# IEC 60870-5-101

Edition 2.1 2015-11

# CONSOLIDATED VERSION

colour inside

## Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 33.200

ISBN 978-2-8322-3051-0

**Warning! Make sure that you obtained this publication from an authorized distributor.**

® Registered trademark of the International Electrotechnical Commission

# IEC 60870-5-101

Edition 2.1 2015-11

# REDLINE VERSION

colour inside

## Telecontrol equipment and systems –
## Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks



IEC 60870-5-101:2003-02+AMD1:2015-11 CSV(en)

# CONTENTS

FOREWORD ..... 7
1 Scope and object ..... 9
2 Normative references ..... 9
3 Terms and definitions ..... 10
4 General rules ..... 11
4.1 Protocol structure ..... 11
4.2 Physical layer ..... 12
4.3 Link layer ..... 13
4.4 Application layer ..... 13
4.5 User process ..... 13
5 Physical layer ..... 13
5.1 Selections from ISO and ITU-T standards ..... 13
5.1.1 ITU-T V.24 or ITU-T V.28 unbalanced interchange circuit ..... 14
5.1.2 ITU-T X.24 or ITU-T X.27 balanced interchange circuit ..... 15
5.1.3 Interfaces to switched communication networks ..... 15
5.1.4 Other compatible interfaces ..... 15
6 Link layer ..... 15
6.1 Selections from IEC 60870-5-1: Transmission frame formats ..... 15
6.2 Selections from IEC 60870-5-2: Link transmission procedures ..... 16
6.2.1 State transition diagrams ..... 16
6.2.2 Definitions of time out interval for repeated frame transmission ..... 25
6.2.3 The use of the different resets ..... 27
7 Application layer and user process ..... 28
7.1 Selections from IEC 60870-5-3: General structure of application data ..... 28
7.2 Selections from IEC 60870-5-4: Definition and coding of application information elements ..... 30
7.2.1 Type identification ..... 30
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 ..... 103
7.3.5 ASDUs for parameter in control direction ..... 108
7.3.6 ASDUs for file transfer ..... 112
7.4 Selections from IEC 60870-5-5: Basic application functions ..... 119
7.4.1 Selections from station initialization ..... 120
7.4.2 Selections from data acquisition by polling ..... 120
7.4.3 Selections from cyclic data transmission ..... 120
7.4.4 Selections from acquisition of events ..... 120
7.4.5 Selections from station interrogation, outstation interrogation ..... 120
7.4.6 Selections from clock synchronization ..... 124

7.4.7 Selections from command transmission ..... 124
7.4.8 Selections from transmission of integrated totals ..... 124
7.4.9 Selections from parameter loading ..... 128
7.4.10 Selections from test procedure ..... 128
7.4.11 Selections from file transfer ..... 128
7.4.12 Selections from acquisition of transmission delay ..... 151
7.4.13 Background scan ..... 151
7.4.14 Read procedure ..... 151
8 Interoperability ..... 152
8.1 System or device ..... 153
8.2 Network configuration ..... 153
8.3 Physical layer ..... 153
8.4 Link layer ..... 154
8.5 Application layer ..... 155
8.6 Basic application functions ..... 160
Annex A (informative) Proof of the synchronization stability of frame format class FT 1.2 ..... 164
Annex B (informative) Admittance of line idle intervals between characters of frame format class FT 1.2 ..... 180

Figure 1 – Selected standard provisions of the defined telecontrol companion standard ..... 12
Figure 2 – Interfaces and connections of controlling and controlled stations ..... 12
Figure 3 – State transition diagram by Grady Booch/Harel ..... 16
Figure 4 – Unbalanced transmission procedures, primary and secondary stations ..... 18
Figure 5 – State transition diagram for unbalanced transmission primary to secondary ..... 19
Figure 6 – State transition diagram for unbalanced transmission secondary to primary ..... 20
Figure 7 – Balanced transmission procedures, primary and secondary link layers ..... 22
Figure 8 – State transition diagram for balanced transmission primary to secondary ..... 23
Figure 9 – State transition diagram for balanced transmission secondary to primary ..... 24
Figure 10 – Structure of an Application Service Data Unit ASDU ..... 29
Figure 11 – Type identification ..... 30
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) ..... 43
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 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 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 43 – ASDU: M_IT_NA_1 Integrated totals ..... 77
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 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 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 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 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 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 ..... 105
Figure 76 – ASDU: C_TS_NA_1 Test command ..... 106
Figure 77 – ASDU: C_RP_NA_1 Reset process command ..... 107
Figure 78 – ASDU: C_CD_NA_1 Delay acquisition command ..... 107
Figure 79 – ASDU: P_ME_NA_1 Parameter of measured values, normalized value ..... 108
Figure 80 – ASDU: P_ME_NB_1 Parameter of measured values, scaled value ..... 109
Figure 81 – ASDU: P_ME_NC_1 Parameter of measured values, short floating point number ..... 110
Figure 82 – ASDU: P_AC_NA_1 Parameter activation ..... 111
Figure 83 – ASDU: F_FR_NA_1 File ready ..... 112
Figure 84 – ASDU: F_SR_NA_1 Section ready ..... 113
Figure 85 – ASDU: F_SC_NA_1 Call directory, select file, call file, call section ..... 114
Figure 86 – ASDU: F_LS_NA_1 Last section, last segment ..... 115
Figure 87 – ASDU: F_AF_NA_1 ACK file, ACK section ..... 116
Figure 88 – ASDU: F_SG_NA_1 Segment ..... 117
Figure 90 – Hierarchical presentation of the allocation of common addresses of ASDUs to LRUs (example) ..... 122
Figure 91 – Sequential procedure of station interrogation to all LRUs of a specific controlled station (example) ..... 123
Figure 92 – General counter model ..... 124
Figure 93 – Sequential procedure of spontaneously transmitted integrated totals (mode A) ..... 125
Figure 94 – Sequential procedure of interrogation of integrated totals (mode B) ..... 126
Figure 95 – Sequential procedure of memorizing of integrated totals without reset (mode C) ..... 127
Figure 96 – Sequential procedure of memorizing of integrated totals with reset (mode C) ..... 127
Figure 97 – Addressing of files (example) ..... 129
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 ..... 142
Figure 105 – Record of sequences of events in the section of a data file ..... 146
Figure 106 – Sequential procedure, transmission of sequences of events ..... 147
Figure 107 – Section of a data file containing sequences of recorded analogue values ..... 148
Figure 108 – Sequential procedure, transmission of sequences of recorded analogue values ..... 150
Figure 109 – Sequential procedure, read procedure ..... 151
Figure B.1 – Shift of a character caused by an inverted additional line idle bit ..... 180
Figure B.2 – Relation of even and odd bit pattern to the parity bit ..... 180
Figure B.3 – Shifted bit pattern ..... 181

Table 1 – Selection from ITU-T V.24 or ITU-T V.28 ..... 14
Table 2 – Selection from ITU-T X.24 or ITU-T X.27 for interfaces to synchronous digital signal multiplexers ..... 15
Table 3 – Permissible combinations of unbalanced link layer services ..... 17
Table 4 – Permissible combinations of balanced link layer services ..... 21
Table 5 – Time out intervals ($T_0$) depending on frame length, transmission speed and project specific parameters (examples) ..... 26
Table 6 – Time out intervals ($T_0$) depending on frame length, transmission speed and project specific parameters (examples) ..... 27
Table 7 – Effects of the different resets ..... 27
Table 8 – Semantics of TYPE IDENTIFICATION – Process information in monitor direction ..... 31
Table 9 – Semantics of TYPE IDENTIFICATION – Process information in control direction ..... 32
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 ..... 33
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 ..... 119
Table 17 – ASDUs involved in the station interrogation procedure ..... 121
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 ..... 151

INTERNATIONAL ELECTROTECHNICAL COMMISSSION

_____

# TELECONTROL EQUIPMENT AND SYSTEMS –

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

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

**DISCLAIMER**
**This Consolidated version is not an official IEC Standard and has been prepared for user convenience. Only the current versions of the standard and its amendment(s) are to be considered the official documents.**

**This Consolidated version of IEC 60870-5-101 bears the edition number 2.1. It consists of the second edition (2003-02) [documents 57/605/FDIS and 57/623/RVD] and its amendment 1 (2015-11) [documents 57/1530/CDV and 57/1592/RVC]. The technical content is identical to the base edition and its amendment.**

**In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.**

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

# 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*

# IEC 60870-5-101

Edition 2.1 2015-11

# FINAL VERSION

## Telecontrol equipment and systems –
## Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks



IEC 60870-5-101:2003-02+AMD1:2015-11 CSV(en)

# CONTENTS

FOREWORD ..... 7
1 Scope and object ..... 9
2 Normative references ..... 9
3 Terms and definitions ..... 10
4 General rules ..... 11
4.1 Protocol structure ..... 11
4.2 Physical layer ..... 12
4.3 Link layer ..... 13
4.4 Application layer ..... 13
4.5 User process ..... 13
5 Physical layer ..... 13
5.1 Selections from ISO and ITU-T standards ..... 13
5.1.1 ITU-T V.24 or ITU-T V.28 unbalanced interchange circuit ..... 14
5.1.2 ITU-T X.24 or ITU-T X.27 balanced interchange circuit ..... 15
5.1.3 Interfaces to switched communication networks ..... 15
5.1.4 Other compatible interfaces ..... 15
6 Link layer ..... 15
6.1 Selections from IEC 60870-5-1: Transmission frame formats ..... 15
6.2 Selections from IEC 60870-5-2: Link transmission procedures ..... 16
6.2.1 State transition diagrams ..... 16
6.2.2 Definitions of time out interval for repeated frame transmission ..... 25
6.2.3 The use of the different resets ..... 27
7 Application layer and user process ..... 28
7.1 Selections from IEC 60870-5-3: General structure of application data ..... 28
7.2 Selections from IEC 60870-5-4: Definition and coding of application information elements ..... 30
7.2.1 Type identification ..... 30
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 ..... 103
7.3.5 ASDUs for parameter in control direction ..... 108
7.3.6 ASDUs for file transfer ..... 112
7.4 Selections from IEC 60870-5-5: Basic application functions ..... 119
7.4.1 Selections from station initialization ..... 120
7.4.2 Selections from data acquisition by polling ..... 120
7.4.3 Selections from cyclic data transmission ..... 120
7.4.4 Selections from acquisition of events ..... 120
7.4.5 Selections from station interrogation, outstation interrogation ..... 120
7.4.6 Selections from clock synchronization ..... 124

7.4.7 Selections from command transmission ..... 124
7.4.8 Selections from transmission of integrated totals ..... 124
7.4.9 Selections from parameter loading ..... 128
7.4.10 Selections from test procedure ..... 128
7.4.11 Selections from file transfer ..... 128
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 ..... 12
Figure 2 – Interfaces and connections of controlling and controlled stations ..... 12
Figure 3 – State transition diagram by Grady Booch/Harel ..... 16
Figure 4 – Unbalanced transmission procedures, primary and secondary stations ..... 18
Figure 5 – State transition diagram for unbalanced transmission primary to secondary ..... 19
Figure 6 – State transition diagram for unbalanced transmission secondary to primary ..... 20
Figure 7 – Balanced transmission procedures, primary and secondary link layers ..... 22
Figure 8 – State transition diagram for balanced transmission primary to secondary ..... 23
Figure 9 – State transition diagram for balanced transmission secondary to primary ..... 24
Figure 10 – Structure of an Application Service Data Unit ASDU ..... 29
Figure 11 – Type identification ..... 30
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) ..... 43
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 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 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 43 – ASDU: M_IT_NA_1 Integrated totals ..... 77
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 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 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 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 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 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 ..... 105
Figure 76 – ASDU: C_TS_NA_1 Test command ..... 106
Figure 77 – ASDU: C_RP_NA_1 Reset process command ..... 107
Figure 78 – ASDU: C_CD_NA_1 Delay acquisition command ..... 107
Figure 79 – ASDU: P_ME_NA_1 Parameter of measured values, normalized value ..... 108
Figure 80 – ASDU: P_ME_NB_1 Parameter of measured values, scaled value ..... 109
Figure 81 – ASDU: P_ME_NC_1 Parameter of measured values, short floating point number ..... 110
Figure 82 – ASDU: P_AC_NA_1 Parameter activation ..... 111
Figure 83 – ASDU: F_FR_NA_1 File ready ..... 112
Figure 84 – ASDU: F_SR_NA_1 Section ready ..... 113
Figure 85 – ASDU: F_SC_NA_1 Call directory, select file, call file, call section ..... 114
Figure 86 – ASDU: F_LS_NA_1 Last section, last segment ..... 115
Figure 87 – ASDU: F_AF_NA_1 ACK file, ACK section ..... 116
Figure 88 – ASDU: F_SG_NA_1 Segment ..... 117
Figure 90 – Hierarchical presentation of the allocation of common addresses of ASDUs to LRUs (example) ..... 122
Figure 91 – Sequential procedure of station interrogation to all LRUs of a specific controlled station (example) ..... 123
Figure 92 – General counter model ..... 124
Figure 93 – Sequential procedure of spontaneously transmitted integrated totals (mode A) ..... 125
Figure 94 – Sequential procedure of interrogation of integrated totals (mode B) ..... 126
Figure 95 – Sequential procedure of memorizing of integrated totals without reset (mode C) ..... 127
Figure 96 – Sequential procedure of memorizing of integrated totals with reset (mode C) ..... 127
Figure 97 – Addressing of files (example) ..... 129
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
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 ..... 14
Table 2 – Selection from ITU-T X.24 or ITU-T X.27 for interfaces to synchronous digital signal multiplexers ..... 15
Table 3 – Permissible combinations of unbalanced link layer services ..... 17
Table 4 – Permissible combinations of balanced link layer services ..... 21
Table 5 – Time out intervals ($T_0$) depending on frame length, transmission speed and project specific parameters (examples) ..... 26
Table 6 – Time out intervals ($T_0$) depending on frame length, transmission speed and project specific parameters (examples) ..... 27
Table 7 – Effects of the different resets ..... 27
Table 8 – Semantics of TYPE IDENTIFICATION – Process information in monitor direction ..... 31
Table 9 – Semantics of TYPE IDENTIFICATION – Process information in control direction ..... 32
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 ..... 33
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 ..... 119
Table 17 – ASDUs involved in the station interrogation procedure ..... 121
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 COMMISSSION

_____

# TELECONTROL EQUIPMENT AND SYSTEMS –

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

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

**DISCLAIMER**
**This Consolidated version is not an official IEC Standard and has been prepared for user convenience. Only the current versions of the standard and its amendment(s) are to be considered the official documents.**

**This Consolidated version of IEC 60870-5-101 bears the edition number 2.1. It consists of the second edition (2003-02) [documents 57/605/FDIS and 57/623/RVD] and its amendment 1 (2015-11) [documents 57/1530/CDV and 57/1592/RVC]. The technical content is identical to the base edition and its amendment.**

**This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.**

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

# 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*