar for the different kinds of products (e.g. gas, water, oil or electricity). Telecontrol systems employed in the operation of electric power systems have been developed to a very advanced state and often serve as examples for applications in other areas. For this reason, the general aspects relating to the operation of any geographically widespread process are explained in the following sub-clauses by reference where appropriate to the operation of an electric power system.

3.1 *The role of telecontrol systems in power systems operation*

The quality of the power supply, which includes its reliability, depends to a large extent on the existence of a coordinated telecontrol system which assures all the necessary supervisory and control functions. The structure of such a telecontrol system is dictated by the power system's architecture and by the strategy of operation adopted by the user(s). It is in essence a distributed process control system conforming to the hierarchical structure of the geographically widespread power transportation and distribution networks. A typical case of a telecontrol system is depicted in Figure 1, page 55.

A system can, from the operational point of view, service a whole power network or be split up into different levels of responsibility or even into partially or fully independent subsystems.

The local control systems of power stations are usually independent of the power network telecontrol system but certain monitored information is fed from the power stations control systems into the power network telecontrol system. Conversely, certain control information, such as set points for power generation, are transmitted into power stations (e.g. in the case of automatic load/frequency control).

Telecontrol system configurations range from a few point-to-point monitoring and control functions up to multilevel systems covering vast geographic areas. The use of computer technology on all levels of the system allows telecontrol systems and architectures to use distributed intelligence with possibilities of preprocessing information to avoid superfluous data flow. Redundancy is provided for vital functions in order to fulfil specified availability and reliability requirements.

Extended processing functions, such as load/frequency control, security analysis, state estimation and short-term predictive energy management, may be carried out either by a separate real-time computer system or by the telecontrol system itself, according to the choice of the systems architecture.

It has also to be noted that equipment and subsystems are often manufactured by different suppliers and/or stem from different generations of technology. Their integration into telecontrol systems thus creates interface problems which are sometimes difficult to solve.

3.2 *The role of the data transmission system*

One of the important factors which has to be taken into account in the planning stage of a telecontrol system is the specification of the data transmission system.

Private or public communication cables, microwave channels and power line carrier (PLC) are most widely used. Since telecontrol systems have to operate in real-time mode, limitations imposed by the telecommunication channels may heavily impair the overall system efficiency. The implication is restricted bandwidth and hence restricted bit rates to be transmitted under noisy environmental conditions, which cause distortion of transmitted signal elements. Conversely specifications of the overall channels have to be chosen to allow optimization of the overall system performance. The data transmission system has to be considered in this sense as an integrated part of the telecontrol system.

In addition, all transmission equipment located in the vicinity of high voltage equipment such as circuit breakers and isolators, is prone to intermittent high noise levels of the burst type and transient voltages. This is especially true for PLC channels.

The performance requirements and boundary conditions for some telecontrol applications, such as teletripping in transmission line protection, generation/load rejection schemes, etc., where instantaneous response in real-time mode is critical, dictate the permanent direct logical connections between data sources and their destinations. This means that the application of store and forward techniques or packet switching are explicitly prohibited in such systems.

There are however telecontrol functions with less demanding performance requirements which may adopt the general techniques and standards which have been developed for office automation applications. Data exchanges among central stations for regions, districts or even nations may fall into that category.

3.3 *Requirements which determine the design of a telecontrol system*

For detailed information, see IEC Publication 870-4.

3.3.1 *Functional characteristics*

The system shall be designed so that the operators will obtain the correct information on actual operational status from strategic points of the power network and shall be able to respond quickly and accurately.

3.3.2 *Environmental conditions*

The installed equipment has to operate correctly under specified operational environmental conditions. Detailed specifications and a classification of environmental conditions are given in IEC Publication 870-2-1.

3.3.3 *Reliability, availability and security (RAS)*

RAS specifications depend on the particular application, and have to be met by the system and all its functional elements. These include uninterrupted power supplies which generally are not considered as being part of the telecontrol system itself. Electromagnetic compatibility has to receive close attention for all electronic equipment involved in telecontrol systems.

Systems should be laid out to operate in a fail safe mode and component failures should be indicated immediately.

3.3.4 *Maintainability, serviceability and expandability, upwards compatibility*

Means for quick fault indication and location are required together with self-diagnosis of the equipment. Both hardware and software should ensure maintainability and expandability, to cope with successive alteration and expansion of the process. Design improvement and changes of technology and of the methods of operation should also be taken into account. The organization of the software should be such as to permit operational control staff to carry out changes quickly and easily to cater for alterations in the power supply network.

3.4 *Main differences between telecontrol systems and local control systems*

The characteristics which differentiate telecontrol systems from local control systems are:

- The use of telecommunication links under restriction of bandwidth and under noisy environmental conditions, requires optimum trade-offs between transmission speed and reliable information transfer in order to cope with the amount of data to be transmitted and the overall transfer time needed.

- Long distance data transmission links or networks, sometimes composed of different transmission media, create problems with occasional high noise levels. The chosen data transmission protocol has to consider these circumstances. High data integrity rates have to be guaranteed at arbitrary high noise levels, whilst taking account of the fact that information transfer rates decrease gradually with increasing noise.

- Numerous geographically widespread plants (and telecontrol stations) have to be controlled by the same centre.

4. Structures and configurations of telecontrol systems

A system's *structure* is understood as the hierarchic order of the basic elements and their interactions, which constitute and characterize that system.

A system *configuration* is a specified arrangement of telecontrol stations and their interconnections.

4.1 *Interrelation of process network architectures and telecontrol system configurations*

In the planning stage, the system configuration has to be defined and tailored according to the user specifications. The configuration of the process, e.g. of a power grid, with the number of voltage levels involved, the number and geographical locations of power stations, control centres, substations and outstations, determines first of all the layout of the data transmission system which has to interconnect these points.

This strategy may differ from country to country and from utility to utility, being state or privately owned.

Emphasis may be given to monitoring functions, leaving control functions partly or entirely to the local operators in substations but providing means for later upgrading of the system. Full operational facilities for remote monitoring and telecontrol functions may be implemented right from the beginning. Even in relatively simple systems, the monitoring and control functions may be quite complex in order to satisfy the many operational requirements for each hierarchical level of a power network. They may also be influenced by security requirements, statutory regulations and economic considerations. The trend to more power grid tie lines, either at company levels or at national levels, calls for high grade application control functions and hence highly sophisticated telecontrol system structures.