

INTERNATIONAL STANDARD

IEC 60870-5-101

Second edition
2003-02

Telecontrol equipment and systems –

Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks

Matériels et systèmes de téléconduite –

*Partie 5-101:
Protocoles de transmission –
Norme d'accompagnement pour les tâches élémentaires
de téléconduite*

© IEC 2003 — Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

CONTENTS

FOREWORD	7
1 Scope and object	8
2 Normative references	8
3 Terms and definitions	9
4 General rules	10
4.1 Protocol structure	10
4.2 Physical layer	11
4.3 Link layer	12
4.4 Application layer	12
4.5 User process	12
5 Physical layer	12
5.1 Selections from ISO and ITU-T standards	12
5.1.1 ITU-T V.24 or ITU-T V.28 unbalanced interchange circuit	13
5.1.2 ITU-T X.24 or ITU-T X.27 balanced interchange circuit	14
5.1.3 Interfaces to switched communication networks	14
5.1.4 Other compatible interfaces	14
6 Link layer	14
6.1 Selections from IEC 60870-5-1: Transmission frame formats	14
6.2 Selections from IEC 60870-5-2: Link transmission procedures	15
6.2.1 State transition diagrams	15
6.2.2 Definitions of time out interval for repeated frame transmission	24
6.2.3 The use of the different resets	26
7 Application layer and user process	27
7.1 Selections from IEC 60870-5-3: General structure of application data	27
7.2 Selections from IEC 60870-5-4: Definition and coding of application information elements	29
7.2.1 Type identification	29
7.2.2 Variable structure qualifier	33
7.2.3 Cause of transmission	36
7.2.4 COMMON ADDRESS OF ASDUs	41
7.2.5 INFORMATION OBJECT ADDRESS	42
7.2.6 INFORMATION ELEMENTS	44
7.3 Definition and presentation of the specific ASDUs	58
7.3.1 ASDUs for process information in monitor direction	59
7.3.2 ASDUs for process information in control direction	98
7.3.3 ASDUs for system information in monitor direction	103
7.3.4 ASDUs for system information in control direction	104
7.3.5 ASDUs for parameter in control direction	109
7.3.6 ASDUs for file transfer	113
7.4 Selections from IEC 60870-5-5: Basic application functions	120
7.4.1 Selections from station initialization	121
7.4.2 Selections from data acquisition by polling	121
7.4.3 Selections from cyclic data transmission	121
7.4.4 Selections from acquisition of events	121
7.4.5 Selections from station interrogation, outstation interrogation	121
7.4.6 Selections from clock synchronization	125

7.4.7	Selections from command transmission.....	125
7.4.8	Selections from transmission of integrated totals	125
7.4.9	Selections from parameter loading	129
7.4.10	Selections from test procedure	129
7.4.11	Selections from file transfer.....	129
7.4.12	Selections from acquisition of transmission delay	148
7.4.13	Background scan	148
7.4.14	Read procedure	148
8	Interoperability	149
8.1	System or device	150
8.2	Network configuration	150
8.3	Physical layer.....	150
8.4	Link layer.....	151
8.5	Application layer	151
8.6	Basic application functions.....	157
Annex A (informative) Proof of the synchronization stability of frame format class FT 1.2.....		161
Annex B (informative) Admittance of line idle intervals between characters of frame format class FT 1.2.....		177
Figure 1 – Selected standard provisions of the defined telecontrol companion standard		11
Figure 2 – Interfaces and connections of controlling and controlled stations		11
Figure 3 – State transition diagram by Grady Booch/Harel		15
Figure 4 – Unbalanced transmission procedures, primary and secondary stations		17
Figure 5 – State transition diagram for unbalanced transmission primary to secondary		18
Figure 6 – State transition diagram for unbalanced transmission secondary to primary		19
Figure 7 – Balanced transmission procedures, primary and secondary link layers.....		21
Figure 8 – State transition diagram for balanced transmission primary to secondary.....		22
Figure 9 – State transition diagram for balanced transmission secondary to primary.....		23
Figure 10 – Structure of an Application Service Data Unit ASDU		28
Figure 11 – Type identification		29
Figure 12 – VARIABLE STRUCTURE QUALIFIER.....		33
Figure 13 – Presentation of types of information objects in priority buffers.....		35
Figure 14 – CAUSE OF TRANSMISSION field.....		36
Figure 15 – Station interrogation via a concentrator station using the originator address.....		38
Figure 16 – Command transmission via a concentrator station using the originator address ...		39
Figure 17 – COMMON ADDRESS of ASDUs (one octet)		41
Figure 18 – COMMON ADDRESS of ASDUs (two octets).....		41
Figure 19 – INFORMATION OBJECT ADDRESS (one octet).....		42
Figure 20 – INFORMATION OBJECT ADDRESS (two octets).....		42
Figure 21 – INFORMATION OBJECT ADDRESS (three octets)		43
Figure 22 – ASDU: M_SP_NA_1 Single-point information without time tag.....		59
Figure 23 – ASDU: M_SP_NA_1 Sequence of single-point information without time tag.....		60
Figure 24 – ASDU: M_SP_TA_1 Single-point information with time tag.....		61
Figure 25 – ASDU: M_DP_NA_1 Double-point information without time tag		62

Figure 26 – ASDU: M_DP_NA_1	Sequence of double-point information without time tag	62
Figure 27 – ASDU: M_DP_TA_1	Double-point information with time tag	63
Figure 28 – ASDU: M_ST_NA_1	Step position information	64
Figure 29 – ASDU: M_ST_NA_1	Sequence of step position information	64
Figure 30 – ASDU: M_ST_TA_1	Step position information with time tag	65
Figure 31 – ASDU: M_BO_NA_1	Bitstring of 32 bit	66
Figure 32 – ASDU: M_BO_NA_1	Sequence of bitstrings of 32 bit	67
Figure 33 – ASDU: M_BO_TA_1	Bitstring of 32 bit	68
Figure 34 – ASDU: M_ME_NA_1	Measured value, normalized value	69
Figure 35 – ASDU: M_ME_NA_1	Sequence of measured values, normalized values	69
Figure 36 – ASDU: M_ME_TA_1	Measured value, normalized value with time tag	70
Figure 37 – ASDU: M_ME_NB_1	Measured value, scaled value	71
Figure 38 – ASDU: M_ME_NB_1	Sequence of measured values, scaled values	72
Figure 39 – ASDU: M_ME_TB_1	Measured value, scaled value with time tag	73
Figure 40 – ASDU: M_ME_NC_1	Measured value, short floating point number	74
Figure 41 – ASDU: M_ME_NC_1	Sequence of measured values, short floating point number	75
Figure 42 – ASDU: M_ME_TC_1	Measured value, short floating point number with time tag	76
Figure 43 – ASDU: M_IT_NA_1	Integrated totals	77
Figure 44 – ASDU: M_IT_NA_1	Sequence of integrated totals	78
Figure 45 – ASDU: M_IT_TA_1	Integrated totals with time tag	79
Figure 46 – ASDU: M_EP_TA_1	Event of protection equipment with time tag	80
Figure 47 – ASDU: M_EP_TB_1	Packed start events of protection equipment with time tag	81
Figure 48 – ASDU: M_EP_TC_1	Packed output circuit information of protection equipment with time tag	82
Figure 49 – ASDU: M_PS_NA_1	Packed single-point information with status change detection	83
Figure 50 – ASDU: M_PS_NA_1	Sequence of packed single-point information with status change detection	84
Figure 51 – ASDU: M_ME_ND_1	Measured value, normalized value without quality descriptor	85
Figure 52 – ASDU: M_ME_ND_1	Sequence of measured values, normalized values without quality descriptor	85
Figure 53 – ASDU: M_SP_TB_1	Single-point information with time tag CP56Time2a	86
Figure 54 – ASDU: M_DP_TB_1	Double-point information with time tag CP56Time2a	87
Figure 55 – ASDU: M_ST_TB_1	Step position information with time tag CP56Time2a	88
Figure 56 – ASDU: M_BO_TB_1	Bitstring of 32 bits with time tag CP56Time2a	89
Figure 57 – ASDU: M_ME_TD_1	Measured value, normalized value with time tag CP56Time2a	90
Figure 58 – ASDU: M_ME_TE_1	Measured value, scaled value with time tag CP56Time2a	91
Figure 59 – ASDU: M_ME_TF_1	Measured value, short floating point number with time tag CP56Time2a	93
Figure 60 – ASDU: M_IT_TB_1	Integrated totals with time tag CP56Time2a	94
Figure 61 – ASDU: M_EP_TD_1	Event of protection equipment with time tag CP56Time2a	95

Figure 62 – ASDU: M_EP_TE_1 Packed start events of protection equipment with time tag CP56Time2a.....	96
Figure 63 – ASDU: M_EP_TF_1 Packed output circuit information of protection equipment with time tag CP56Time2a.....	97
Figure 64 – ASDU: C_SC_NA_1 Single command.....	98
Figure 65 – ASDU: C_DC_NA_1 Double command.....	98
Figure 66 – ASDU: C_RC_NA_1 Regulating step command.....	99
Figure 67 – ASDU: C_SE_NA_1 Set-point command, normalized value.....	100
Figure 68 – ASDU: C_SE_NB_1 Set-point command, scaled value.....	100
Figure 69 – ASDU: C_SE_NC_1 Set-point command, short floating point number.....	101
Figure 70 – ASDU: C_BO_NA_1 Bitstring of 32 bit.....	102
Figure 71 – ASDU: M_EI_NA_1 End of initialization.....	103
Figure 72 – ASDU: C_IC_NA_1 Interrogation command.....	104
Figure 73 – ASDU: C_CI_NA_1 Counter interrogation command.....	104
Figure 74 – ASDU: C_RD_NA_1 Read command.....	105
Figure 75 – ASDU: C_CS_NA_1 Clock synchronization command.....	106
Figure 76 – ASDU: C_TS_NA_1 Test command.....	107
Figure 77 – ASDU: C_RP_NA_1 Reset process command.....	107
Figure 78 – ASDU: C_CD_NA_1 Delay acquisition command.....	108
Figure 79 – ASDU: P_ME_NA_1 Parameter of measured values, normalized value.....	109
Figure 80 – ASDU: P_ME_NB_1 Parameter of measured values, scaled value.....	110
Figure 81 – ASDU: P_ME_NC_1 Parameter of measured values, short floating point number.....	111
Figure 82 – ASDU: P_AC_NA_1 Parameter activation.....	112
Figure 83 – ASDU: F_FR_NA_1 File ready.....	113
Figure 84 – ASDU: F_SR_NA_1 Section ready.....	114
Figure 85 – ASDU: F_SC_NA_1 Call directory, select file, call file, call section.....	115
Figure 86 – ASDU: F_LS_NA_1 Last section, last segment.....	116
Figure 87 – ASDU: F_AF_NA_1 ACK file, ACK section.....	117
Figure 88 – ASDU: F_SG_NA_1 Segment.....	118
Figure 89 – ASDU: F_DR_TA_1 Directory.....	119
Figure 90 – Hierarchical presentation of the allocation of common addresses of ASDUs to LRUs (example).....	123
Figure 91 – Sequential procedure of station interrogation to all LRUs of a specific controlled station (example).....	124
Figure 92 – General counter model.....	125
Figure 93 – Sequential procedure of spontaneously transmitted integrated totals (mode A).....	126
Figure 94 – Sequential procedure of interrogation of integrated totals (mode B).....	127
Figure 95 – Sequential procedure of memorizing of integrated totals without reset (mode C).....	128
Figure 96 – Sequential procedure of memorizing of integrated totals with reset (mode C).....	128
Figure 97 – Addressing of files (example).....	130
Figure 98 – Request from protection equipment.....	131
Figure 99 – Request from substation automation system.....	132

Figure 100 – Structure of disturbance data of a protection equipment.....	133
Figure 101 – Allocation of data types (ASDUs) of IEC 60870-5-103 to the sections of disturbance data files	134
Figure 102 – Allocation of the data unit type 23 to the directory F_DR_TA_1	135
Figure 103 – Sequential procedure, transmission of the directory	138
Figure 104 – Sequential procedure, transmission of disturbance data files.....	139-141
Figure 105 – Record of sequences of events in the section of a data file	143
Figure 106 – Sequential procedure, transmission of sequences of events.....	144
Figure 107 – Section of a data file containing sequences of recorded analogue values	145
Figure 108 – Sequential procedure, transmission of sequences of recorded analogue values	147
Figure 109 – Sequential procedure, read procedure	148
Figure B.1 – Shift of a character caused by an inverted additional line idle bit.....	177
Figure B.2 – Relation of even and odd bit pattern to the parity bit	177
Figure B.3 – Shifted bit pattern	178
Table 1 – Selection from ITU-T V.24 or ITU-T V.28.....	13
Table 2 – Selection from ITU-T X.24 or ITU-T X.27 for interfaces to synchronous digital signal multiplexers.....	14
Table 3 – Permissible combinations of unbalanced link layer services	16
Table 4 – Permissible combinations of balanced link layer services.....	20
Table 5 – Time out intervals (T_0) depending on frame length, transmission speed and project specific parameters (examples).....	25
Table 6 – Time out intervals (T_0) depending on frame length, transmission speed and project specific parameters (examples)	26
Table 7 – Effects of the different resets	26
Table 8 – Semantics of TYPE IDENTIFICATION – Process information in monitor direction	30
Table 9 – Semantics of TYPE IDENTIFICATION – Process information in control direction	31
Table 10 – Semantics of TYPE IDENTIFICATION – System information in monitor direction	32
Table 11 – Semantics of TYPE IDENTIFICATION – System information in control direction	32
Table 12 – Semantics of TYPE IDENTIFICATION – Parameter in control direction.....	32
Table 13 – Semantics of TYPE IDENTIFICATION – File transfer.....	33
Table 14 – Semantics of CAUSE OF TRANSMISSION.....	40
Table 15 – ASDUs in the monitor direction which may transmit objects with equal information object addresses	44
Table 16 – Respond priorities of the controlled station	120
Table 17 – ASDUs involved in the station interrogation procedure	122
Table 18 – Allocation of type identification to type identification (IEC 60870-5-101 and IEC 60870-5-103).....	136
Table 19 – Example for the definition of information object addresses (directory or subdirectory)	136
Table 20 – Allocation of SOF status of file to SOF status of fault (IEC 60870-5-101 and IEC 60870-5-103).....	137
Table 21 – Type identifications for background scan	148

INTERNATIONAL ELECTROTECHNICAL COMMISSION

TELECONTROL EQUIPMENT AND SYSTEMS –

Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters, express as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60870-5-101 has been prepared by IEC technical committee 57: Power system control and associated communications.

This second edition cancels and replaces the first edition published in 1995, its amendments 1 (2000) and 2 (2001) and constitutes a technical revision.

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

FDIS	Report on voting
57/605/FDIS	57/623/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.

A bilingual version of this publication may be issued at a later date.

TELECONTROL EQUIPMENT AND SYSTEMS –

Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks

1 Scope and object

This part of IEC 60870-5 applies to telecontrol equipment and systems with coded bit serial data transmission for monitoring and controlling geographically widespread processes. It defines a telecontrol companion standard that enables interoperability among compatible telecontrol equipment. The defined telecontrol companion standard utilizes standards of the IEC 60870-5 series of documents. The specifications of this standard present a functional profile for basic telecontrol tasks. Further companion standards, based on the IEC 60870-5 series are under consideration.

This standard defines ASDUs with time tags CP24Time2a which includes three octets binary time from milliseconds to minutes. In addition to these specifications, ASDUs with time tags CP56Time2a, which includes seven octets binary time from milliseconds to years, are defined in this standard (see 6.8 of IEC 60870-5-4 and 7.2.6.18 of this standard).

ASDUs with time tags CP56Time2a are used when the controlling station is not able to add the time from hours to years unambiguously to the received ASDUs which are tagged from milliseconds to minutes. This may happen when using networks with uncertain transmission delays or if temporary failure of a network occurs.

Although this companion standard defines the most important user functions, other than the actual communication functions, it cannot guarantee complete compatibility and interoperability between equipment of different vendors. An additional mutual agreement is normally required between concerned parties regarding the methods of use of the defined communication functions, taking into account the operation of the entire telecontrol equipment.

Standards specified in this standard are compatible with standards defined in IEC 60870-5-1 to IEC 60870-5-5 (see Clause 2).

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 60050(371):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 371: Telecontrol*

IEC 60870-1-1:1988, *Telecontrol equipment and systems – Part 1: General considerations – Section 1: General principles*

IEC 60870-5-1:1990, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 1: Transmission frame formats*

IEC 60870-5-2:1992, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 2: Link transmission procedures*

IEC 60870-5-3:1992, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 3: General structure of application data*

IEC 60870-5-4:1993, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 4: Definition and coding of application information elements*

IEC 60870-5-5:1995, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 5: Basic application functions*

IEC 60870-5-103:1997, *Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment*

ISO/IEC 8824-1:2000, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

ITU-T V.24:2000, *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)*

ITU-T V.28:1993, *Electrical characteristics for unbalanced double-current interchange circuits*

ITU-T X.24:1988, *List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) on public data networks*

ITU-T X.27:1996, *Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s*

IEEE 754:1985, *Binary floating-point arithmetic*