

Telecontrol equipment and systems —

Part 5: Transmission protocols —

Section 5.1 Transmission frame formats

The European Standard EN 60870-5-1:1993 has the status of a
British Standard

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Policy Committee (PEL/-) to Technical Committee PEL/89, upon which the following bodies were represented:

- Association of Consulting Engineers
- BAMEMA (BEAMA)
- BEAMA Ltd.
- EEA (the Association of Electronics, Telecommunications and Business Equipment Industries)
- Electricity Supply Industry in United Kingdom
- GAMBICA (BEAMA Ltd.)
- North of Scotland Hydro-Electric Board
- Telecommunication Engineering and Manufacturing Association
- Transmission and Distribution Association (BEAMA Ltd.)

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 31 October 1991

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Publication(s) referred to	Inside back cover

National foreword

This Section of BS 7404 has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee and is identical with IEC Publication 870-5-1:1989 “*Telecontrol equipment and systems — Part 5: Transmission protocols — Section 1 — Transmission frame formats*”, published by the international Electrotechnical Commission (IEC).

In 1993 the European Committee for Electrotechnical Standardization (CENELEC) accepted IEC 870-5-1:1990 as European Standard EN 60870-5-1:1993. As a consequence of implementing the European Standard this British Standard is renumbered as BS EN 60870-5-1 and any reference to BS 7404-5.1 should be read as a reference to BS EN 60870-5-1.

The international standard does not give the up-to-date relation between this Part of the IEC standard and the other published and envisaged Parts and Sections. Other Parts and Sections of this British Standard are as follows.

- *Part 1: General considerations;*
- *Section 1.1: General principles;*
- *Section 1.2: Guide for specifications;*
- *Section 1.3: Glossary;*
- *Section 1.4: Basic aspects of telecontrol data transmission¹⁾;*
- *Part 2: Operating conditions;*
- *Section 2.1: Specification for classes of environmental conditions and power supplies;*
- *Section 2.2: Specification for electromagnetic compatibility and erosive and corrosive influences²⁾;*
- *Part 3: Specification for interfaces (electrical characteristics);*
- *Part 4: Specification for performance;*
- *Part 5: Transmission protocols;*
- *Section 5.1: Specification for transmission frame formats;*
- *Section 5.2: Specification for transmission procedures;*
- *Section 5.3: Specification for structure of application data;*
- *Section 5.4: Specification for coding specifications of application data;*
- *Part 6: Specification for telecontrol protocols compatible with ISO and CCITT standards²⁾.*

Cross-references

International standard	Corresponding British Standard
	BS 7404 Telecontrol equipment and systems
IEC 870-1-1:1988	Section 1.1:1991 General principles (Identical)
IEC 870-5-2	Section 5.2 Specification for transmission procedures (Identical)

¹⁾ Will be published after IEC 870-1-4 has been published.

²⁾ Not yet published, envisaged as future work by IEC.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, the EN title page, pages 2 to 30, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Descriptors: Telecontrol, data transmission, open system interconnection, protocol, data structure, frame, format

English version

Telecontrol equipment and systems
Part 5: Transmission protocols
Section 1: Transmission frame formats

(IEC 870-5-1:1990)

Matériels et systèmes de téléconduite
Partie 5: Protocoles de transmission
Section un: Formats de trames de transmission
(CEI 870-5-1:1990)

Fernwirkeinrichtungen und Fernwirkssysteme
Teil 5: Übertragungsprotokolle
Hauptabschnitt eins: Telegrammformate
(IEC 870-5-1:1990)

This European Standard was approved by CENELEC on 1993-07-06. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 870-5-1:1990 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 60870-5-1 on 6 July 1993.

The following dates were fixed:

- latest date of publication of
an identical national
standard (dop) 1994-08-01
- latest date of withdrawal of
conflicting national
standards (dow) 1994-08-01

Annexes designated “normative” are part of the body of the standard. In this standard, Annex ZA is normative.

Introduction

This section highlights specific requirements and conditions for data transmission in telecontrol systems and shows ways to meet those requirements. Existing standards for data transmission protocols are adopted where they fulfil the specific telecontrol requirements.

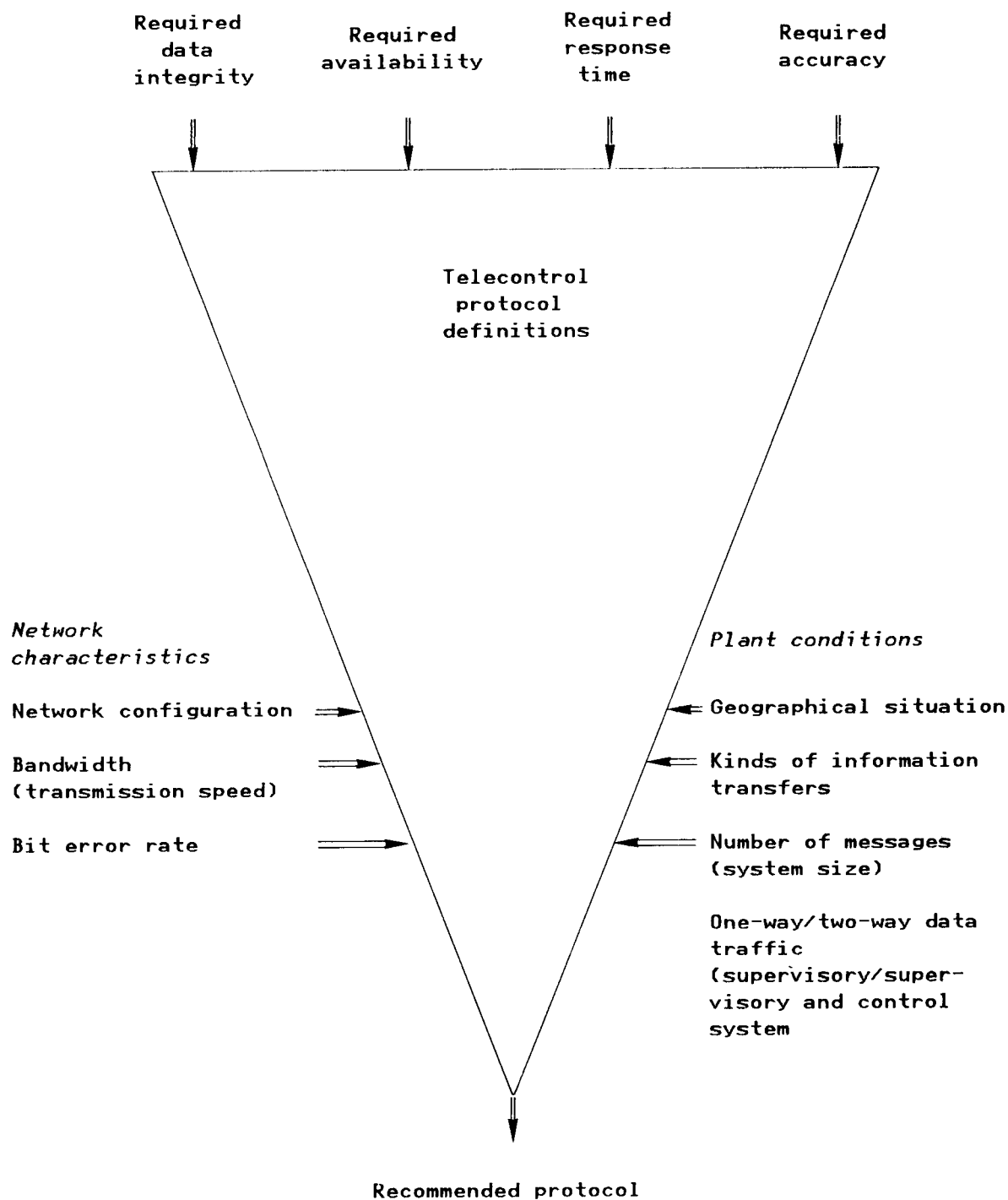
In terms of the OSI (Open System Interconnection) reference model of ISO-CCITT, which subdivides communication into seven layers, this specifies standards for the two lowest layers, namely the physical layer and the link layer. In particular the document specifies formats for bit serial frame transmission which comply with specified classes of data integrity.

Publication 870-5-2-2: Transmission Procedures (in preparation) will specify further standards for the link layer and for higher layers. This comprises dispositions for data contents within frames, i.e. services in various traffic modes and for various link — and network configurations.

The ultimate purpose of the communication function in process monitoring and control is to achieve maximum system consistency, i.e. there should be no discrepancies between the physical states of process variables and their image in the data base of the telecontrol system. This ultimate goal cannot be achieved completely. The laws of causality dictate that the information about process states is delayed and environmental noise or component failures may falsify the information. All that can be expected is that the communication allows a high degree of system consistency to be maintained. For this reason the data transmission method shall support upgraded *reliable* and *efficient* information throughput in particular for short and urgent messages. The exploitation of the installed bandwidth with respect to these two qualities is the critical measure for telecontrol protocols, because the available bandwidths are limited.

In an imperfect environment, however, high data integrity and efficient data transmission are conflicting properties: increasing demands for data integrity can be fulfilled at the expense of decreasing net speed of information flow. It is necessary, therefore, to find an acceptable compromise between these two properties, based on an analysis of the requirements. A pre-supposition for analytical treatment is the objective measurement of the required properties.

Data transport is only one function of the total system. The speed and integrity requirements of data transmission shall be chosen to be consistent with the accuracy of the total system, i.e. all the system parameters should be matched. In addition to the required compromise between transmission speed and transmission integrity there are further conditions which influence the choice of an appropriate telecontrol protocol, as shown in the following diagram:

Functional requirements

1 Scope

This series of standards applies to telecontrol equipment and systems with coded bit serial data transmission for monitoring and controlling geographically widespread processes. This standard covers asynchronous data transmission with half duplex and duplex link protocols operating with window size one for message transfers.

2 Object

This section specifies the basic requirements for services to be provided by the link plus physical layers, for telecontrol applications. In particular it specifies standards on coding, forming and synchronizing data frames of variable and fixed lengths which meet specified data integrity requirements.

The specified block codes are suited for the transmission of bit serial frames over binary symmetric transmission channels using a *memoryless* bit encoding method. This means that the signal specification of each transmitted bit shall not depend on signals transmitted before that bit.

NOTE Recommendations for data transmission services using other than memoryless bit encoding methods (for example digital pulse duration modulation (DPDM), HDLC, etc.) and duplex link protocols with window sizes greater than one are under consideration.

3 Requirements for data transmission in telecontrol systems

According to the basic goals of telecontrol systems and to the particular environmental conditions, it is necessary that data transmission fulfils the following requirements:

3.1 High data integrity and data consistency

Correct data transmission is required in the presence of harsh environmental conditions, such as electromagnetic interferences, differences in earth potential, ageing components and other sources of disturbance and noise incident on the transmission path. Under these conditions it is necessary to provide efficient protection of messages against:

- undetected bit errors;
- undetected frame errors caused by synchronization errors;
- undetected loss of information;
- gain of unintended information (i.e. simulation of messages by noise);
- separation or perturbation of coherent information.

3.2 Short telecontrol transfer time (see IEC 371-08-16)

Provision of short information transmission times by application of efficient frame transmission protocols, particularly for event initiated messages over transmission paths with limited bandwidth and with uncertain noise characteristics.

3.3 Support of bit oriented (code transparent) data transmission

No code restrictions on user data are required. The data link protocol accepts and transmits arbitrary bit sequence structures from the data source.

4 Quantified rating of data integrity

A quantitative specification of the data integrity in information transport systems is achieved by evaluating the contributions of the complement of data integrity, the non integrity of data. Basically there are two sources causing non integrity of data in a receiving station, namely:

- i) residual error rate (see IEC 371-08-05) =

$$\frac{\text{number of undetected wrong messages}}{\text{total number of messages sent}}$$

- ii) rate of residual information loss (see IEC 371-08-09) =

$$\frac{\text{number of undetected lost messages}}{\text{total number of messages sent}}$$

It is emphasized that only rates of *undetected* errors or losses contribute to the non integrity of information transmission. Detected errors and losses are handled by predefined strategies such as automatic retransmission or reports to the user. They may affect the system availability as a whole but, in reporting these errors, the data transmission protocol has fulfilled its function.

4.1 Quantitative requirements for data integrity in telecontrol systems

Three different data integrity classes I1, I2 and I3 have been established for telecontrol data transmission. The use of each class depends on the nature of the data. Figure 1 shows a graphical representation of the upper limits of the residual error rate R depending on the bit error rate (see IEC 371-08-01) for these three classes. The graphs end at the bit error rate $p = 0.5$, the case of arbitrary bit reception, where no signal and only noise is received. The slope of the curves for $p < 10^{-4}$ represents the Hamming distance d of the applied coding method. This results from the introduction of double logarithmic scaling in Figure 1, and the fact that bit error patterns with d inverted bits furnish the predominating contribution to residual errors for $p < 10^{-4}$.

The quality of transmission channels should be supervised continuously. The average bit error probability is supposed to be less than 10^{-4} to achieve required overall data integrity values and overall information transfer times.

Minimum Hamming distance 2 is required in the lowest data integrity class I1 while classes I2 and I3 require codes with minimum Hamming distance 4. In addition there is the requirement that in class I3 the residual error rate shall not exceed $R = 10^{-12}$ for any bit error rate. In order to *illustrate* the significance of these three data integrity classes we assume a telecontrol channel with white noise causing the bit error rate $p = 10^{-4}$, which specifies low, but not worst case transmission quality.

A system which permanently transmits message blocks of 100 bit at a rate of 1 200 bit/s over this channel causes the following residual message error probabilities (R) and expected mean times (T) between undetected erroneous messages, as shown in the table below.

The relation between expected mean time between undetected erroneous message transfers T and residual error probability R is given by the relation:

$$T = \frac{n}{v \cdot R} \quad (\text{s})$$

where

n is the message length (in bits)

v is the transmission speed (in bit/s)

Integrity figures for: $n = 100$ bit frames at $v = 1\,200$ bit/s and $p = 10^{-4}$			
Data integrity class	Residual error rate R	Mean time between undetected errors T	Typical application
I1	10^{-6}	1 day	Cyclic updating systems; telemetry
I2	10^{-10}	26 years	Event initiated transmission; teleindication; telecounting
I3	10^{-14}	260 000 years	Critical information transmission; telecommands