

Performance and testing of teleprotection equipment of power systems —

Part 2: Analogue comparison system —

**(Implementation of
CENELEC HD 543.2.S1)**

Committees responsible for this British Standard

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

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National foreword

This Part of BS 7494 has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee. It is identical with IEC 834-2:1993 *Performance and testing of teleprotection equipment of power systems — Part 2: Analogue comparison systems* published by the International Electrotechnical Commission (IEC).

In 1995 the European Committee for Electrotechnical Standardization (CENELEC) accepted the text of IEC 834-2:1993, with common modifications, as Harmonization Document HD 543.2.S1.

Cross-references

International Standard	Corresponding British Standard
IEC 50(151):1978	BS 4727 <i>Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms</i> Part 1:Group 02:1980 <i>Electrical and magnetic devices terminology</i> (Technically equivalent)
IEC 255-5:1977	BS 5992 <i>Electrical relays</i> Part 3:1980 <i>Specification for the insulation testing of electrical relays</i> (Identical)
IEC 255-22-1:1988	BS 142 <i>Electrical protection relays</i> Subsection 1.4.1:1990 <i>1 MHz burst disturbance tests</i> (Identical)

The Technical Committee has reviewed the provisions of IEC 255-4:1976, IEC 255-6:1988 and IEC 834-1:1988, to which normative reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. There are no equivalent British Standards.

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 and ii, the HD title page, pages 2 to 28, 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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Performance and testing of teleprotection equipment of power systems Part 2: Analogue comparison systems

(IEC 834-2:1993, modified)

This Harmonization Document was approved by CENELEC on 1994-12-06. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for implementation of this Harmonization Document on a national level.

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

This Harmonization Document exists in three official versions (English, French, German).

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
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Foreword

The text of the International Standard IEC 834-2:1993, prepared by IEC TC 57, Telecontrol, teleprotection and associated telecommunications for electric power systems, together with common modifications prepared by Reporting Secretariat SR 57, was submitted to the formal vote and was approved by CENELEC as HD 543.2 S1 on 1994-12-06.

NOTE Austria has no obligation to implement this European Standard.

The following dates were fixed:

- latest date by which the existence of the HD has to be announced at national level (doa) 1995-06-01
- latest date by which the HD has to be implemented at national level by publication of a harmonized national standard or by endorsement (dop) 1995-12-01
- latest date by which the national standards conflicting with the HD have to be withdrawn (dow) 1995-12-01

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given for information only. In this standard, Annex ZA is normative and Annex A, Annex B, and Annex C are informative. Annex ZA has been added by CENELEC.

HD 543 consists of the following parts, under the general Performance and testing of teleprotection equipment of power systems:

- *Part 1:1991, Narrow-band command systems* (IEC 834-1:1988, modified);
- *Part 2:1995, Analogue comparison systems* (IEC 834-2:1993, modified).

Section 1. General

1.1 Scope and object

This part of IEC 834 applies to narrowband and wideband teleprotection systems used to convey analogue information about the primary quantities such as phase or phase and amplitude. The teleprotection equipment can either be separate or integrated in one unit with the protection equipment or the telecommunication equipment.

Narrow-band systems include systems operating within a 4 kHz band (for each direction of transmission).

Wide-band systems include systems occupying more than 4 kHz bandwidth (for each direction of transmission).

Broad-band command systems are not dealt with in this standard.

The object of this part of IEC 834 is to establish performance requirements and recommended testing methods for analogue comparison teleprotection equipments used in connection with power network protection systems and to define the associated terminology. The information conveyed and compared such as phase or phase and amplitude quantities can be in analogue or digital form.

In addition to the power supply and the interfaces belonging to the teleprotection equipment, the performance of the teleprotection equipment in conjunction with the protection equipment shall be tested.

All the tests should be considered as type tests [see IEC 50(151)].

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 834. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 834 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(151):1978, *International Electrotechnical Vocabulary (IEV) — Chapter 151: Electrical and magnetic devices*.

IEC 255-4:1976, *Electrical relays — Part 4: Single input energizing quantity measuring relays with dependent specified time*.

IEC 255-5:1977, *Electrical relays. — Part 5: Insulation tests for electrical relays*.

IEC 255-6:1988, *Electrical relays. — Part 6: Measuring relays and protection equipment*.

IEC 255-22-1:1988, *Electrical relays — Part 22: Electrical disturbance tests for measuring relays and protection equipment — Section 1: 1 MHz burst disturbance tests*.

IEC 834-1:1988, *Performance and testing of teleprotection equipment of power systems — Part 1: Narrow-band command systems*.

CCITT Recommendation V.11:1976, *Electrical characteristics for balanced double-current interchange circuit for general use with integrated circuit equipment in the field of data communications. CCITT Red Book, volume VIII — fascicle VIII.1, 1985*.

CCITT Recommendation V.28:1972, *Electrical characteristics for unbalanced double-current interchange circuits. CCITT Red Book, volume VIII — fascicle VIII.1, 1985*.

CCITT Recommendation G.703:1972, *Physicalelectrical characteristics of hierarchical digital interfaces. CCITT Red Book, volume III — fascicle III.3, 1985*.

CIGRÉ SC 34 and 35 — WG 05:1987, *Protection systems using telecommunication*.

CIGRÉ SC 35:1979, *Guide on power line carrier*.

1.3 Service conditions

1.3.1 Ambient conditions

The stated performance requirements shall be satisfied for the following conditions:

— temperature range	– 5 °C + 40 °C
— maximum rate of change	10 °C/h
— relative humidity	5 % to 95 %
— maximum water content	28 g/m ³

1.3.2 Supply voltage with battery operation

(See 3.2 of IEC 834-1.)

1.3.3 Supply voltage with a.c. mains operation

The stated performance requirements shall be satisfied for the following conditions:

— voltage tolerance	+ 10 % to – 15 %
— frequency tolerance	± 5 %
— harmonic content	< 10%

1.3.4 Storage conditions

(See 3.4 of 834-1.)

1.4 Telecommunication system used

Figure 1 shows the configuration of a teleprotection system and applies to both narrow-band and wide-band systems. The signals are conveyed from the transmitter to the receiver via a telecommunication system which has to be capable of transmitting the required bandwidths in accordance with certain parameters, for example group delay distortion, frequency/attenuation response, etc.

The telecommunication systems should be chosen with care, as they will be influenced by noise, changes of parameters and any kind of interference which may cause maloperation or non-operation of the teleprotection equipment.

The telecommunication systems that can be used are listed in clause 4 of IEC 834-1.

Section 2. Terminology

Terminology not defined by IEC but often used is listed in this section.

2.1

analogue protection system

(CIGRÉ SC 34/35-WG 05)

a protection system using telecommunication in which analogue power quantities are transmitted from one end of a power line by the telecommunication system either in analogue or digital form for comparison at the other end

examples:

phase comparison protection system, longitudinal differential protection system

2.2

dependability (CIGRÉ SC 34/35-WG 05)

the probability of not having a failure to trip operation

2.3

fault clearance time (T_c) (clearing time)

(CIGRÉ SC 34/35-WG 05)

the time interval between the instant of occurrence of a fault and the instant of the fault clearance by the automatic tripping of the appropriate circuit breakers. The fault clearance time is the sum of the protection system operating time and circuit breaker operating time

2.4

non-segregated protection system

(CIGRÉ SC 34/35-WG 05)

a protection system using a mixing transformer or phase sequence network or other means to supply one protection equipment common for all three power phases

2.5

propagation time

(CIGRÉ SC 34/35-WG 05)

the time elapsed between the instant of application to a telecommunication system, under stated conditions, of a specific value of the transmitted signal and the instant when the received signal assumes the corresponding value at the input of the teleprotection receiver

2.6

security (CIGRÉ SC 34/35-WG 05)

the probability of not having an unwanted operation

2.7

segregated protection

(CIGRÉ SC 34/35-WG 05)

normally consists of one protection for each phase (Compare with non-segregated protection.)

2.8

teleprotection channel [See 5.10 b) of

IEC 834-1]

NOTE The teleprotection channel may be either analogue or digital. In an analogue teleprotection channel the instantaneous value of the signal varies continuously, even though the information may be of a digital nature (e.g. FSK signalling). In a digital teleprotection channel only certain discrete levels (usually two or three) are permitted.

Section 3. Characteristic of analogue comparison teleprotection schemes

3.1 Arrangement of teleprotection schemes and their associated interfaces

The arrangement of analogue comparison teleprotection schemes and their various interfaces will depend on whether the teleprotection is an integrated part of or separate from the protection equipment. The principal interfaces are referred to in Figure 1.

In an integrated arrangement the interface between the protection equipment and the teleprotection equipment will invariably be within the same equipment case or cubicle. Furthermore, the two parts will have been designed as one, so that interface levels, impedance matching, etc., and other specialized requirements will be a function of the design and not a function of the external environment. As a result of this internal interface some of the requirements and tests specified in this standard will not apply to this category of equipment. However, the requirements and testing of the interface between the telecommunication system and the teleprotection will, in most instances, still be applicable.

In the separated arrangement, the teleprotection will most likely be physically divorced from the protection equipment, and, since it will not have been designed as a complete unit, all the recommendations in this standard apply.

Correspondingly, the teleprotection equipment and the telecommunication equipment may form an integrated arrangement. In this case some of the requirements and tests concerning interface b) of Figure 1 will not apply whereas the requirements and tests concerning interface a) are still applicable.

Another interface, shown in Figure 1, exists between the current transformers and the protection equipment. Since the recommendations in this standard apply only to the teleprotection equipment, performance requirements associated with this interface are not defined. However, when the teleprotection channel quality tests are to be performed, it is necessary to set up the power frequency currents into the protection equipment as indicated in Figure 3.

Secondary interfaces, not shown in Figure 1, that are associated with the teleprotection equipment may exist at the power supply terminals and alarm indication terminals, for example. These will invariably need to be tested in a separated arrangement. In an integrated arrangement, however, these secondary interfaces may exist within the protection equipment and therefore the specific recommendations may not be applicable.

3.2 Teleprotection operating time (T_A or T_o)

T_A is the time in a teleprotection system elapsed between the instant of variation of the input quantities under stated conditions at the transmitter equipment input and the instant of the corresponding variation of the output quantities at the receiver equipment output including propagation time and additional delay. The delay T_A has to be considered in the design of analogue comparison systems.

There are basically three solutions:

- a) it can be kept low as in wide-band systems;
- b) it may be compensated for, for example delaying the local signal before comparison is made. In this solution, the adjustable delay is a constant for fixed links;
- c) the delay can be automatically adjusted by a loop control circuit.

The teleprotection operating time excluding propagation delay (T_o) may be measured and quoted if interface a) of Figure 1 is accessible.

3.3 Protection operating time (T_B or T_p)

T_B is the time interval between the instant a specific set of values of the input energizing quantities is applied under specific conditions at the input of the protection system, including CT's, VT's instrument transformers, and the instant when the protection output circuits are operated.

Typical values for protection operating time are given in Figure 2.

The protection operating time excluding propagation time, T_p , may be measured and quoted. In general, T_p will be increased by noise.

The interrelationship between the maximum operating time T_{pmax} , dependability and signal-to-noise ratio is illustrated in Figure 4.

Section 4. Requirements

4.1 General equipment interface requirements

The following requirements apply to the interface between protection equipment and teleprotection equipment as well as to the interface between teleprotection equipment and telecommunication system, interfaces a) and b) as defined in Figure 1, where the equipments are separated from each other.

If the protection equipment and the teleprotection equipment form an integrated system, the requirements for interface a) are not applicable. If the teleprotection equipment and the telecommunication equipment are designed as a common apparatus, the requirements for interface b) are not applicable.

4.1.1 Insulation levels (See 17.1 of IEC 834-1)

For signal terminals and alarm circuit terminals connected to the protection equipment and operating at voltages of less than 20 V [interface a) in Figure 1], a test voltage of 500 V r.m.s. shall be used.

4.1.2 Impulse withstand level (See 17.2 of IEC 834-1)

4.1.3 High frequency disturbance level (See 17.3 of IEC 834-1)

The test shall be applied to all input and output circuits, power supply terminals included, with the exception of digital signal interfaces operating at high data rates. Such interfaces are designed for serial data streams of typically 64 kbit/s and faster and can therefore not be protected against galvanically coupled additive 1 MHz transients of high amplitude. Thus special care shall be taken to avoid or suppress all kinds of interference by careful installation planning and the use of well-balanced and shielded interface cables.

4.1.4 Specific requirements for interface between separate protection equipment and teleprotection equipment [interface a) in Figure 1]

Due to the use of different transmission media, different cable lengths between protection equipment and teleprotection equipment as well as other specific application conditions, the interface specifications shall be subject to agreement between user and manufacturer.

To avoid signal errors (amplitude, phase or bit errors) caused by 50/60 Hz and transient crosstalk from power installations, measures shall be taken to protect the interface between protection equipment and teleprotection equipment (e.g. balanced and shielded cables or optical fibre cables).

4.1.4.1 Phase comparison systems

For phase comparison systems, single- or double-current (unipolar or bipolar) interfaces are used. These interfaces are similar to low speed asynchronous data transmission interfaces. Therefore the relevant data transmission interface specifications may apply also to phase comparison systems.

Examples of recommended conditions:

- $\pm 5...15$ V interface according to CCITT V.28;
- $\pm 2...6$ V differential interface according to CCITT V.11;
- ± 20 mA loop;
- $\pm 4...8$ V, $600\ \Omega$ interface
(low level: $0... \pm 0,775$ V, high level: $\pm 4...8$ V).

4.1.4.2 Longitudinal (current) differential systems

Examples of recommended conditions:

a) Digital signal interface

The measured quantities are coded digitally (pulse code modulation or delta modulation). The interface is similar to high speed data transmission interfaces, and therefore the relevant specifications may apply.

Example:

- $\pm 1,0/3,4$ V, $110\ \Omega$ bipolar 64 kbit/s interface according to CCITT G.703;
- $\pm 2...6$ V differential interface according to CCITT V.11.

b) Analogue signal interface

The interface is similar to analogue input/output interfaces used in telecontrol systems, and therefore the relevant specifications may apply.

Example:

- ± 5 V peak interface (low impedance source, high impedance load);
- ± 5 mA peak interface (high impedance source, low impedance load).

4.2 Specific power supply requirements

The following requirements may not apply to the teleprotection equipment when integrated with the protection equipment.

4.2.1 Power supply variations

(See 18.1 of IEC 834-1)

4.2.2 Interruptions

All teleprotection equipments shall sustain (without any unwanted or missing command at the output of the corresponding protection equipment) single short interruptions of the power supply voltage not longer than 20 ms.

With a.c. feeding, larger interruptions can occur. In this case, an uninterruptible power supply (UPS) may be required.

If the test is carried out with such interruptions occurring in a random sequence (for a period not longer than 20 s), no unwanted command at the output of the corresponding protection equipment shall occur. Also, if the power is switched off for a longer time and then switched on, no such command shall occur.

Other interruption times may be agreed between the user and the manufacturer.

4.2.3 Reflected noise

(See 18.3 of IEC 834-1.)

4.2.4 Reverse polarity

(See 18.4 of IEC 834-1.)

4.3 Operational requirements

4.3.1 Overall protection requirements

The requirements on the teleprotection are more severe for analogue systems as compared to command systems because of the higher information content to be transmitted. As mentioned above we can distinguish between two basic schemes:

- 1) the current differential scheme which requires the transmission of the measured quantities both in amplitude and phase;
- 2) the phase comparison protection schemes which require transmission of reduced information only about the phase (e.g. zero-crossings).

In analogue systems using telecommunication the information transmitted is not a change of state as for command systems but represents the measured analogue values of an electrical quantity at one terminal.

The deviation or error as well as the delays introduced in the reproduction of transmitted quantities by the teleprotection equipment shall be kept to a minimum. These, together with the principle of operation of the protection equipment, will determine the performance of the protection system as a whole.

The minimum bandwidth needed for transmission is determined by the method of modulation and coding, the number and required accuracy of measured values transmitted and the transmission time tolerated.

In view of the interdependence of dependability, security, bandwidth and signal-to-noise ratio, it is essential to specify relay settings (phase or phase and amplitude deviation) which will define the performance of the teleprotection system.

The operating principle of the protection, i.e. whether segregated or non-segregated type of equipment, will also determine the tolerances of the maximum deviation (error) permitted. In addition, the capacitive line loss due to the shunt capacitance of the protected line during normal load and during abnormal conditions has to be taken into account. The performance of the peripheral equipment such as the tolerances and the characteristics of transient behaviour of line current transformers, etc. will also influence the performance of the protection system.

Summarizing, the relay performance has to take into account the following different factors:

- the tolerances of line current transformers during normal and abnormal conditions;
- the shunt capacitance of the line protected and its possible compensation;
- the principle of operation and tolerances of the protection equipment (including starting equipment for normally quiescent systems);
- the tolerances in the accurate reproduction of the teleprotection signal due to modulation, demodulation, gain control, group delay distortion and band limitation;
- the influence of noise, interference and variations in the transmission characteristics of the telecommunication system.