

AS 60870.5.1—1998

IEC 60870-5-1:1990

Reconfirmed 2015

Australian Standard®

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## **Telecontrol equipment and systems**

### **Part 5.1: Transmission protocols— Transmission frame formats**

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[IEC title: Telecontrol equipment and systems, Part 5: Transmission protocols—Section One—Transmission frame formats]

This Australian Standard was prepared by Committee IT/24, Supervisory Control and Data Acquisition. It was approved on behalf of the Council of Standards Australia on 5 January 1998 and published on 5 April 1998.

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**RECONFIRMATION**

**OF**

**AS 60870.5.1—1998**

**Telecontrol equipment and systems**

**Part 5.1: Transmission protocols—Transmission frame formats**

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## NOTES

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**Telecontrol equipment and systems**

**Part 5.1: Transmission protocols—  
Transmission frame formats**

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## PREFACE

This Standard was prepared by the Standards Australia Committee IT/24, Supervisory Control and Data Acquisition.

The Standard is identical with and has been reproduced from IEC 60870-5-1:1990, *Telecontrol equipment and systems*, Part 5: *Transmission protocols*, Section One—*Transmission frame formats*.

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This Standard is identical with a pre-1997 document therefore it uses the old series of numbers.

The objective of this Standard is to provide manufacturers and users of telecontrol equipment and systems with a specification of the basic requirements for services to be provided by the link and physical layers in order to achieve system interoperability within Australia.

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## AUSTRALIAN STANDARD

### Telecontrol equipment and systems

#### Part 5.1

#### Transmission protocols—Transmission frame formats

#### 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.

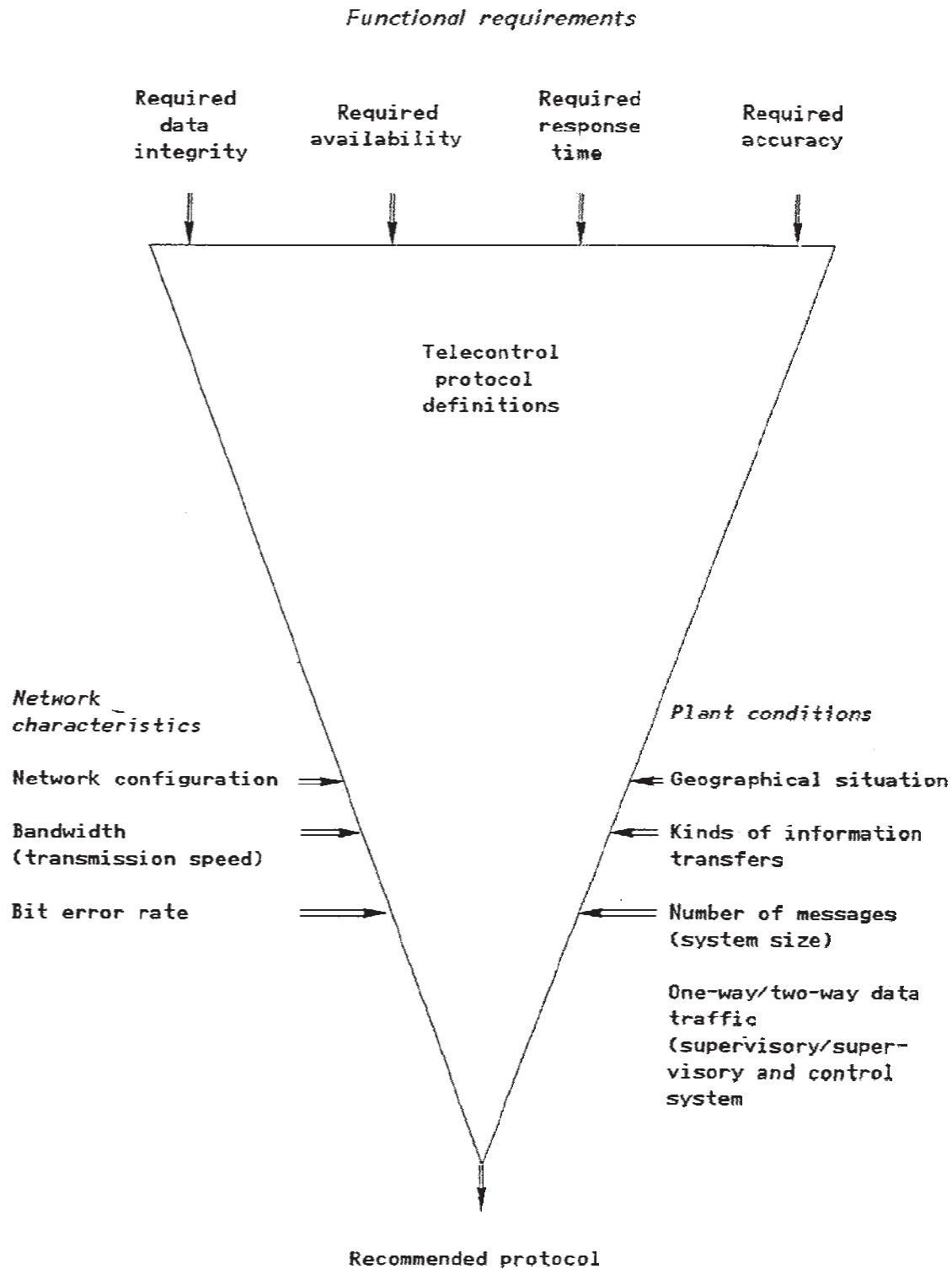
In terms of the OSI (Open System Interconnection) reference model of ISO-CCITT, which subdivides communication into seven layers, this specifies standards for the two lowest layers, namely the physical layer and the link layer. In particular the document specifies formats for bit serial frame transmission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

Publication 870-5-2: Section Two: 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:



## 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, formatting 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 IEV 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 IEV 371-08-05) =

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

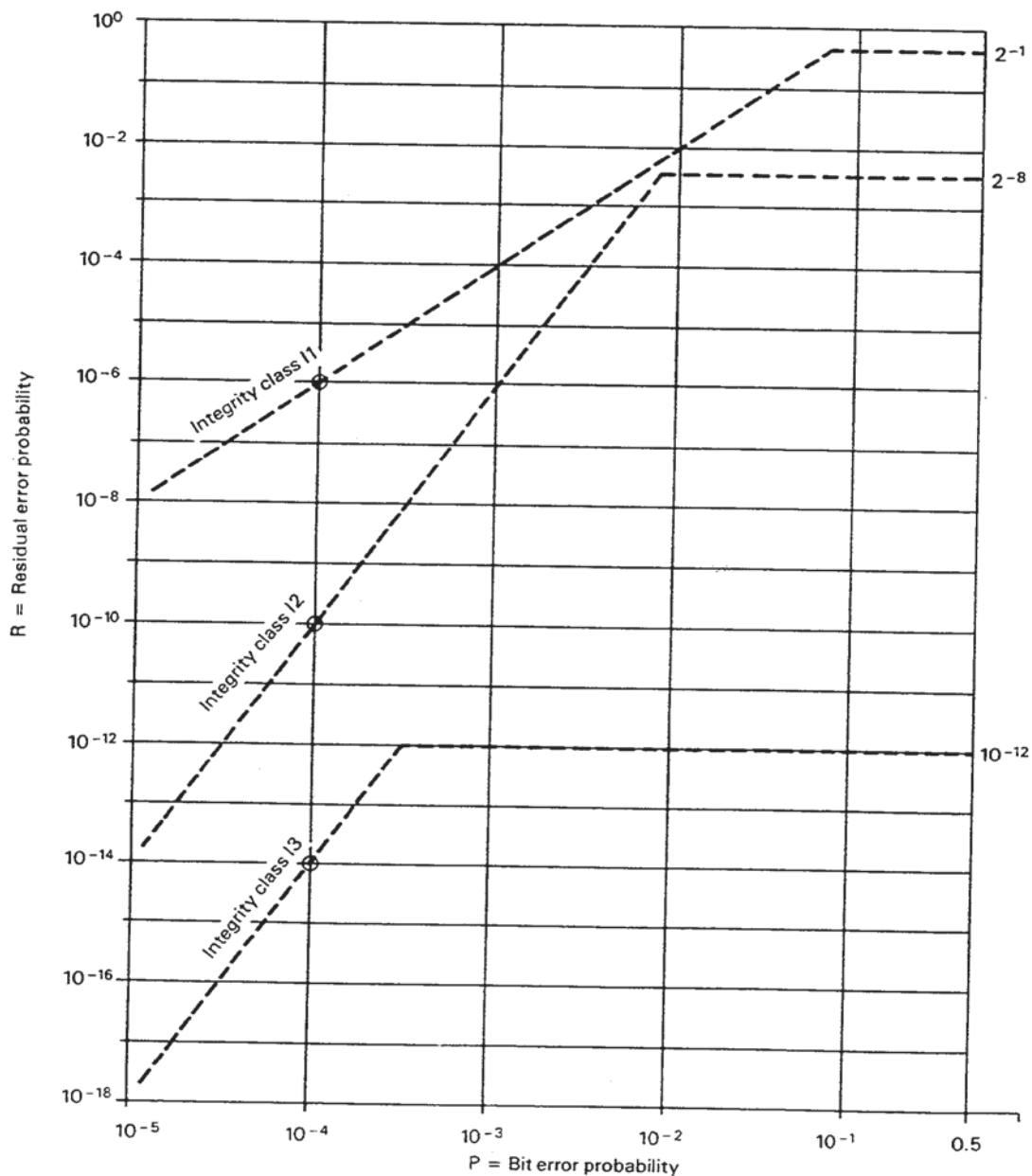
- (ii) rate of residual information loss (see IEV 371-08-09) =

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

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  $p < 10^{-4}$ .



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Figure 1.- Data integrity classes.

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<br>v = 1 200 bit/s and p = $10^{-4}$ |                          |                                          |                                                            |
|-----------------------------------------------------------------------------------|--------------------------|------------------------------------------|------------------------------------------------------------|
| Data integrity class                                                              | Residual error rate<br>R | Mean time between undetected errors<br>T | Typical application                                        |
| I1                                                                                | $10^{-6}$                | 1 day                                    | Cyclic updating systems; telemetering                      |
| I2                                                                                | $10^{-10}$               | 26 years                                 | Event initiated transmission; teleindication; telecounting |
| I3                                                                                | $10^{-14}$               | 260 000 years                            | Critical information transmission; telecommands            |

## 5. Quantified rating of transmission efficiency

The information transfer efficiency is the ratio of the information content of a message transferred from a data source and accepted as valid by a data sink to the total number of bits used for the message transfer (see IEV 371-08-12). This means that the transmission efficiency of an individual frame is the ratio of correctly transferred information bits  $k$  to the total number of bits per frame  $n$ .

FRAME TRANSMISSION EFFICIENCY =

$$k \cdot q^n / n$$

where:

$k$  is the number of information bits per frame

$q$  is the probability of receiving correct bits

$n$  is the total number of bits per frame including frame delimiters and error check bits

$q$  is related to the bit error rate  $p = (\text{number of bits received inverted}) / (\text{total number of bits sent})$  by:

$$q = 1 - p$$

in case of a transmission over a binary symmetric channel without signal quality supervision.

If signal quality supervision is used ("binary symmetric erasure channel"), the rate of receiving correct bits reduces to:

$$q = 1 - p - r$$

where:

$r$  specifies the rate of receiving bits with insufficient signal quality ("bit erasure rate", see Appendix A).

The information transfer rate is defined by the average number of bits of information per second transferred from a data source and accepted as valid by a data sink (see IEV 371-08-11):

FRAME TRANSMISSION RATE = (FRAME TRANSMISSION EFFICIENCY)  $\cdot v$  bit/s

where:

$v$  specifies the bit signalling rate of the transmission line expressed in bits per second.