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

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FOREWORD

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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- withdrawn;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*

3 Terms and definitions

For the purpose of this part of IEC 60870-5, the following definitions apply.

3.1
companion standard
a companion standard adds semantics to the definitions of the basic standard or a functional profile. This may be expressed by defining particular uses for information objects or by defining additional information objects, service procedures and parameters of the basic standard

NOTE Companion standards do not alter the standards to which they refer, but make explicit the relationship between those used together for a specific domain of activity.

3.2
group (of information objects)
selection of COMMON ADDRESSES or INFORMATION ADDRESSES which is specifically defined for a particular system

3.3
control direction
direction of transmission from the controlling station to a controlled station

3.4
monitor direction
direction of transmission from a controlled station to the controlling station

3.5
system parameter
a system parameter (or system-specific parameter) is valid for the complete telecontrol system which uses this companion standard. The telecontrol system consists of the entire controlled and controlling stations which may be connected via different network configurations

3.6
network-specific parameter
a network-specific parameter is valid for all the stations which are connected via a particular network configuration

3.7
station-specific parameter
a station-specific parameter is valid for particular stations

3.8
object-specific parameter
an object-specific parameter is valid for a particular information object or a specific group of information objects

4 General rules

This Clause provides general rules for constructing companion standards for the transmission protocol of specific telecontrol systems, using the IEC 60870-5 series protocol.

These general rules are applied in the following Subclauses.

4.1 Protocol structure

The IEC 60870-5 series protocol is based on the three-layer reference model "Enhanced Performance Architecture" (EPA), as specified in Clause 4 of IEC 60870-5-3.

The physical layer uses ITU-T recommendations that provide binary symmetric and memoryless transmission on the required medium in order to preserve the high level of data integrity of the defined block encoding method in the link layer.

The link layer consists of a number of link transmission procedures using explicit LINK PROTOCOL CONTROL INFORMATION (LPCI) that are capable of carrying APPLICATION SERVICE DATA UNITS (ASDUs) as link-user data. The link layer uses a selection of frame formats to provide the required integrity/efficiency and convenience of transmission.

The application user layer contains a number of "Application Functions" that involve the transmission of APPLICATION SERVICE DATA UNITS (ASDUs) between source and destination.

The application layer of this companion standard does not use explicit APPLICATION PROTOCOL CONTROL INFORMATION (APCI). This is implicit in the contents of the ASDU DATA UNIT IDENTIFIER field and in the type of link service used.

Figure 1 shows the Enhanced Performance Architecture model (EPA) and the selected standard definitions of the companion standard.

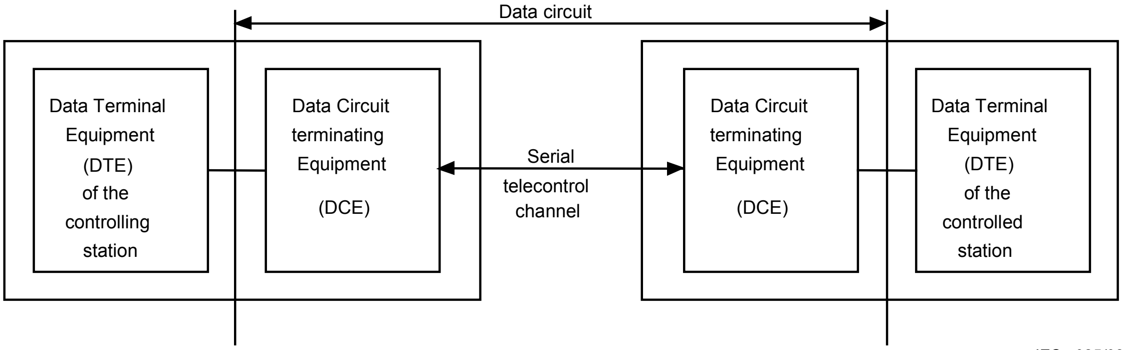
Selected application functions of IEC 60870-5-5	**User process**
Selected application information elements of IEC 60870-5-4	**Application (layer 7)**
Selected application service data units of IEC 60870-5-3	
Selected link transmission procedures of IEC 60870-5-2	**Link (layer 2)**
Selected transmission frame formats of IEC 60870-5-1	
Selected ITU-T recommendations	**Physical (layer 1)**

IEC 084/03

Figure 1 – Selected standard provisions of the defined telecontrol companion standard

4.2 Physical layer

The companion standard specifies ITU-T recommendations which define the interfaces between data circuit terminating equipment (DCE) and data terminating equipment (DTE) of the controlling and the controlled station (see Figure 2, as well as Figure 2 of IEC 60870-1-1).



IEC 085/03

Figure 2 – Interfaces and connections of controlling and controlled stations

The standard interface between DTE and DCE is the asynchronous ITU-T V.24/ITU-T V.28 interface. The use of the required interface signals depends on the operational mode of the used transmission channel. Therefore the companion standard defines a selection of interchange circuits (signals) which may but need not be used.

NOTE Data transmission methods that are used to increase the exploitation of the bandwith of a given transmission channel should be avoided unless it can be proven that the used method (that usually violates the required memoryless channel encoding principle) does not reduce the data integrity of the data block encoding method of the selected frame format in the link layer.

4.3 Link layer

IEC 60870-5-2 offers a selection of link transmission procedures using a control field and the optional address field. Links between stations may be operated in either an unbalanced or a balanced transmission mode. Appropriate function codes for the control field are specified for both modes of operation.

If the links from a central control station (controlling station) to several outstations (controlled stations) share a common physical channel, then these links must be operated in an unbalanced mode to avoid the possibility of more than one outstation attempting to transmit on the channel at the same time. The sequence in which the various outstations are granted access to transmit on the channel is then determined by an application layer procedure in the controlling station, see 6.2 in IEC 60870-5-5.

The companion standard specifies whether an unbalanced or a balanced transmission mode is used, together with which link procedures (and corresponding link function codes) are to be used.

The companion standard specifies an unambiguous address (number) for each link. Each address may be unique within a specific system, or it may be unique within a group of links sharing a common channel. The latter needs a smaller address field but requires the controlling station to map addresses by channel number.

A companion standard shall specify one frame format chosen from those offered in IEC 60870-5-1. The format chosen shall provide the required data integrity together with the maximum efficiency available for an acceptable level of convenience of implementation. In addition, a companion standard specifies the time-out interval (T_0) of the primary station and the maximum permitted reaction time (T_r) of the secondary station for all links (see A.1 of IEC 60870-5-2 for details of link timing).

4.4 Application layer

A companion standard shall define appropriate ASDUs from a given general structure in IEC 60870-5-3. These ASDUs are constructed using the definition and coding specifications for application information elements given in IEC 60870-5-4.

A companion standard shall specify one chosen order of transport for application data fields (see 4.10 of IEC 60870-5-4). The order (mode 1 or mode 2) may be chosen to provide the maximum overall convenience of programming for the various computers in the specific telecontrol system's stations.

4.5 User process

IEC 60870-5-5 offers an assortment of basic application functions. A companion standard contains one or more instances of these functions chosen to provide the required set of input/output application procedures to suit the specific telecontrol system.

5 Physical layer

5.1 Selections from ISO and ITU-T standards

The following fixed network configurations are supported:

– point-to-point;

– multiple point-to-point;

– multipoint-star;

– multipoint-party line;

– multipoint-ring.

The subset of the ITU-T V.24 and ITU-T V.28 recommendations, defined in 5.1.1, is valid.

In case of digital transmission methods using digital signal multiplexers the ITU-T X.24 or ITU-T X.27 interface may be used for channels up to 64 kbit/s by special agreement (see 5.1.2).

In this companion standard, the "Data circuit" is treated separately from the telecontrol stations because it is often implemented by separate hardware. Consequentially the companion standard includes a full specification of the DTE/DCE interface but only a requirement specification for suitable DCEs is given.

5.1.1 ITU-T V.24 or ITU-T V.28 unbalanced interchange circuit

This companion standard specifies a subset of the ITU-T V.24, using the signal levels specified by ITU-T V.28.

Table 1 – Selection from ITU-T V.24 or ITU-T V.28

Interchange circuit number	Interchange circuit name	From DCE	To DCE
102	Signal ground or common return	–	–
103	Transmitted data		X
104	Received data	X	
105 [a]	Request to send		X
106 [b]	Ready for sending	X	
107 [b]	Data set ready	X	
108 [a]	Data terminal ready		X
109 [b]	Data channel received line signal detector	X	

[a] May have constant potential.

[b] Not mandatory. It can be used to supervise the transmission circuit.

The standard transmission speeds may be specified for the directions of transmission and reception separately. The following choice of standard transmission speeds are supported.

The standard transmission speeds of the ITU-T V.24 or ITU-T V.28FSK-interface should be:

– 100 bit/s
– 200 bit/s
– 300 bit/s
– 600 bit/s
– 1,2 kbit/s

The standard transmission speeds of the ITU-T V.24 or ITU-T V.28MODEM-interface are:

– 300 bit/s
– 600 bit/s
– 1,2 kbit/s
– 2,4 kbit/s [1]
– 4,8 kbit/s [1]
– 9,6 kbit/s [1]

The standard transmission speeds of digital signal multiplexers (used asynchronously) are the same as for the MODEM-interface.

1 See the note at the end of 4.2.

5.1.2 ITU-T X.24 or ITU-T X.27 balanced interchange circuit

Table 2 shows the ITU-T X.24 or ITU-T X.27 balanced interchange circuit (used synchronously) of digital signal multiplexers. The interface that is operated with symmetric difference signals is suited for 64 kbit/s.

Table 2 – Selection from ITU-T X.24 or ITU-T X.27 for interfaces to synchronous digital signal multiplexers

Interchange circuit number	Interchange circuit name	From DCE	To DCE
G	Signal ground or common return	–	–
T	Transmit		X
R	Receive	X	
C [1)]	Control		X
I [1)]	Indication	X	
S	Signal element timing	X	
[1)] Control and indication signals are dispensable if DTEs are connected to the digital signal multiplexer. The signals may, however, be used for supervisory purposes.			

The standard transmission speeds may be specified for the directions of transmission and reception separately. The standard transmission speeds are:

- 2,4 kbit/s
- 4,8 kbit/s
- 9,6 kbit/s
- 19,2 kbit/s
- 38,4 kbit/s
- 56 kbit/s
- 64 kbit/s

5.1.3 Interfaces to switched communication networks

This companion standard does not specify applications using switched communication networks.

5.1.4 Other compatible interfaces

Physical interfaces other than those which are recommended in the IEC 60870-5 series may be used, according to agreement between user and vendor. However, if other interfaces are used, it is the responsibility of the user and the vendor to prove their functionality and interoperability.

6 Link layer

The following international standards are valid:

IEC 60870-5-1

IEC 60870-5-2

6.1 Selections from IEC 60870-5-1: Transmission frame formats

This companion standard admits exclusively frame format FT1.2 that is defined in subclause 6.2.4.2 of IEC 60870-5-1. Formats with fixed and with variable block length are admitted. Also the single control character I transmission is admitted. When an ASDU is to be transmitted, a frame with variable length must be used. When no ASDU is to be transmitted, frames with fixed length or the single character must be used.

NOTE 1 The rules defined in 6.2.4.2 of IEC 60870-5-1 should be completely observed.

NOTE 2 The FT 1.2 frame is basically asynchronous, with the timing of each constituent 11-bit character, starting with its first bit and stopping with its last bit. However, when used with the synchronous interface, defined in 5.1.2 above, the signal element timing is derived from the DCE and runs continuously. In this case, the frame should be transmitted and received isochronously.

Transmission rule R3 states that no idle line intervals are admitted between characters. This may not be possible to achieve in some practical implementations, particularly with high bit rate transmission, because of unavoidable hardware or software delays.

However, Annex B demonstrates that a line idle interval between characters that has a duration not longer than one transmitted bit time does not reduce the frame integrity. Therefore, transmission rule R3 may be relaxed to allow line idle intervals of up to one transmitted bit time duration between characters. The line idle intervals between characters extend the transmission time of time critical information (for example, clock synchronization) which may reduce the accuracy of clocks in controlled stations.

There is no requirement for the receiver to measure line idle intervals between characters. For example, the receiver may be implemented using an industry standard UART circuit alone, without any special hardware or software concerned with the duration of gaps between characters in a received frame.

6.2 Selections from IEC 60870-5-2: Link transmission procedures

The maximum length of link frames is set as a fixed system (network-specific) parameter. If required the maximum length for each direction may be different.

The frame with fixed length has no link user data.

The transmission procedures SEND/NO REPLY, SEND/CONFIRM and REQUEST/RESPOND have to be used as required. The interface between the link layer and the service user is not defined in this companion standard.

6.2.1 State transition diagrams

This Subclause adds more detail to the base definitions of link transmission procedures given in IEC 60870-5-2. State transition diagrams are used to define the procedures more exactly so that link layers implemented by different manufacturers can be made fully interoperable. State transition diagrams represent the states (in this case of the link layer defined in IEC 60870-5-2) and the transitions from one state into another. The actions (send a frame Tx and receive a frame Rx) are included. In addition to the states, important internal processes are described.

The state transition diagrams are presented in the format defined by Grady Booch/Harel. The explanation of the particular elements is shown in Figure 3.

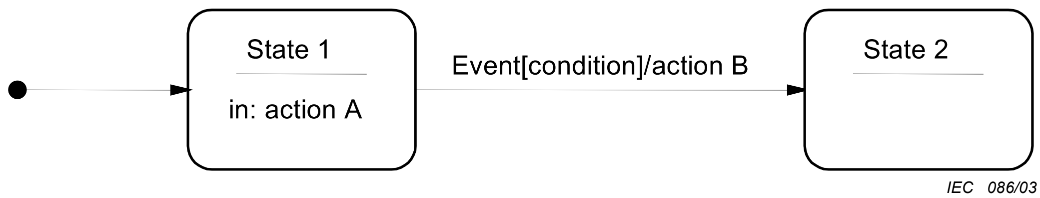


Figure 3 – State transition diagram by Grady Booch/Harel

The word “in” describes an action which is triggered when a transition into a new state occurs. The transition to the next state may be triggered by the termination of the current state, in the case where there is no defined event to cause the transition.

The notation used in the following state transition diagrams is:

FC0 to FC15 = function code number 0 to 15, see Tables 1 to 4 of IEC 60870-5-2

FCB = frame count bit

FCV = frame count bit valid

DFC = data flow control

ACD = access demand

PRM = primary message

SC = single character

6.2.1.1 Unbalanced transmission procedures

In unbalanced transmission systems, outstations are always secondary (slaves). The control centre is primary (master).

In hierarchical systems, any intermediate nodes are primary in direction of the outstation and secondary in direction of the control centre.

The RES-bit in the control field is not used and set to zero.

The address field A of the link is either one or two octets as determined by a fixed system parameter. The address number of the broadcast command (always the SEND/NO REPLY-service) is 255 (corresponding to one octet) or 65535 (corresponding to two octets). The SEND/NO REPLY service is used when issuing a user data message to all stations (broadcast address).

There are no group addresses defined.

In polling systems, the basic transmission procedure uses the REQUEST/RESPOND-service function code 11 (request user data class 2). Class 1 data are indicated via the ACD-bit as defined in IEC 60870-5-2. The assignment of the causes of transmission to the two classes is defined in 7.4.2. Controlled stations that have no data of data class 2 available may respond to the class 2 request with class 1 data.

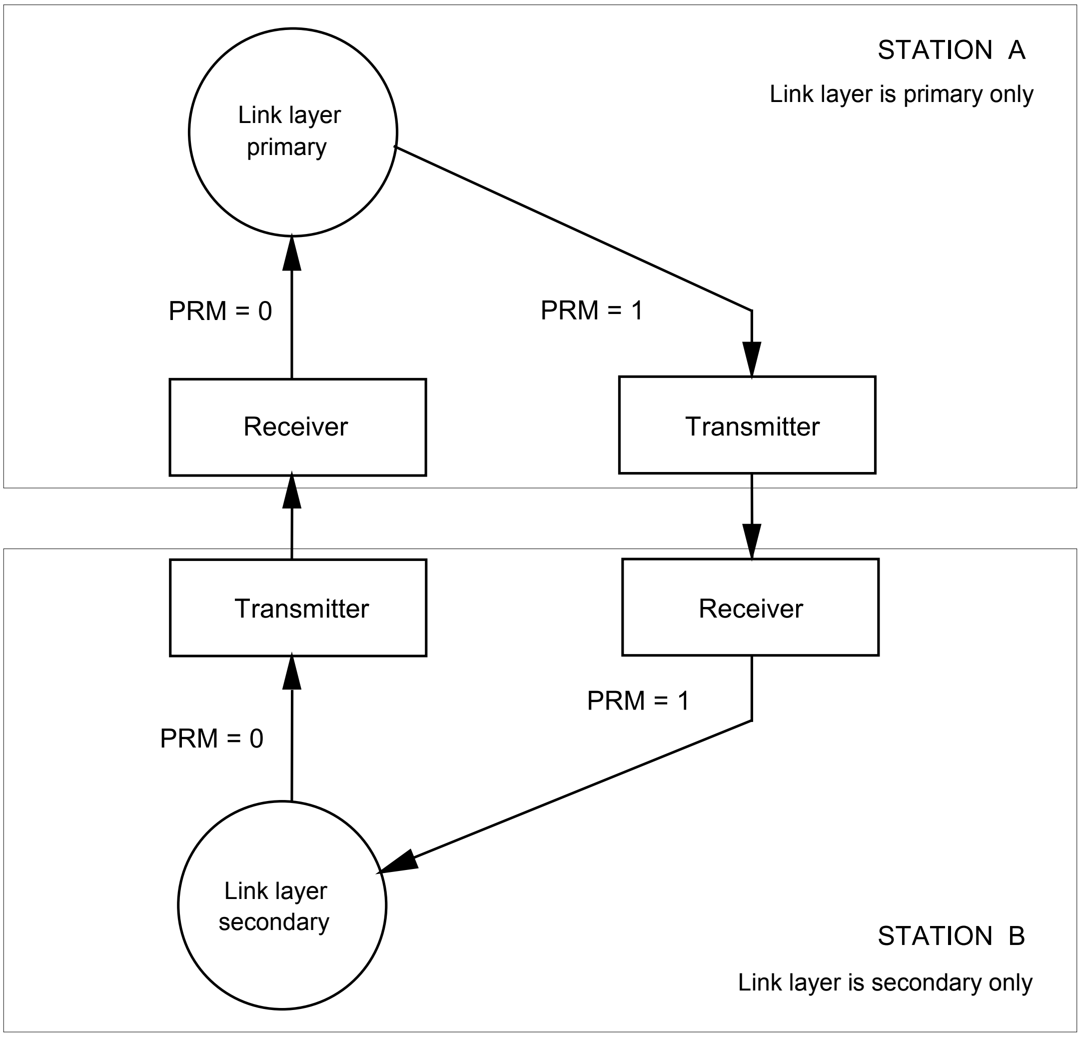
Table 3 shows the permissible combinations of the unbalanced link layer procedures.

Table 3 – Permissible combinations of unbalanced link layer services

Function codes and services in the primary direction	Permitted function codes and services in the secondary direction
<0> Reset of remote link	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<1> Reset of user process	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<3> SEND/CONF user data	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<4> SEND/NO REPLY user data	No reply
<8> REQUEST for access demand	<11> RESPOND: status of link
<9> REQUEST/RESP request status of link	<11> RESPOND: status of link
<10> REQUEST/RESP request user data class 1	<8> RESPOND: user data or <9> RESPOND: requested data not available
<11> REQUEST/RESP request user data class 2	<8> RESPOND: user data or <9> RESPOND: requested data not available

Responses <14> Link service not functioning or <15> Link service not implemented are also permitted. The single control character E5 may be used instead of a fixed length CONFIRM ACK (secondary function code <0>) or fixed length RESPOND NACK (secondary function code <9>) except when there is an access demand for class 1 data (ACD = 1) or further messages may cause an overflow (DFC = 1). This is shown in Figures 5 and 6. The single character A2 must not be used.

For unbalanced transmission procedures, The primary station contains only a primary link layer and the secondary station contains only a secondary link layer (see Figure 4). More than one secondary station may be connected to one primary station. Compatible communication between the primary station and a particular secondary station relies on these two stations alone. The polling procedure for requesting data from multiple secondary stations is a local internal function of the primary station and need not be shown in Figures 4 to 6. Consequently, these diagrams only show the primary station and a single secondary station. In the case of more than one secondary station, the primary station has to remember the current state of each secondary station.



IEC 087/03

Figure 4 – Unbalanced transmission procedures, primary and secondary stations

Figure 5 shows the state transition diagram of the primary station, Figure 6 that of the secondary station.

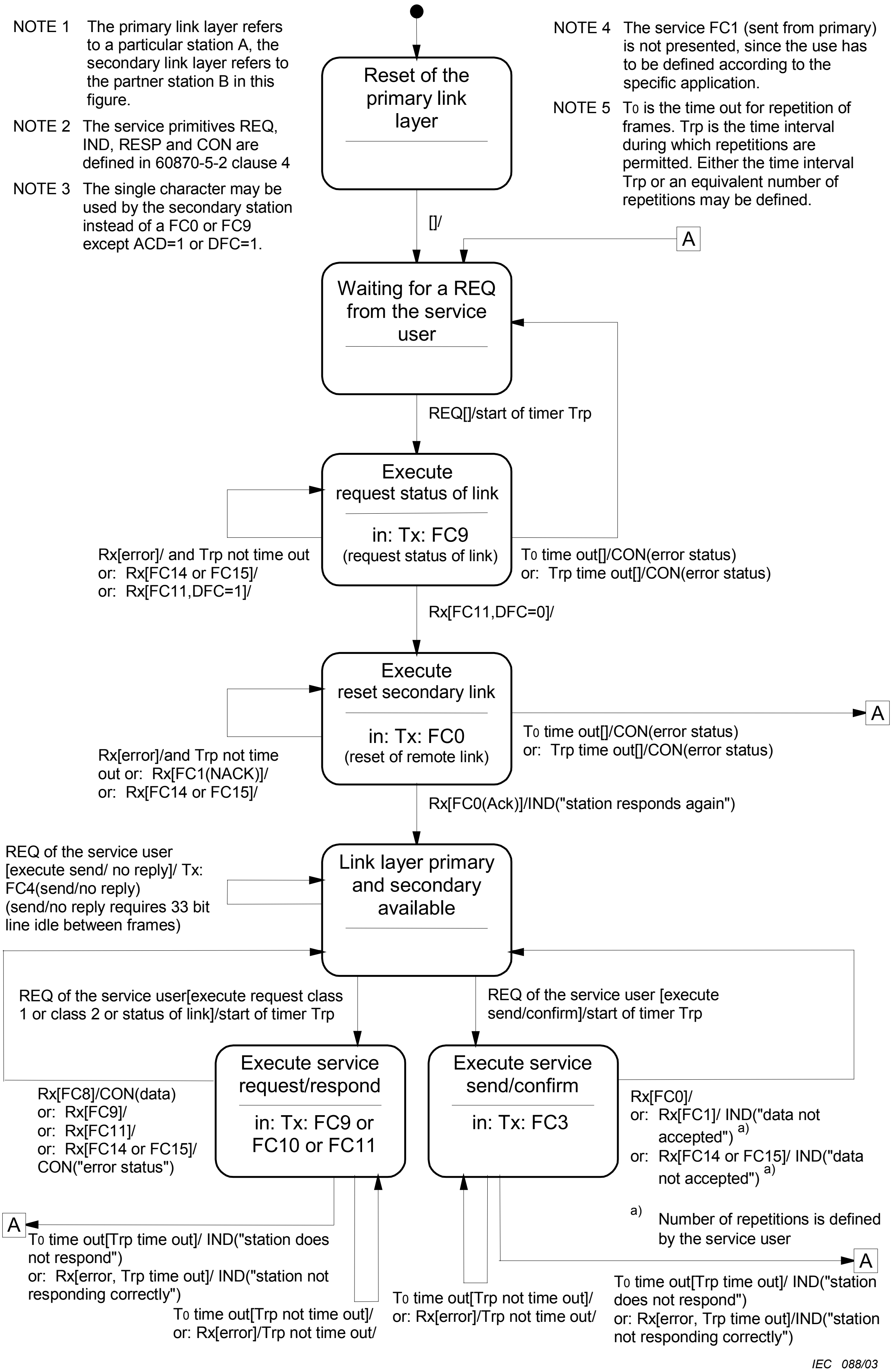


Figure 5 – State transition diagram for unbalanced transmission primary to secondary

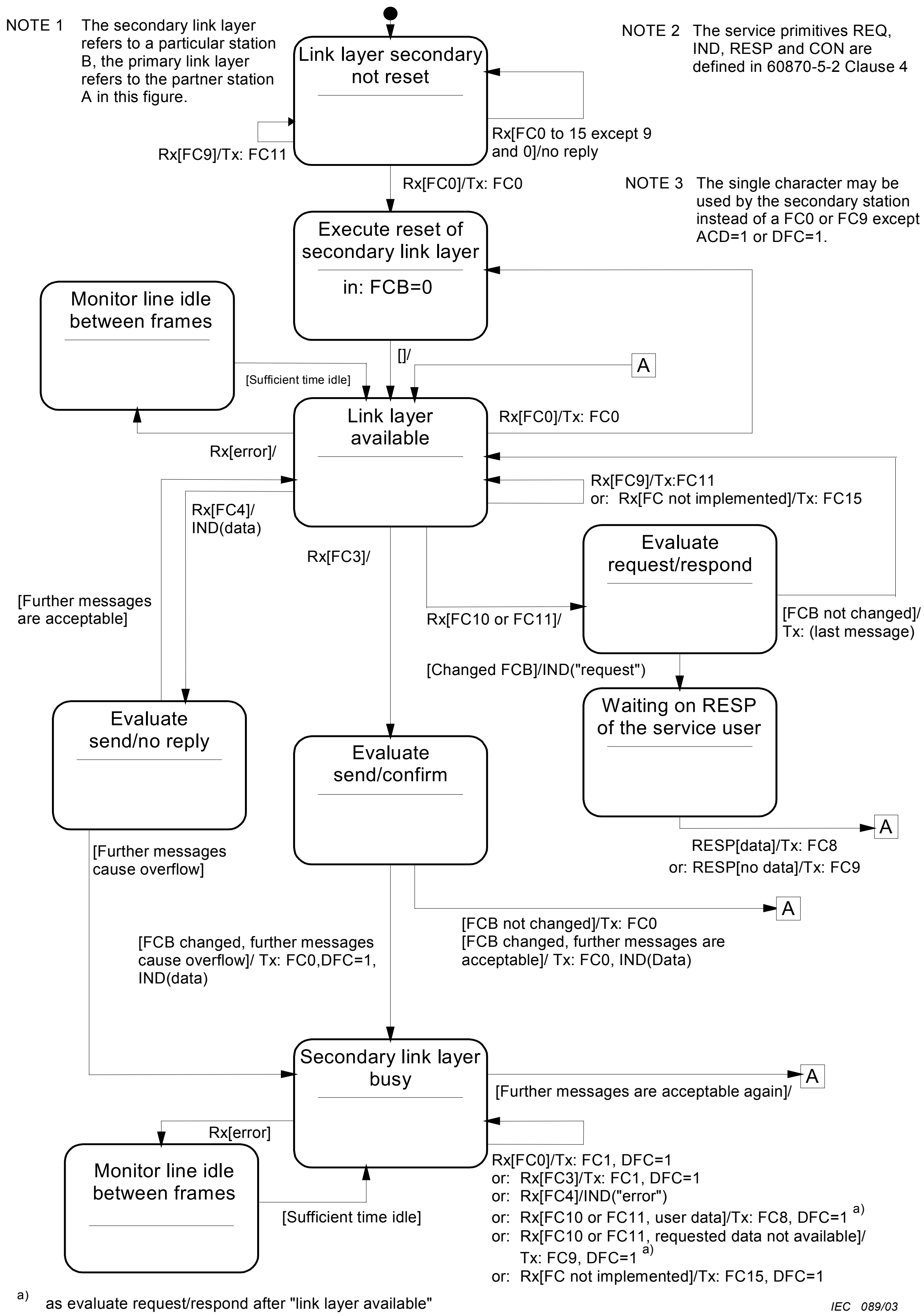


Figure 6 – State transition diagram for unbalanced transmission secondary to primary balanced transmission procedures

The request to all standardized function codes in primary direction (0 up to 4 and 9) have to receive positive or negative responses. In the case of an unimplemented service, the secondary station has to answer with the function code 15 for link service not implemented.

The following Table shows the permissible combinations of the balanced link layer procedures.

Table 4 – Permissible combinations of balanced link layer services

Function codes and services in the primary direction	Permitted function codes and services in the secondary direction
<0> Reset of remote link	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<1> Reset of user process	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<2>SEND/CONF test function for link	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<3> SEND/CONF user data	<0> CONFIRM: ACK or <1> CONFIRM: NACK
<4> SEND/NO REPLY user data	No reply
<9> REQUEST/RESP request status of link	<11> RESPOND: status of link

Responses <14> link service not functioning or <15> link service not implemented are also permitted. The single control character E5 may be used instead of a fixed length CONFIRM ACK (secondary function code <0>) except when further messages may cause an overflow (DFC = 1).

The address field A is optional. If it is defined, it consists of one or two octets specified per system. In balanced transmission systems, no broadcast command is defined.

The RES-bit in the control field is not used and is set to zero.

The link layers for balanced transmission procedures consist of two decoupled logical processes, one logical process represents station A as the primary station and station B as the secondary station and the other logical process represents station B as the primary station and station A as the secondary station (each station is a combined station). Thus, two independent processes exist in each station to control the link layer in the logical primary and in the secondary direction. Figure 7 shows the typical arrangement of the link layer using balanced transmission procedures.

NOTE The physical transmission direction is fixed defined by the bit DIR. The logical processes primary or secondary may change from station A to B and vice versa. The primary message is defined by the bit PRM = 1, the secondary message by the bit PRM = 0 (see 6.1.2 of IEC 60870-5-2).

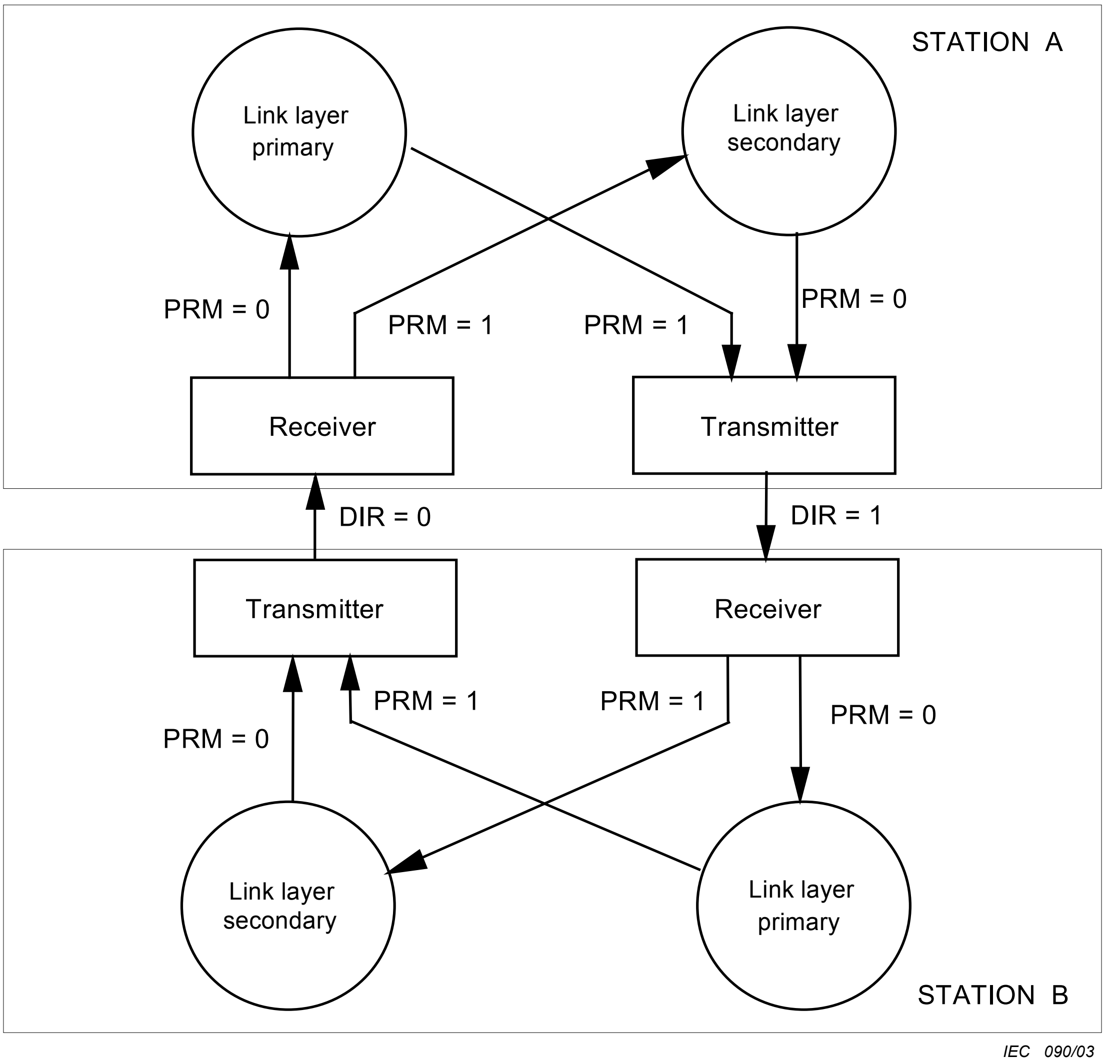


Figure 7 – Balanced transmission procedures, primary and secondary link layers

Figures 8 and 9 do not show the reactions of the link layer in the case of receiving corrupted frames. These frames are already rejected by a process which is not shown in the following. This process is also responsible for the control of the time out interval. Figure 8 shows the state transition diagram of the primary link layer using balanced transmission procedures. Figure 9 shows the secondary link layer.

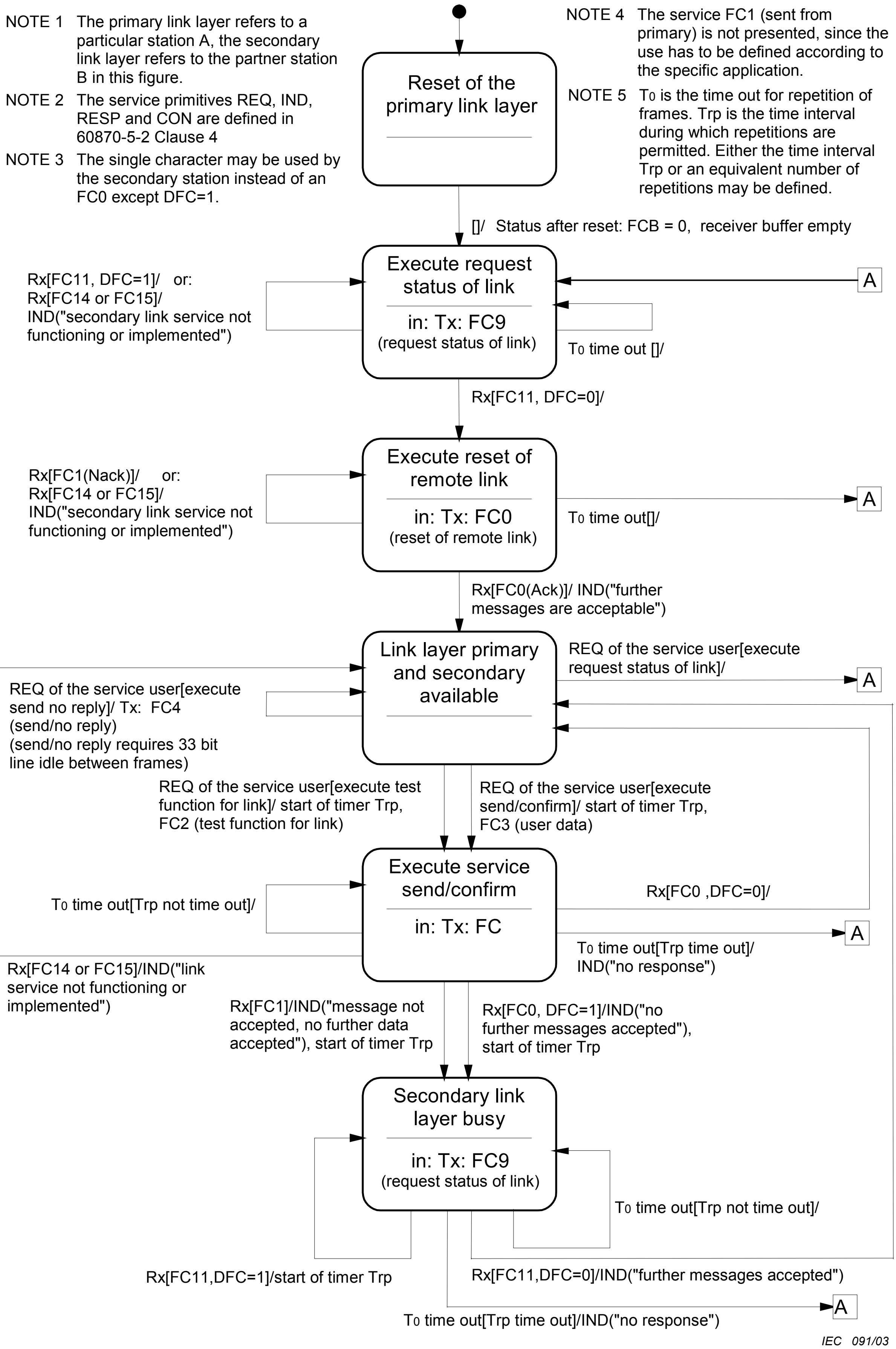


Figure 8 – State transition diagram for balanced transmission primary to secondary

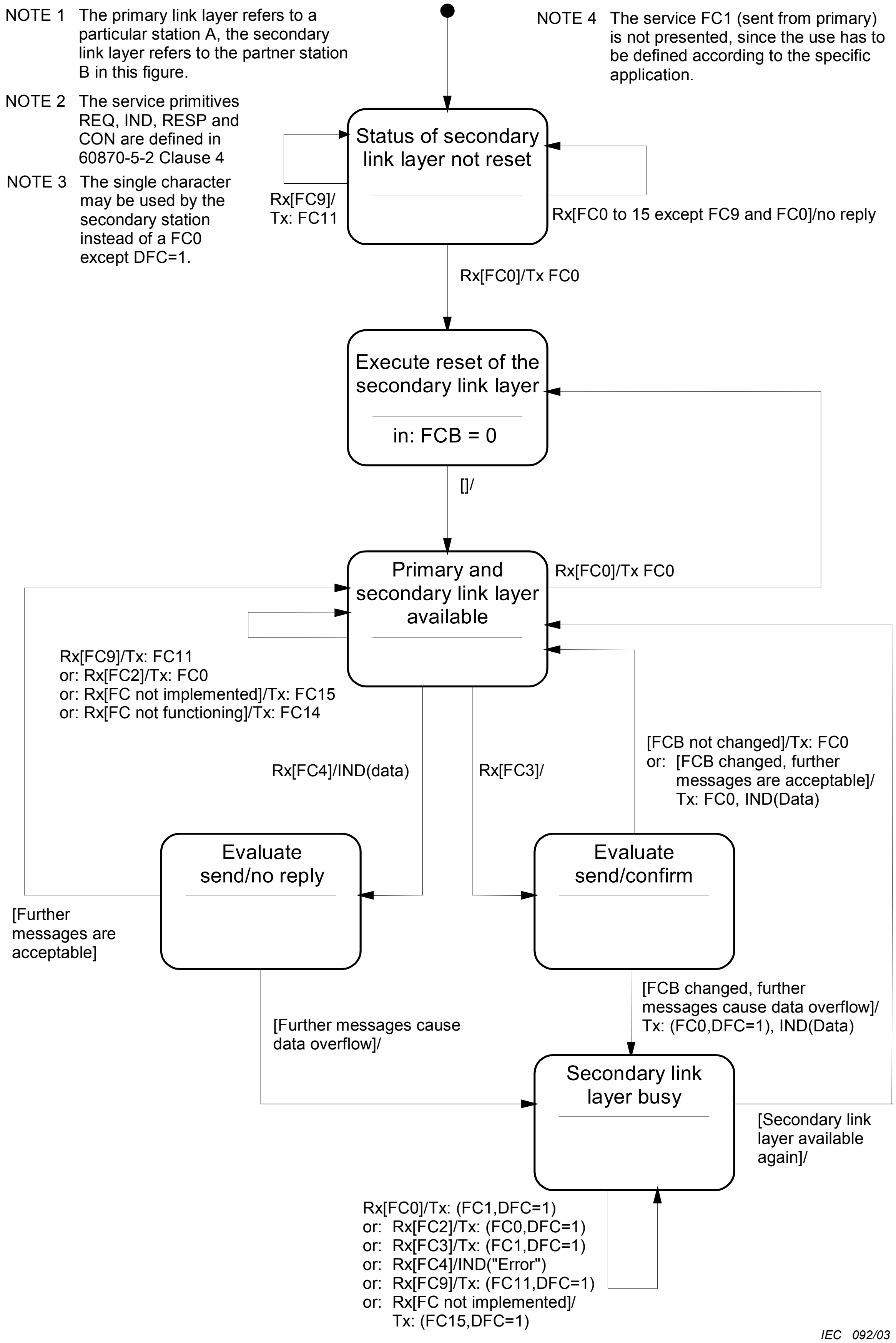


Figure 9 – State transition diagram for balanced transmission secondary to primary

DIR defines the physical transmission direction (see 6.1.2 of IEC 60870-5-2):

1 = station A (controlling station) to station B (controlled station)

0 = station B (controlled station) to station A (controlling station)

All messages sent by the controlling station will have the data link control field DIR bit set to 1. All messages sent by the controlled station will have the data link control field DIR bit set to 0.

In the case of two equivalent stations (for example, two control centres), the DIR is defined by agreement.

If defined, the balanced mode address field will contain the destination address for both primary and secondary messages.

6.2.2 Definitions of time out interval for repeated frame transmission

Formulae are given in Annex A of IEC 60870-5-2 for calculating the time out interval for repeated transmissions, assuming two cases and a variety of project-specific parameters. The matched time out interval as described in the Figures A.2 or A.4, case 2 of IEC 60870-5-2 is not used. The time out interval which is specified in the Figures A.2/A.4 case 1 is applicable. The time out interval T_0 is constant for each defined combination of transmission speeds.

This present Subclause clarifies the use of the formulae by calculating two tables which give examples of time out intervals for a number of typical conditions for both balanced and unbalanced transmission.

Reference: IEC 60870-5-2, Annex A, – Figure A.2, case 1 (unbalanced transmission procedures);
IEC 60870-5-2, Annex A – Figure A.4, case 1 (balanced transmission procedures).

Abbreviations not defined in IEC 60870-5-2:

BAB transmission speed from station A to station B

BBA transmission speed from station B to station A

LBAmax number of octets of the longest frame from B to A

LADDR length of the link address field

BAB, BBA, LBAmax, LADDR, t_R and t_{RB} are project-specific parameters.

6.2.2.1 Unbalanced transmission

The following condition is valid for the time out interval T_0:

$$T_0 > t_{LD} + T_{LBA}$$

where

t_{LD} = $t_{DAB} + t_R + t_{DBA}$

t_R = reaction time of station B (specific per equipment)

t_{DAB} = 0,5/BAB (see note below)

t_{DBA} = 0,5/BBA (see note below)

T_{LBA} = $11 \times$ LBAmax/BBA

Examples for the specification of the time out interval

Definitions: station B = controlled station
equal transmission speed in both directions
reaction time of station B t_R = 50 ms.

NOTE The signal delays t_{DAB} and t_{DBA} (see IEC 60870-5-2, Annex A) are assumed to be half the transmission time of a data bit.

Table 5 – Time out intervals (T_0) depending on frame length, transmission speed and project specific parameters (examples)

LBAmax	**Transmission speed** bit/s	t_{LD} ms	T_{LBA} ms	T_0 ms
20	100	60,0	2 200,0	2 260,0
	600	51,7	366,7	418,4
	1 200	50,8	183,3	234,1
	9 600	50,1	22,9	73,0
	19 200	50,0	11,4	61,4
	64 000	50,0	3,4	53,4
240	100	60,0	26 400,0	26 460,0
	600	51,7	4 400,0	4 451,7
	1 200	50,8	2 200,0	2 250,8
	9 600	50,1	275,0	325,1
	19 200	50,0	137,5	187,5
	64 000	50,0	41,3	91,3

6.2.2.2 Balanced transmission

The following condition is valid for the time out interval T_0:

$$T_0 > t_{LDA} + T_{LSPBA} + t_{GB} + T_{LPSBA}$$

where

t_{LDA} = $t_{DAB} + t_{RB} + t_{DBA}$

and

t_{RB} is the reaction time of station B (specific per equipment)

t_{DAB} = 0,5/BAB (see note below)

t_{DBA} = 0,5/BBA (see note below)

t_{GB} = 33/BBA [1)]

T_{LPSBA} = 11 × LBAmax/BBA

T_{LSPBA} = 11(LADDR + 4)/BBA

NOTE The signal delays t_{DAB} and t_{DBA} (see IEC 60870-5-2, Annex A) are assumed to be half the transmission time of a data bit.

Examples for the specification of the time out interval

Definitions: station B = controlled station
equal transmission speed in both directions
reaction time of station B t_R = 50 ms
length of address field LADDR = 1

[1)] t_{GB} = 33 bit is the critical case for the definition of T_0.
t_{GB} is a system specific parameter which may be significantly less than 33 bit (for example, 0,5 bit).

Table 6 – Time out intervals (T_0) depending on frame length, transmission speed and project specific parameters (examples)

LBAmax	Transmission speed bit/s	t_{LDA} ms	t_{GB} ms	T_{LSPBA} ms	T_{LPSBA} ms	T_0 ms
20	100	60,0	330,0	550,0	2 200,0	3 140,0
	600	51,7	55,0	91,7	366,7	565,1
	1 200	50,8	27,5	45,8	183,3	307,4
	9 600	50,1	3,4	5,7	22,9	82,1
	19 200	50,0	1,7	2,9	11,4	66,0
	64 000	50,0	0,5	0,9	3,4	54,8
240	100	60,0	330,0	550,0	26 400,0	27 340,0
	600	51,7	55,0	91,7	4 400,0	4 598,4
	1200	50,8	27,5	45,8	2 200,0	2324,1
	9 600	50,1	3,4	5,7	275,0	334,2
	19 200	50,0	1,7	2,9	137,5	192,1
	64 000	50,0	0,5	0,9	41,3	92,7

6.2.3 The use of the different resets

IEC 60870-5-2 defines the services FC0 reset of remote link and FC1 reset of user process. Additionally, IEC 60870-5-5 and this standard define the remote initialization procedure which uses the reset process command C_RP_NA_1 type identification number <105>.

The use of the different resets is specified in Table 7.

Table 7 – Effects of the different resets

Controlling station layer 7 and user	Primary link	Secondary link	Controlled station layer 7 and user
	Reset of remote link (FC0)	Secondary link reset	–
	Reset of user process (FC1)	Reset	Reset
Reset process command	–	–	Reset

Reset of remote link is used when the secondary link is reset independently from the layers above the link. In this case, the frame count bit of the control field is always set to zero. A pending secondary link layer message is deleted.

Reset of user process as a link function is used if the link layer is still working but the process functions of the controlled station are not available. In this case, a reset of the user process via a link service might put the user process into operation. This service can only be used if the link layer is able to reset the user process via a separate signal.

The use of the **reset process command** is defined in detail in 6.1.4 and 6.1.7 of IEC 60870-5-5.

7 Application layer and user process

The following international standards apply:

IEC 60870-5-3

IEC 60870-5-4

IEC 60870-5-5

7.1 Selections from IEC 60870-5-3: General structure of application data

IEC 60870-5-3 describes the Basic Application Data Units in transmission frames of telecontrol systems. This Subclause selects specific field elements out of that standard and defines APPLICATION SERVICE DATA UNITS (ASDUs) used in this telecontrol companion standard.

A LINK PROTOCOL DATA UNIT (LPDU) of this companion standard contains no more than one APPLICATION SERVICE DATA UNIT (ASDU).

The APPLICATION SERVICE DATA UNIT (ASDU, see Figure 10) is composed of a DATA UNIT IDENTIFIER and one or more INFORMATION OBJECTS.

The DATA UNIT IDENTIFIER has always the same structure for all ASDUs. The INFORMATION OBJECTS of an ASDU are always of the same structure and type, which are defined in the TYPE IDENTIFICATION field. Each ASDU always contains a single type identification and a single cause of transmission.

The structure of the DATA UNIT IDENTIFIER is:

– one octet TYPE IDENTIFICATION
– one octet VARIABLE STRUCTURE QUALIFIER
– one or two octets CAUSE OF TRANSMISSION
– one or two octets COMMON ADDRESS OF ASDUs

The size of the COMMON ADDRESS OF ASDUs is determined by a fixed system (network-specific) parameter, in this case one or two octets. The COMMON ADDRESS is the station address, which may be structured to permit the addressing of the whole station or just a particular station sector.

There is no data field LENGTH OF ASDU. Each frame has only a single ASDU available. The LENGTH OF ASDU is determined by the frame length (as announced in the link protocol length field) minus a fixed integer specified by a system parameter (which is 1 in case of no link address, 2 when there is one octet link address or 3 when the link address of two octets are defined).

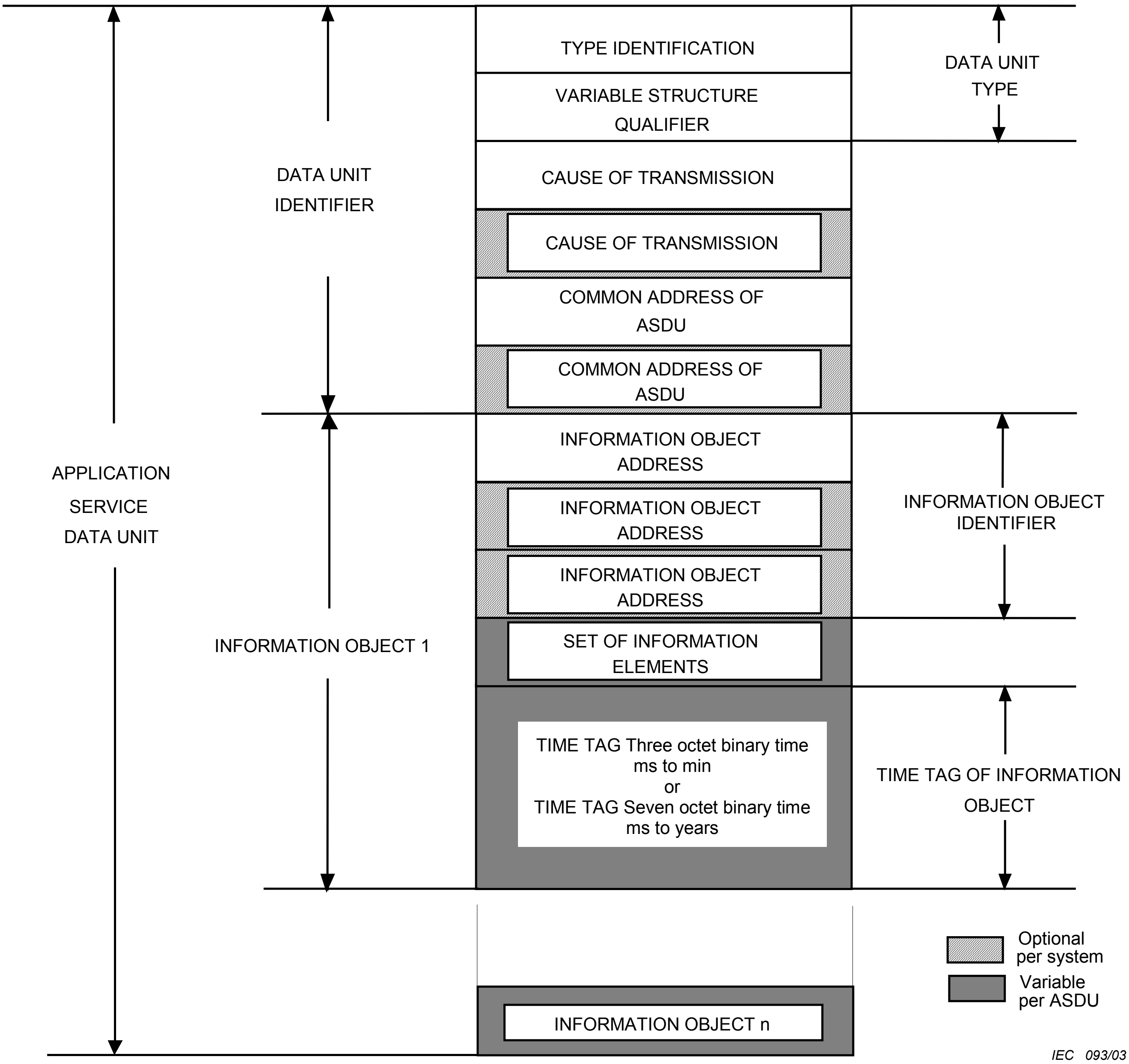
TIME TAGS (if present) always belong to an individual INFORMATION OBJECT.

The INFORMATION OBJECT consists of an INFORMATION OBJECT IDENTIFIER, a SET OF INFORMATION ELEMENTS and, if present, a TIME TAG OF INFORMATION OBJECT.

The INFORMATION OBJECT IDENTIFIER consists only of the INFORMATION OBJECT ADDRESS. In most cases, the COMMON ADDRESS OF ASDUs together with the INFORMATION OBJECT ADDRESS distinguishes the complete SET OF INFORMATION ELEMENTS within a specific system. The combination of both addresses shall be unambiguous per system. The TYPE IDENTIFICATION is not a part of a COMMON ADDRESS or an INFORMATION OBJECT ADDRESS.

The SET OF INFORMATION ELEMENTS consists of an individual SINGLE INFORMATION ELEMENT/ COMBINATION OF INFORMATION ELEMENTS or a sequence of SINGLE INFORMATION ELEMENTS/ COMBINATIONS OF INFORMATION ELEMENTS.

NOTE The TYPE IDENTIFICATION defines the structure, the type and the format of the INFORMATION OBJECT. All INFORMATION OBJECTS of a specific ASDU are of the same structure, type and format.



DATA UNIT IDENTIFIER	:=	CP16+8a+8b{TYPE IDENTIFICATION,VARIABLE STRUCTURE QUALIFIER, CAUSE OF TRANSMISSION,COMMON ADDRESS}
Fixed system parameter a	:=	number of octets of COMMON ADDRESS (1 or 2)
Fixed system parameter b	:=	number of octets of CAUSE OF TRANSMISSION (1 or 2)
INFORMATION OBJECT	:=	CP8c+8d+8t{INFORMATION OBJECT ADDRESS,SET OF INFORMATION ELEMENTS,TIME TAG(opt)}
Fixed system parameter c	:=	number of octets of INFORMATION OBJECT ADDRESS (1, 2 or 3)
Variable parameter *d*	:=	number of octets of SET OF INFORMATION ELEMENTS
Variable parameter *t*	:=	3 or 7 if TIME TAG is present, 0 if TIME TAG is not present

Figure 10 – Structure of an Application Service Data Unit ASDU

7.2 Selections from IEC 60870-5-4: Definition and coding of application information elements

The sizes and the contents of individual information fields of ASDUs are specified according to the declaration rules for information elements defined in IEC 60870-5-4.

7.2.1 Type identification

Octet 1, TYPE IDENTIFICATION defines structure, type and format of the following INFORMATION OBJECT(s).

TYPE IDENTIFICATION is defined as:

TYPE IDENTIFICATION := UI8[1..8]<1..255>

Bit	8	7	6	5	4	3	2	1	
	2^7							2^0	TYPE IDENTIFICATION

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Figure 11 – Type identification

INFORMATION OBJECTS with or without TIME TAGs are distinguished with different numbers of the TYPE IDENTIFICATION.

ASDUs with undefined values of TYPE IDENTIFICATION are discarded by controlling stations.

7.2.1.1 Definition of the semantics of the values of the TYPE IDENTIFICATION field

The value <0> is not used. The range of values (numbers) 1 to 127 is defined in this companion standard. The range of numbers 128 to 255 is not defined. TYPE IDENTIFICATION numbers 136 to 255 may be defined independently of each other by users of this standard. However, full interoperability would then be obtained only when using ASDUs having TYPE IDENTIFICATION numbers in the range 1 to 127.

The following Tables show the definition of TYPE IDENTIFICATION numbers for process and system information in monitor and control direction. In standard operations, there is a vertical flow of information between stations in a network. Commands are sent down from the central controlling station to one of several controlled stations and events/measurements are sent up from a controlled station to the central controlling station.

In some installations, there may be an additional need for information to flow laterally between stations of equal rank. This may be done using a dual-mode option so that both commands and event/measurements may be sent in both directions. A common link layer may support both standard direction operation and reverse direction operation. Individual application functions and ASDUs may be chosen for standard direction use, reverse direction use or for both uses as required.

A dual-mode station may be run on top of either a balanced or an unbalanced link layer. When an unbalanced link is used to connect to a dual-mode station, the role of the primary link layer must be established during system design and does not change during communications. In the case of an unbalanced link, the command ASDUs in reverse direction are requested by the unbalanced link layer request/respond service.

A dual-mode station must set the Common Address of ASDU in each transmitted message corresponding to the station currently acting as a controlled station. The receiving station may use the Common Address of ASDU to determine if the message should be interpreted as a request or a response.

Type identification 7, 8, 33 and 51 (bitstring of 32 bits in monitor and command direction) shall only be used when no other appropriate data types are defined. These types must not include data that appear in single- or double-point information (whether packed or unpacked).

TYPE IDENTIFICATION := UI8[1..8]<1..255>

<1..127>	:=	for standard definitions of this companion standard (compatible range)
<128..135>	:=	reserved for routing of messages (private range)
<136..255>	:=	for special use (private range) [2]

Table 8 – Semantics of TYPE IDENTIFICATION –
Process information in monitor direction

TYPE IDENTIFICATION := UI8[1..8]<0..44>

<0>	:=	not defined	
<1>	:=	single-point information	M_SP_NA_1
<2>	:=	single-point information with time tag	M_SP_TA_1
<3>	:=	double-point information	M_DP_NA_1
<4>	:=	double-point information with time tag	M_DP_TA_1
<5>	:=	step position information	M_ST_NA_1
<6>	:=	step position information with time tag	M_ST_TA_1
<7>	:=	bitstring of 32 bit	M_BO_NA_1
<8>	:=	bitstring of 32 bit with time tag	M_BO_TA_1
<9>	:=	measured value, normalized value	M_ME_NA_1
<10>	:=	measured value, normalized value with time tag	M_ME_TA_1
<11>	:=	measured value, scaled value	M_ME_NB_1
<12>	:=	measured value, scaled value with time tag	M_ME_TB_1
<13>	:=	measured value, short floating point number	M_ME_NC_1
<14>	:=	measured value, short floating point number with time tag	M_ME_TC_1
<15>	:=	integrated totals	M_IT_NA_1
<16>	:=	integrated totals with time tag	M_IT_TA_1
<17>	:=	event of protection equipment with time tag	M_EP_TA_1
<18>	:=	packed start events of protection equipment with time tag	M_EP_TB_1
<19>	:=	packed output circuit information of protection equipment with time tag	M_EP_TC_1
<20>	:=	packed single-point information with status change detection	M_PS_NA_1
<21>	:=	measured value, normalized value without quality descriptor	M_ME_ND_1
<22..29>	:=	reserved for further compatible definitions	
<30>	:=	single-point information with time tag CP56Time2a	M_SP_TB_1
<31>	:=	double-point information with time tag CP56Time2a	M_DP_TB_1
<32>	:=	step position information with time tag CP56Time2a	M_ST_TB_1
<33>	:=	bitstring of 32 bits with time tag CP56Time2a	M_BO_TB_1
<34>	:=	measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
<35>	:=	measured value, scaled value with time tag CP56Time2a	M_ME_TE_1

[2] It is recommended that the data unit identifier fields of private ASDUs have the same format as standard ASDUs.

<36>	:= measured value, short floating point number with time tag CP56Time2a	M_ME_TF_1
<37>	:= integrated totals with time tag CP56Time2a	M_IT_TB_1
<38>	:= event of protection equipment with time tag CP56Time2a	M_EP_TD_1
<39>	:= packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
<40>	:= packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

<41..44> := reserved for further compatible definitions

Table 9 – Semantics of TYPE IDENTIFICATION – Process information in control direction

TYPE IDENTIFICATION := UI8[1..8]<45..69>

CON	<45>	:= single command	C_SC_NA_1
CON	<46>	:= double command	C_DC_NA_1
CON	<47>	:= regulating step command	C_RC_NA_1
CON	<48>	:= set point command, normalized value	C_SE_NA_1
CON	<49>	:= set point command, scaled value	C_SE_NB_1
CON	<50>	:= set point command, short floating point number	C_SE_NC_1
CON	<51>	:= bitstring of 32 bits	C_BO_NA_1

<52..69> := reserved for further compatible definitions

NOTE ASDUs marked (**CON)** in control direction are confirmed application services and may be mirrored in monitor direction with different causes of transmission. These mirrored ASDUs are used for positive/negative acknowledgements (verifications). The causes of transmission are defined in 7.2.3.

Table 10 – Semantics of TYPE IDENTIFICATION – System information in monitor direction

TYPE IDENTIFICATION		:= UI8[1..8]<70..99>	
	<70>	:= end of initialization	M_EI_NA_1
	<71..99>	:= reserved for further compatible definitions	

Table 11 – Semantics of TYPE IDENTIFICATION – System information in control direction

TYPE IDENTIFICATION		:= UI8[1..8]<100..109>	
CON	<100>	:= interrogation command	C_IC_NA_1
CON	<101>	:= counter interrogation command	C_CI_NA_1
CON	<102>	:= read command	C_RD_NA_1
CON	<103>	:= clock synchronization command	C_CS_NA_1
CON	<104>	:= test command	C_TS_NA_1
CON	<105>	:= reset process command	C_RP_NA_1
CON	<106>	:= delay acquisition command	C_CD_NA_1
	<107..109>	:= reserved for further compatible definitions	

Table 12 – Semantics of TYPE IDENTIFICATION – Parameter in control direction

TYPE IDENTIFICATION		:= UI8[1..8]<110..119>	
CON	<110>	:= parameter of measured value, normalized value	P_ME_NA_1
CON	<111>	:= parameter of measured value, scaled value	P_ME_NB_1
CON	<112>	:= parameter of measured value, short floating point number	P_ME_NC_1
CON	<113>	:= parameter activation	P_AC_NA_1
	<114..119>	:= reserved for further compatible definitions	

Table 13 – Semantics of TYPE IDENTIFICATION – File transfer

TYPE IDENTIFICATION	:= UI8[1..8]<120..127>	
<120>	:= file ready	F_FR_NA_1
<121>	:= section ready	F_SR_NA_1
<122>	:= call directory, select file, call file, call section	F_SC_NA_1
<123>	:= last section, last segment	F_LS_NA_1
<124>	:= ack file, ack section	F_AF_NA_1
<125>	:= segment	F_SG_NA_1
<126>	:= directory	F_DR_TA_1
<127>	:= reserved for further compatible definitions	

NOTE ASDUs marked (**CON**) in control direction are confirmed application services and may be mirrored in monitor direction with different causes of transmission. These mirrored ASDUs are used for positive/negative acknowledgements (verifications). The causes of transmission are defined in 7.2.3.

7.2.2 Variable structure qualifier

Octet 2 of the DATA UNIT IDENTIFIER of the ASDU defines the VARIABLE STRUCTURE QUALIFIER which is specified in the following.

Bit	8	7	6	5	4	3	2	1	
	SQ	2^6			Number			2^0	VARIABLE STRUCTURE QUALIFIER

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Figure 12 – VARIABLE STRUCTURE QUALIFIER

7.2.2.1 Definition of the semantics of the values of the VARIABLE STRUCTURE QUALIFIER field

VARIABLE STRUCTURE QUALIFIER := CP8{number, SQ}

number=N	:=	UI7[1..7]<0..127>
<0>	:=	ASDU contains no INFORMATION OBJECT
<1..127>	:=	number of INFORMATION OBJECTs or ELEMENTs (single elements or equal combinations of elements)
SQ=Single/sequence	:=	BS1[8] <0..1>
<0>	:=	addressing of individual SINGLE INFORMATION ELEMENTs or COMBINATION OF INFORMATION ELEMENTs in a number of INFORMATION OBJECTs of the same type
<1>	:=	addressing of a sequence of SINGLE INFORMATION ELEMENTS or equal COMBINATIONS OF INFORMATION ELEMENTs of a single object per ASDU
SQ<0>and N<0..127>	:=	number of INFORMATION OBJECTs i
SQ<1>and N<0..127>	:=	number of SINGLE INFORMATION ELEMENTs or COMBINATIONs OF INFORMATION ELEMENTs j

The SQ bit specifies the method of addressing the following INFORMATION OBJECTs or SINGLE INFORMATION ELEMENTs/COMBINATION OF INFORMATION ELEMENTs.

SQ = 0: Each SINGLE INFORMATION ELEMENT or a COMBINATION OF INFORMATION ELEMENTS is addressed by the INFORMATION OBJECT ADDRESS. The ASDU may consist of one or more than one equal INFORMATION OBJECTS. The number N is binary coded and defines the number of the INFORMATION OBJECTS.

SQ = 1: A sequence of SINGLE INFORMATION ELEMENTS or equal COMBINATIONS OF INFORMATION ELEMENTS (for example measured values of identical format) is addressed (see 5.1.5 of IEC 60870-5-3) by the INFORMATION OBJECT ADDRESS. The INFORMATION OBJECT ADDRESS specifies the associated address of the first SINGLE INFORMATION ELEMENT/COMBINATION OF INFORMATION ELEMENTS of the sequence. The following SINGLE INFORMATION ELEMENTS/COMBINATIONS OF INFORMATION ELEMENTS are identified by numbers incrementing continuously by +1 from this offset. The number N is binary coded and defines the number of the SINGLE INFORMATION ELEMENTS/COMBINATIONS OF INFORMATION ELEMENTS. In case of a sequence of SINGLE INFORMATION ELEMENTS/COMBINATIONS OF INFORMATION ELEMENTS only one INFORMATION OBJECT per ASDU is allocated.

7.2.2.2 Requirements for the transmission of information objects in chronological order

For information objects to be correctly transmitted in chronological order while preserving priority classes specified by the controlled station's priority control manager, the following specifications are valid.

Monitored information objects may be transmitted with the following causes of transmission:

- cyclic/periodic,
- background scan,
- spontaneous,
- requested,
- return information caused by a remote command,
- return information caused by a local command,
- interrogated by station and group interrogation,
- interrogated by general and counter request.

The transmission of successive values of a particular INFORMATION OBJECT must always be in the chronological order in which the values were measured.

NOTE To ensure that the transmission of successive values of an INFORMATION OBJECT is always in the correct chronological order, it may be necessary to ensure that all the values of the INFORMATION OBJECT use a single priority buffer, or that there is coordination between values of the INFORMATION OBJECT that may be placed in different priority buffers.

For the transmission of INFORMATION OBJECTS buffered in priority buffers, the conditions shown in Figure 13 are valid.

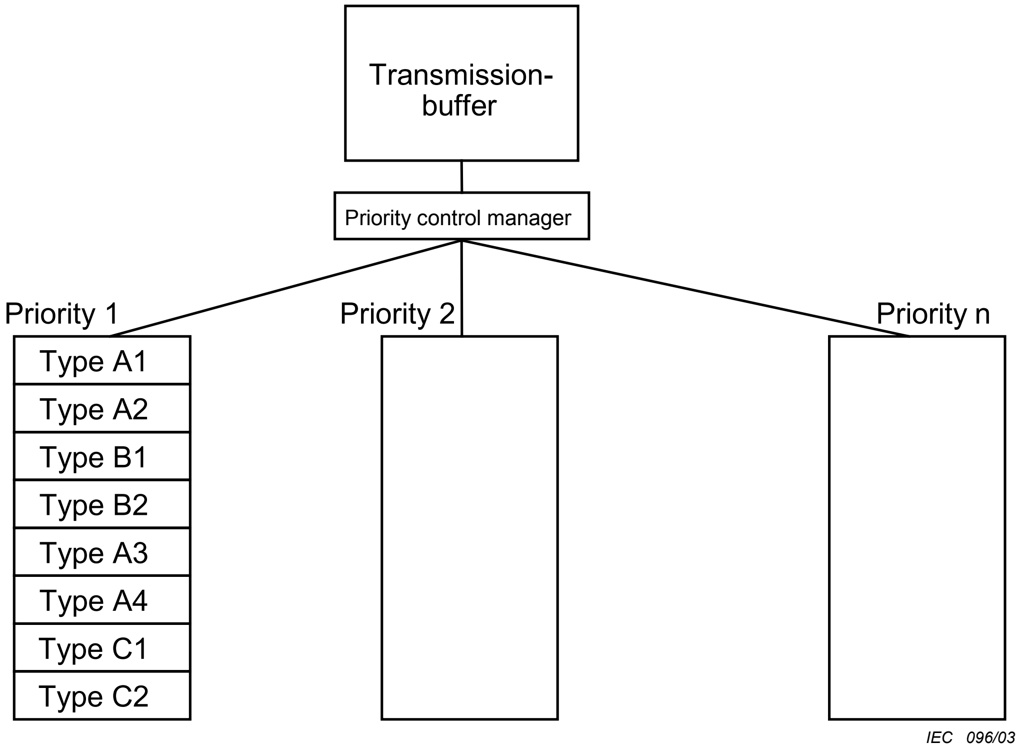

Figure 13 – Presentation of types of information objects in priority buffers

To transmit correct chronological sets of information objects from a priority buffer, the following procedure should be implemented. In the example in Figure 13, the information objects having type identifications A, B and C are shown in a randomly buffered order in the priority buffer 1. For the transmission of the information objects from this buffer, the first two objects of type identification A, namely A1 and A2, are packed in one ASDU. The objects B1 and B2 are packed in a second ASDU, then the objects A3 and A4 follow in a third ASDU, etc. In general, the priority buffer is examined closely for objects having a particular type identification and cause of transmission that are buffered in a chronologically correct order without any intermediate objects having a different identification. Only these homogeneous groups of objects are transmitted together in one ASDU. When an object having a different type identification is encountered in the buffer, that object is transmitted in the next following ASDU, which may consist again of packed objects having the same type identification. The packed objects transmitted in one ASDU always have the same transmission priority class.

The maximum length of the transmission frame is a fixed parameter. Since the lengths of objects of different type identification are not all the same, the maximum number of objects of a given type that may be sent in an ASDU may vary from one type to another. The ASDUs are automatically filled with the objects up to the maximum length specified, if there is a sufficient number of sequential buffered objects with the same type identification and cause of transmission available in one priority buffer.

It is not permissible to delay the transmission of an ASDU while waiting for further buffered objects which could be used to fill that ASDU to the maximum possible length.

Best efficiency can be achieved by defining objects with only a single type identification in each priority buffer. This is normally performed by configuration parameters.

This Subclause refers to the spontaneous transmission of events and does not specify the construction of sequences of information elements which are used in ASDUs with unstructured information object addresses, such as responses to a station interrogation. However, the requirement that all values reported for a particular information object are in correct chronological order must be observed.

When implementing the priority buffers and priority control manager defined in this Subclause, it is necessary to ensure that an information object without a time tag is not transmitted to the controlling station before all versions of the same object, generated before the present version, have been transmitted.

Care must be taken for a number of reasons including

a) the time taken to generate an object for different causes of transmission (for example, as a sample for a background scan or an event for spontaneous transmission) may not be exactly the same. Thus, two versions of the same object may not be entered into the priority buffers in the correct chronological order, when their times of generation are very close together;

b) the streams of objects in different priority buffers are unlikely to progress through the buffers at the same speed. This means that objects entered into the buffers in the correct chronological order may not be presented to the priority control manager still in that correct order;

c) objects waiting in the transmission buffer may not be transmitted in the same order as they were entered, when unbalanced mode link procedures are being used. This is because the controlled station has no control over the order in which requests for class 1 and requests for class 2 data are received.

The method used to maintain the correct chronological order in any implementation is a local matter (internal to the particular controlled station) and is not defined in this standard.

NOTE When using structured information object addresses, the ASDUs that are defined for sequences of information elements in a single information object might not be completed to optimal lengths due to possible gaps in the address numbering. Typically this reduces the packing efficiency for station interrogation procedures.

7.2.2.3 Buffer overflow

A controlled station may assign a single-point information object to indicate a buffer overflow status (status = <1> overflow, status = <0> no overflow). The action being taken by the controlling station after a buffer overflow is implementation specific.

7.2.3 Cause of transmission

Octet 3 of the DATA UNIT IDENTIFIER of the ASDU defines the CAUSE OF TRANSMISSION field which is specified in the following.

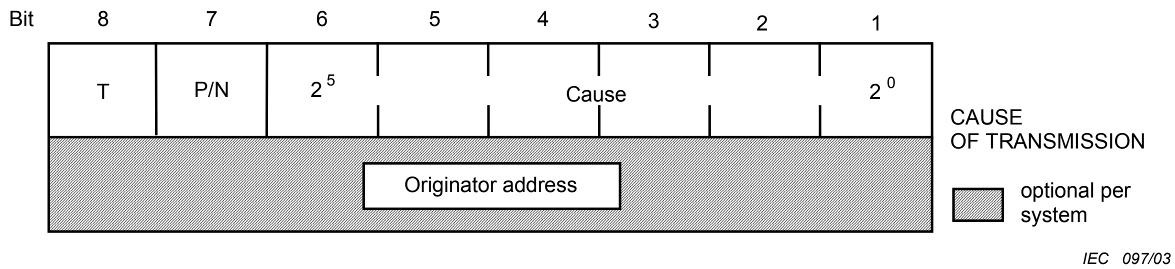

Figure 14 – CAUSE OF TRANSMISSION field

Definition of the semantics of the values of the CAUSE OF TRANSMISSION field

CAUSE OF TRANSMISSION	:=	CP16{Cause,P/N,T,Originator Address (opt)}
Cause	:=	UI6[1..6]<0..63>
<0>	:=	not defined
<1..63>	:=	number of cause
<1..47>	:=	for standard definitions of this companion standard (compatible range) see Table 14
<48..63>	:=	for special use (private range)

P/N	:=	BS1[7] <0..1>
<0>	:=	positive confirm
<1>	:=	negative confirm
T=test	:=	BS1[8] <0..1>
<0>	:=	no test
<1>	:=	test
Originator address	:=	UI8[9..16]<0..255>
<0>	:=	default
<1..255>	:=	number of originator address

ASDUs with undefined values of CAUSE OF TRANSMISSION for a given type identification are discarded by controlling stations.

The CAUSE OF TRANSMISSION directs the ASDU to a specific application task (program) for processing.

The P/N-bit indicates the positive or negative confirmation of activation requested by the primary application function. In the case of irrelevance, the P/N-bit is zero.

In addition to the cause, the test-bit defines ASDUs which were generated during test conditions. It is used for example to test transmission and equipment without controlling the process.

ASDUs marked (**CON)** in control direction are confirmed application services and may be mirrored in monitor direction with different CAUSES OF TRANSMISSION (see Tables 9, 11 and 12). The originator address directs these mirrored ASDUs and interrogated ASDUs in monitor direction (for example interrogated by general interrogation) to the source that activated the procedure.

If the originator address is not used and there is more than a single source in a system defined, the ASDUs in the monitor direction have to be directed to all relevant sources of the system. In this case, the specific affected source has to select its specific ASDUs.

If the originator address is used, the following definitions are valid:

<0> = default

<0> is used to define process information as return information, events, etc. that are stored in network images and which have to be transmitted to all parts of a distributed system.

<1..255>

This range may be used to address the specific part of the system to which the corresponding information in the monitor direction is returned.

Within a system, parts of the system can be information sources which may initiate station interrogations, requests for integrated totals, commands, etc. The returned information is only of importance for the source which initiated the request or the command. In these systems, the information source should set the originator address of the ASDUs in the command direction, and the controlled station should echo this originator address in the response in the monitor direction.

EXAMPLE 1

The station interrogation initiated by a specific source (controlling station A in Figure 15) returns interrogated information in monitor direction which are exclusively directed to the particular source and not to other parts of the system (for example, controlling station B in Figure 15). The ASDUs which are used for this station interrogation are marked with a specific originator address (of range <1..255>) which is used to route the interrogated information in monitor direction (for example, via a concentrator station in Figure 15) to the initiating source.

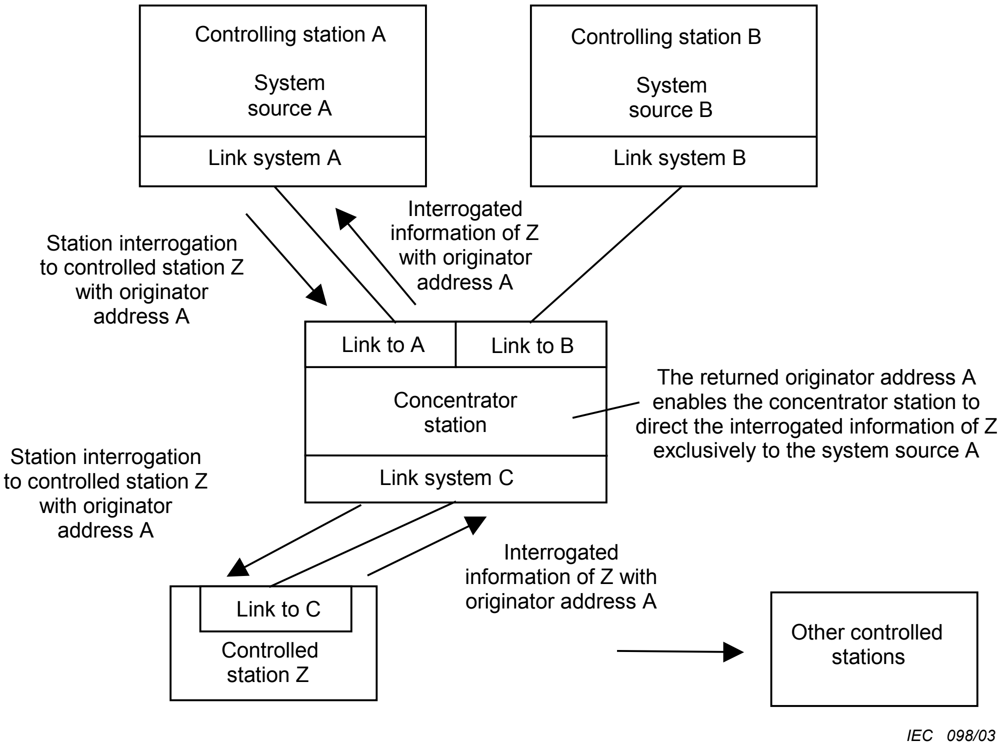

Figure 15 – Station interrogation via a concentrator station using the originator address

EXAMPLE 2

The command initiated by a specific source (cause of transmission = act, controlling station A in Figure 16) initiates acknowledges which are returned (cause of transmission = actcon, actterm) that are only of importance for the source which initiated the command. Therefore, the actcon and actterm should be routed (for example, via a concentrator station in Figure 16) via the originator address to this specific point only. However, the corresponding return information (cause of transmission 11 or 12) represents process information which is memorized and controlled in different network images of the whole system (controlling stations A and B in Figure 16) and which has to carry the originator address = 0 to be distributed to all parts of the equipment where it is needed.

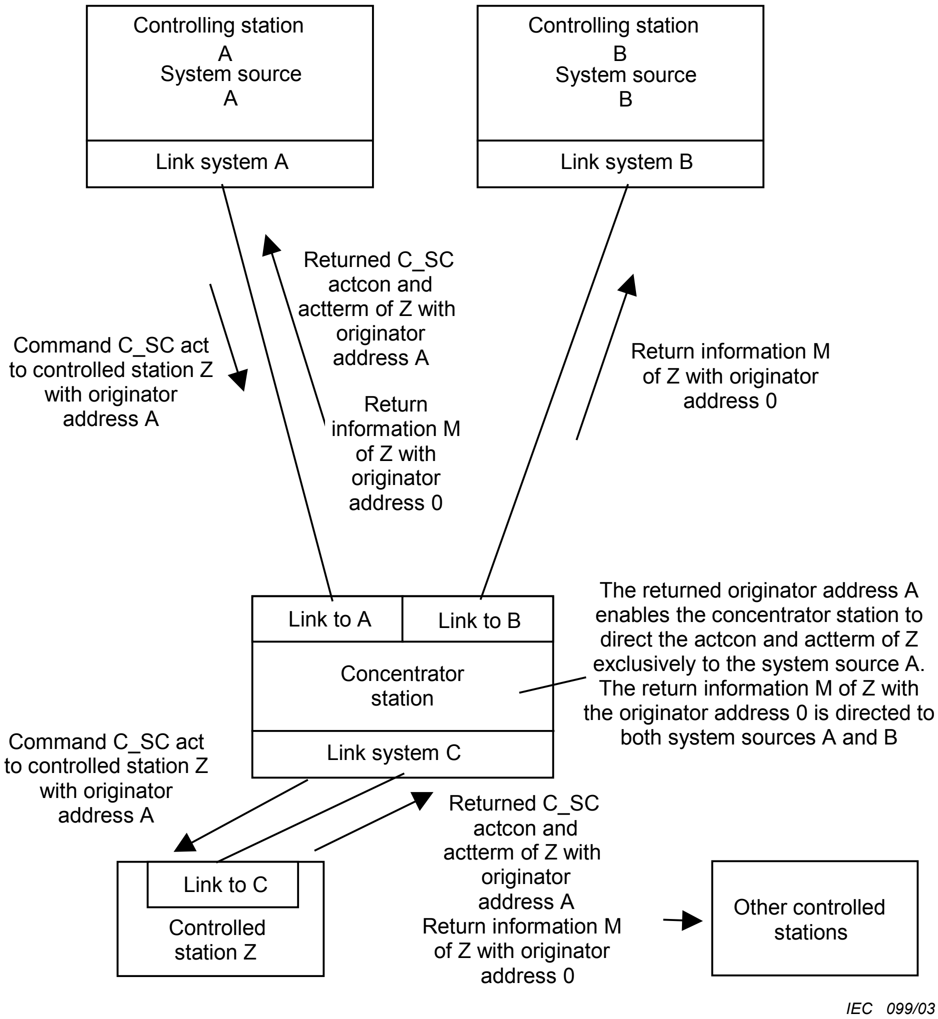

Figure 16 – Command transmission via a concentrator station using the originator address

Table 14 – Semantics of CAUSE OF TRANSMISSION

Cause	:=	UI6[1..6]<0..63>	
<0>	:=	not used	
<1>	:=	periodic, cyclic	per/cyc
<2>	:=	background scan[3]	back
<3>	:=	spontaneous	spont
<4>	:=	initialized	init
<5>	:=	request or requested	req
<6>	:=	activation	act
<7>	:=	activation confirmation	actcon
<8>	:=	deactivation	deact
<9>	:=	deactivation confirmation	deactcon
<10>	:=	activation termination	actterm
<11>	:=	return information caused by a remote command	retrem
<12>	:=	return information caused by a local command	retloc
<13>	:=	file transfer	file
<14..19>	:=	reserved for further compatible definitions	
<20>	:=	interrogated by station interrogation	inrogen
<21>	:=	interrogated by group 1 interrogation	inro1
<22>	:=	interrogated by group 2 interrogation	inro2
<23>	:=	interrogated by group 3 interrogation	inro3
<24>	:=	interrogated by group 4 interrogation	inro4
<25>	:=	interrogated by group 5 interrogation	inro5
<26>	:=	interrogated by group 6 interrogation	inro6
<27>	:=	interrogated by group 7 interrogation	inro7
<28>	:=	interrogated by group 8 interrogation	inro8
<29>	:=	interrogated by group 9 interrogation	inro9
<30>	:=	interrogated by group 10 interrogation	inro10
<31>	:=	interrogated by group 11 interrogation	inro11
<32>	:=	interrogated by group 12 interrogation	inro12
<33>	:=	interrogated by group 13 interrogation	inro13
<34>	:=	interrogated by group 14 interrogation	inro14
<35>	:=	interrogated by group 15 interrogation	inro15
<36>	:=	interrogated by group 16 interrogation	inro16
<37>	:=	requested by general counter request	reqcogen
<38>	:=	requested by group 1 counter request	reqco1
<39>	:=	requested by group 2 counter request	reqco2
<40>	:=	requested by group 3 counter request	reqco3
<41>	:=	requested by group 4 counter request	reqco4
<42..43>	:=	reserved for further compatible definitions	
<44>	:=	unknown type identification	
<45>	:=	unknown cause of transmission	
<46>	:=	unknown common address of ASDU	
<47>	:=	unknown information object address	
<48..63>	:=	for special use (private range)	

3 Used in the monitor direction to synchronize the process information of the controlling and controlled stations on a low priority continuous basis.

ASDUs in the control direction with undefined values in the data unit identifier (except the variable structure qualifier) and the information object address are mirrored by the controlled station with bit “P/N := <1> negative confirm” and the following causes of transmission:

Unknown	Cause of transmission
type identification	44
cause of transmission	45
common address of ASDU	46
information object address	47

A controlling station may monitor for and maintain a communications error log reporting each time that the following ASDUs are received:

- ASDUs in the monitor direction with undefined values in the data unit identifier (except the variable structure qualifier);
- ASDUs in the monitor direction with undefined values of information object address;
- mirrored ASDUs due to unknown numbers in the control direction (type identifications 45 to 51).

Receipt of one of these ASDUs does not affect the processing of subsequent messages.

7.2.4 COMMON ADDRESS OF ASDUs

Octet 4 and optionally 5 of the DATA UNIT IDENTIFIER of the ASDU define the station address which is specified in the following. The length of the COMMON ADDRESS (one or two octets) is a parameter which is fixed per system.

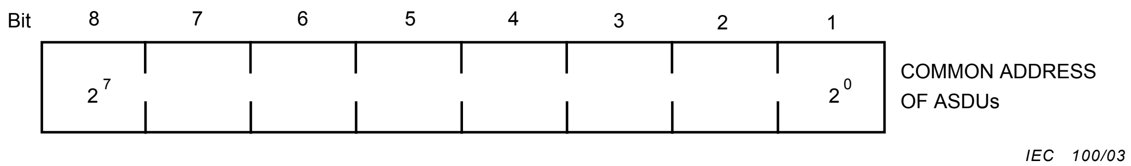

Figure 17 – COMMON ADDRESS of ASDUs (one octet)

COMMON ADDRESS := UI8[1..8]<0..255>

<0>	:=	not used
<1..254>	:=	station address
<255>	:=	global address

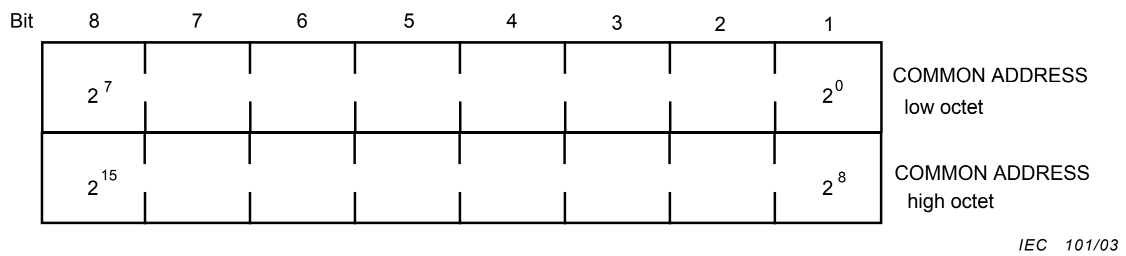

Figure 18 – COMMON ADDRESS of ASDUs (two octets)

COMMON ADDRESS := UI16[1..16]<0..65535>

<0>	:=	not used
<1..65534>	:=	station address
<65535>	:=	global address

ASDUs with undefined values of COMMON ADDRESS are discarded by controlling stations.

The COMMON ADDRESS is associated with all objects in an ASDU (see IEC 60870-5-3, Table 1). The global address is a broadcast address directed to all stations of a specific system. ASDUs with a broadcast address in the control direction have to be answered in the monitor direction by ASDUs that contain the specific defined COMMON ADDRESS (station address).

When using the common address FF or FFFF (broadcast address, request of all), ACTCON, ACTTERM and the interrogated information objects (if any) are returned with the specific common addresses of the controlled stations as they would be when caused by commands to specific controlled stations.

The use of the common address FF or FFFF is restricted to the following ASDUs in the control direction:

type Identification <100> :=	interrogation command	C_IC_NA_1
type Identification <101> :=	counter interrogation command	C_CI_NA_1
type Identification <103> :=	clock synchronization command	C_CS_NA_1
type Identification <105> :=	reset process command	C_RP_NA_1

The common address FF or FFFF may be used when the same application function in all stations of a specific system have to be initiated at the same time, for example, to synchronize the local clocks by a clock synchronization command or to freeze the integrated totals by a counter interrogation command.

7.2.5 INFORMATION OBJECT ADDRESS

Octet 1, optionally 2 and optionally 3 of the INFORMATION OBJECT are defined in the following. The length of the INFORMATION OBJECT ADDRESS (one, two or three octets) is a parameter which is fixed per system.

The INFORMATION OBJECT ADDRESS is used as a destination address in control direction and a source address in the monitor direction.

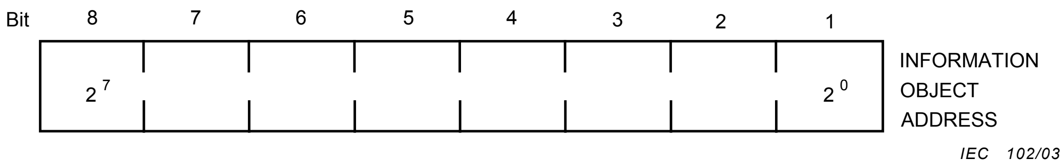

Figure 19 – INFORMATION OBJECT ADDRESS (one octet)

INFORMATION OBJECT ADDRESS := UI8[1..8]<0..255>

<0>	:=	INFORMATION OBJECT ADDRESS is irrelevant
<1..255>	:=	INFORMATION OBJECT ADDRESS

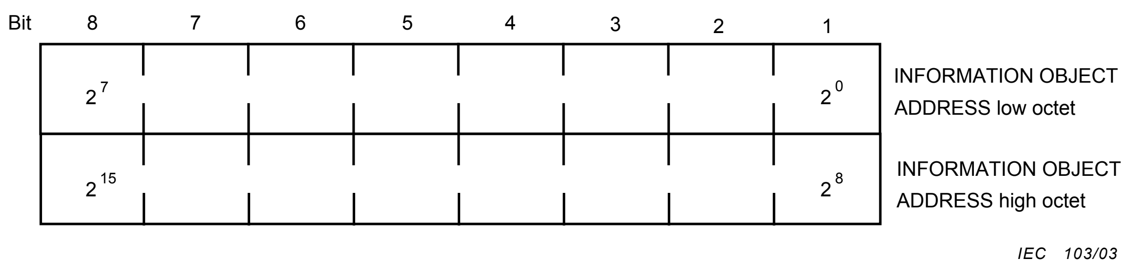

Figure 20 – INFORMATION OBJECT ADDRESS (two octets)

INFORMATION OBJECT ADDRESS := UI16[1..16]<0..65535>

<0>	:=	INFORMATION OBJECT ADDRESS is irrelevant
<1..65535>	:=	INFORMATION OBJECT ADDRESS

Bit	8	7	6	5	4	3	2	1	
	2^7							2^0	INFORMATION OBJECT ADDRESS low octet
	2^{15}							2^8	
	2^{23}							2^{16}	INFORMATION OBJECT ADDRESS high octet

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Figure 21 – INFORMATION OBJECT ADDRESS (three octets)

INFORMATION OBJECT ADDRESS := UI24[1..24]<0..16777215>

<0>	:=	INFORMATION OBJECT ADDRESS is irrelevant
<1..16777215>	:=	INFORMATION OBJECT ADDRESS

ASDUs with undefined values of INFORMATION OBJECT ADDRESS are discarded by controlling stations.

The third octet is only used in the case of structuring the INFORMATION OBJECT ADDRESS to define unambiguous addresses within a specific system. In all cases, the maximum number of different INFORMATION OBJECT ADDRESSes is limited with 65536 (as for two octets). If the INFORMATION OBJECT ADDRESS is not relevant (not used) in some ASDUs, it is set to zero.

An information object is a well-defined piece of information which requires a name (information object address) in order to identify its use in an instance of communication (see 3.31 of ISO/IEC 8824-1 and 3.3 of IEC 60870-5-3). As defined, the information objects carry information elements that identify single information points which are unambiguously addressed by the information object addresses. For example: an information object which transmits return information must have a different information object address to the information object which transmits the belonging command.

The read command C_RD_NA_1 is a general exception since its information object address serves to address available information objects which are returned in the monitor direction.

The information object address may be specified independently from the ASDU (type identification) which transmits the particular information object. Information objects may be transmitted with the same information object addresses using different ASDUs, for example, as a single-point information with or without time tag.

Table 15 – ASDUs in the monitor direction which may transmit objects with equal information object addresses

Type identification	Type identification with time tag	Alternative format type identification
1	2 or 30	20
3	4 or 31	17 or 38
5	6 or 32	
7	8 or 33	
9	10 or 34	21
11	12 or 35	
13	14 or 36	
15	16 or 37	

There are no other combinations of ASDUs of specific common addresses per line which may carry the same information object addresses in the monitor or (and) in the control direction. Specifically, commands (ASDU types 45 to 69) and parameters (ASDU types 110 to 119) cannot use the same information object address values as monitored data (ASDU types 1 to 44).

In the case of a single status change of an information point, the same information object with the same information object address may be transmitted twice, with and without a time tag. The information object without the time tag is normally transmitted with high priority to be available in the controlling station for process control purposes as soon as possible. The information object with the time tag may be transmitted with low priority to be used, for example for later verifications of series of events. All information objects which may be transmitted with cause of transmission 3 (spontaneous) are allowed to be transmitted twice. This mode is called “double transmission” and has to be defined by a fixed station-specific parameter.

For all ASDU types not indicated as supporting double transmission, a single status change will only cause the transmission of a single information object.

7.2.6 Information elements

The following information elements are used in the ASDUs defined in this standard. They are structured according to the definitions of IEC 60870-5-4.

7.2.6.1 Single-point information (IEV 371-02-07) with quality descriptor

SIQ		:=	CP8{SPI,RES,BL,SB,NT,IV}	
SPI		:=	BS1[1]<0..1>	(Type 6)
	<0>	:=	OFF	
	<1>	:=	ON	
RES = RESERVE		:=	BS3[2..4]<0>	(Type 6)
BL		:=	BS1[5]<0..1>	(Type 6)
	<0>	:=	not blocked	
	<1>	:=	blocked	
SB		:=	BS1[6]<0..1>	(Type 6)
	<0>	:=	not substituted	
	<1>	:=	substituted	
NT		:=	BS1[7]<0..1>	(Type 6)
	<0>	:=	topical	
	<1>	:=	not topical	
IV		:=	BS1[8]<0..1>	(Type 6)
	<0>	:=	valid	
	<1>	:=	invalid	

Definition of quality descriptor (BL,SB,NT,IV) see 7.2.6.3, quality descriptor QDS

7.2.6.2 Double-point information (IEV 371-02-08) with quality descriptor

DIQ		:=	CP8{DPI,RES,BL,SB,NT,IV}	
DPI		:=	UI2[1..2]<0..3>	(Type 1.1)
	<0>	:=	indeterminate or intermediate state	
	<1>	:=	determined state OFF	
	<2>	:=	determined state ON	
	<3>	:=	indeterminate state	
RES = RESERVE		:=	BS2[3..4]<0>	(Type 6)
BL		:=	BS1[5]<0..1>	(Type 6)
	<0>	:=	not blocked	
	<1>	:=	blocked	
SB		:=	BS1[6]<0..1>	(Type 6)
	<0>	:=	not substituted	
	<1>	:=	substituted	
NT		:=	BS1[7]<0..1>	(Type 6)
	<0>	:=	topical	
	<1>	:=	not topical	
IV		:=	BS1[8]<0..1>	(Type 6)
	<0>	:=	valid	
	<1>	:=	invalid	

Definition of quality descriptor (BL,SB,NT,IV) see 7.2.6.3, quality descriptor QDS

7.2.6.3 Quality descriptor (separate octet)

The quality descriptor consists of five defined quality bits which may be set independently from each other. The quality descriptor provides the controlling station with additional information on the quality of an information object.

QDS		:=	CP8{OV,RES,BL,SB,NT,IV}	
OV		:=	BS1[1]<0..1>	(Type 6)
	<0>	:=	no overflow	
	<1>	:=	overflow	
RES = RESERVE		:=	BS3[2..4]<0>	(Type 6)
BL		:=	BS1[5]<0..1>	(Type 6)
	<0>	:=	not blocked	
	<1>	:=	blocked	
SB		:=	BS1[6]<0..1>	(Type 6)
	<0>	:=	not substituted	
	<1>	:=	substituted	
NT		:=	BS1[7]<0..1>	(Type 6)
	<0>	:=	topical	
	<1>	:=	not topical	
IV		:=	BS1[8]<0..1>	(Type 6)
	<0>	:=	valid	
	<1>	:=	invalid	

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analog values).

BL = BLOCKED/NOT BLOCKED

The value of the INFORMATION OBJECT is blocked for transmission; the value remains in the state that was acquired before it was blocked. Blocking and deblocking may be initiated for example by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by the input of an operator (dispatcher) or by an automatic source.

NT = NOT TOPICAL/TOPICAL

A value is topical if the most recent update was successful. It is not topical if it was not updated successfully during a specified time interval or if it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognizes abnormal conditions of the information source (missing or non-operating updating devices) the value is then marked invalid. The value of the INFORMATION OBJECT is not defined under this condition. The mark INVALID is used to indicate to the destination that the value may be incorrect and cannot be used.

Intermediate devices may modify the quality descriptors BL, SB, NT and IV.

BL: if an intermediate device blocks the transmission of an information object, it shall assert the quality descriptor BL. Otherwise it shall report the quality descriptor BL as reported from the lower level device.

SB: if an intermediate device substitutes the value of an information object, it shall assert the quality descriptor SB. Otherwise it shall report the quality descriptor SB as reported from the lower level device.

NT: if an intermediate device cannot obtain the value of an information object, it shall assert the quality descriptor NT. Otherwise it shall report the quality descriptor NT as reported from the lower level device.

IV: if an intermediate device identifies that an information object is not valid, it shall assert the quality descriptor IV. Otherwise it shall report the quality descriptor IV as reported from the lower level device.

Example 1

Suppose that the monitored status of a circuit-breaker is blocked because the field interface is in test mode. In this case, the quality descriptor (BL = 1 “blocked”) will be transferred unchanged through all system levels from the field interface to the controlling station.

Example 2

A substituted value may be assigned automatically or manually to a measured value, for example when the data acquisition is disturbed. This substituted measured value is transmitted to the controlling station with the quality bit SB = 1 substituted.

If the value of an information object is automatically marked with a new quality descriptor due to specific conditions, the quality descriptor may be reset manually or automatically when the conditions change.

If a given information object is normally only reported spontaneously, every change of the quality descriptor initiates a spontaneous transmission. Information objects with a time tag are transmitted with the point of time at which the change of the quality descriptor occurred.

The station interrogation procedure interrogates all information objects which are defined for the specific interrogation group independently of the content of the quality descriptor. In this case, the quality descriptor contains the most recent state when the information object is interrogated. This guarantees that a completeness check may be performed in the controlling station.

7.2.6.4 Quality descriptor for events of protection equipment (separate octet)

QDP		:=	CP8{RES,EI,BL,SB,NT,IV}	
RES = RESERVE		:=	BS3[1..3]<0>	(Type 6)
EI		:=	BS1[4]<0..1>	(Type 6)
	<0>	:=	elapsed time valid	
	<1>	:=	elapsed time invalid	
BL		:=	BS1[5]<0..1>	(Type 6)
	<0>	:=	not blocked	
	<1>	:=	blocked	
SB		:=	BS1[6]<0..1>	(Type 6)
	<0>	:=	not substituted	
	<1>	:=	substituted	
NT		:=	BS1[7]<0..1>	(Type 6)
	<0>	:=	topical	
	<1>	:=	not topical	
IV		:=	BS1[8]<0..1>	(Type 6)
	<0>	:=	valid	
	<1>	:=	invalid	

EI = ELAPSED TIME INVALID

Elapsed time is valid if it was correctly acquired. If the acquisition function recognizes abnormal conditions, the elapsed time is marked invalid. The elapsed time of the INFORMATION OBJECT is not defined under this condition. The mark INVALID is used to indicate to the destination that the elapsed time may be incorrect and cannot be used.

For the definition of the quality descriptor (BL,SB,NT,IV) see 7.2.6.3, quality descriptor QDS.

7.2.6.5 Value with transient state indication

Can be used for step position of transformers or other step position information

VTI		:=	CP8{Value,Transient}	
Value		:=	I7[1..7]<–64..+63>	(Type 2.1)
Transient		:=	BS1[8]<0..1>	(Type 6)
	<0>	:=	equipment is not in transient state	
	<1>	:=	equipment is in transient state	

7.2.6.6 Normalized value

NVA	:=	F16[1..16]<–1..+1 -2^{-15}>	(Type 4.1)

The resolution of measured values is not defined. If the resolution of the measured value is coarser than the unit of the LSB, then the least significant bits are set to zero.

7.2.6.7 Scaled value

SVA := I16[1..16]<-2^{15}..$+2^{15}-1$> (Type 2.1)

The resolution of measured values is not defined. If the resolution of the measured value is coarser than the unit of the LSB, then the least significant bits are set to zero.

This INFORMATION ELEMENT is defined for the transmission of technological values such as current, voltage, power in their physical units (for example A, kV, MW). Range and position of decimal point are fixed parameters.

EXAMPLES

Current: 103 A; transmitted value 103

Voltage: 10,3 kV; transmitted value 103, decimal point 10^{-1}

7.2.6.8 Short floating point number

R32-IEEE STD 754 := R32.23{Fraction,Exponent,Sign} (Type 5)

The resolution of measured values is not defined. If the resolution of the measured value is coarser than the unit of the LSB, then the least significant bits are set to zero.

7.2.6.9 Binary counter reading

BCR		:=	CP40{Counter reading, Sequence notation}	
Counter reading		:=	I32[1..32]<-2^{31}..$+2^{31}-1$>	(Type 2.1)
Sequence notation		:=	CP8{SQ,CY,CA,IV}	
SQ		:=	UI5[33..37]<0..31>	(Type 1.1)
CY		:=	BS1[38]<0..1>	(Type 6)
	<0>	:=	no counter overflow occurred in the corresponding integration period	
	<1>	:=	counter overflow occurred in the corresponding integration period	
CA		:=	BS1[39]<0..1>	(Type 6)
	<0>	:=	counter was not adjusted since last reading	
	<1>	:=	counter was adjusted since last reading	
IV		:=	BS1[40]<0..1>	(Type 6)
	<0>	:=	counter reading is valid	
	<1>	:=	counter reading is invalid	

SQ = sequence number

CY = carry
(Counter overflow occurs when the value increments from $+2^{31}-1$ to zero or from -2^{31} to zero)

CA = counter was adjusted
(The counter is considered to have been adjusted if a counter is initialized to some value, for example set to zero or another value at startup).

IV = invalid

Note that CA, CY and IV are only modified when the value is determined. This may be in response to a counter interrogation command or in response to an automatic internal function that performs the counter freeze or freeze and reset command.

7.2.6.10 Single event of protection equipment

SEP		:= CP8{ES,RES,EI,BL,SB,NT,IV}	
ES=Event State		:= UI2[1..2]<0..3>	(Type 1.1)
	<0>	:= indeterminate state	
	<1>	:= OFF	
	<2>	:= ON	
	<3>	:= indeterminate state	
RES = RESERVE		:= BS1[3]<0>	(Type 6)
EI		:= BS1[4]<0..1>	
	<0>	:= elapsed time valid	
	<1>	:= elapsed time invalid	
BL		:= BS1[5]<0..1>	(Type 6)
	<0>	:= not blocked	
	<1>	:= blocked	
SB		:= BS1[6]<0..1>	(Type 6)
	<0>	:= not substituted	
	<1>	:= substituted	
NT		:= BS1[7]<0..1>	(Type 6)
	<0>	:= topical	
	<1>	:= not topical	
IV		:= BS1[8]<0..1>	(Type 6)
	<0>	:= event valid	
	<1>	:= event invalid	

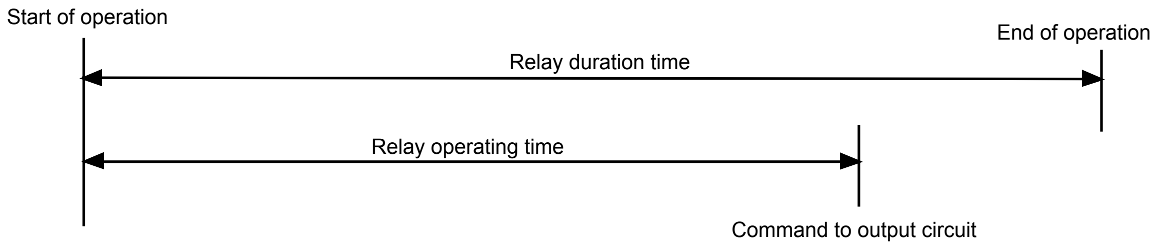
Definition of quality descriptor (EI,BL,SB,NT,IV) see 7.2.6.4 quality descriptor for events of protection equipment QDP.

7.2.6.11 Start events of protection equipment

SPE		:= BS8{GS,SL1,SL2,SL3,SIE,SRD,RES}	
GS = general start of operation		:= BS1[1]<0..1>	(Type 6)
	<0>	:= no general start of operation	
	<1>	:= general start of operation	
SL1 = start of operation phase L1		:= BS1[2]<0..1>	(Type 6)
	<0>	:= no start of operation L1	
	<1>	:= start of operation L1	
SL2 = start of operation phase L2		:= BS1[3]<0..1>	(Type 6)
	<0>	:= no start of operation L2	
	<1>	:= start of operation L2	
SL3 = start of operation phase L3		:= BS1[4]<0..1>	(Type 6)
	<0>	:= no start of operation L3	
	<1>	:= start of operation L3	
SIE = start of operation IE (earth current)		:= BS1[5]<0..1>	(Type 6)
	<0>	:= no start of operation IE	
	<1>	:= start of operation IE	
SRD = start of operation in reverse direction		:= BS1[6]<0..1>	(Type 6)
	<0>	:= no start of operation in reverse direction	
	<1>	:= start of operation in reverse direction	
RES = RESERVE		:= BS2[7..8]<0>	(Type 6)

Definitions:

Start events are generated by the protection equipment when it detects faults. Start events are transient information.



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Commands to output circuits are generated by the protection equipment when it decides to trip the circuit-breaker. Output circuit information is transient information.

The time between start and end of operation is the relay duration time. The time between the start of the operation and the command to output circuit is the relay operating time.

7.2.6.12 Output circuit information of protection equipment

OCI	:=	BS8{GC,CL1,CL2,CL3,RES}	
GC = general command to output circuit	:=	BS1[1]<0..1>	(Type 6)
<0>	:=	no general command to output circuit	
<1>	:=	general command to output circuit	
CL1 = command to output circuit phase L1	:=	BS1[2]<0..1>	(Type 6)
<0>	:=	no command to output circuit phase L1	
<1>	:=	command to output phase circuit L1	
CL2 = command to output circuit phase L2	:=	BS1[3]<0..1>	(Type 6)
<0>	:=	no command to output circuit phase L2	
<1>	:=	command to output circuit phase L2	
CL3 = command to output circuit phase L3	:=	BS1[4]<0..1>	(Type 6)
<0>	:=	no command to output circuit phase L3	
<1>	:=	command to output circuit phase L3	
RES = RESERVE	:=	BS4[5..8]<0>	(Type 6)

7.2.6.13 Binary state information (IEV 371-02-03) 32 bit

BSI	:=	32BS1[1..32]<0..1>	(Type 6)

7.2.6.14 Fixed test bit pattern, two octets

FBP	:=	UI16[1..16]<55AAH>	(Type 1.1)

7.2.6.15 Single command (IEV 371-03-02)

SCO	:=	CP8{SCS,BS1,QOC}	
SCS=Single command state	:=	BS1[1]<0..1>	(Type 6)
<0>	:=	OFF	
<1>	:=	ON	
RES= RESERVE	:=	BS1[2]<0>	(Type 6)
QOC	:=	CP6[3..8]{QU,S/E}	see 7.2.6.26 QOC

7.2.6.16 Double command (IEV 371-03-03)

DCO	:=	CP8{DCS,QOC}	
DCS=Double command state	:=	UI2[1..2]<0..3>	(Type 1.1)
<0>	:=	not permitted	
<1>	:=	OFF	
<2>	:=	ON	
<3>	:=	not permitted	
QOC	:=	CP6[3..8]{QU,S/E}	see 7.2.6.26 QOC

7.2.6.17 Regulating step command (IEV 371-03-13)

RCO	:=	CP8{RCS,QOC}	
RCS=Regulating step command state	:=	UI2[1..2]<0..3>	(Type 1.1)
<0>	:=	not permitted	
<1>	:=	next step LOWER	
<2>	:=	next step HIGHER	
<3>	:=	not permitted	
QOC	:=	CP6[3..8]{QU,S/E}	see 7.2.6.26 QOC

7.2.6.18 Seven octet binary time

CP56Time2a := CP56{milliseconds,minutes,RES1,invalid,hours,RES2,summer time,day of month,day of week,months,RES3,years,RES4}

This binary time is defined in 6.8 of IEC 60870-5-4.

Day of week := <0> not used

Day of week := <1..7> used (optional)

Monday	:=	<1>
Tuesday	:=	<2>
Wednesday	:=	<3>
Thursday	:=	<4>
Friday	:=	<5>
Saturday	:=	<6>
Sunday	:=	<7>

The summer-time bit SU may optionally be used as an additional information to indicate the presently valid time (standard or summer-time). This may be useful to assign the correct hour to information objects which are generated during the first hour after switching from standard to summer-time.

For systems that span time-zone boundaries, the adoption of UTC for all time tags is recommended.

The RES1-bit may be used in the monitor direction to indicate whether the time tag was added to the information object when it was acquired by the RTU (genuine time) or the time tag was substituted by intermediate equipment such as concentrator stations or by the controlling station itself (substituted time).

RES1 := GEN (genuine time)

<0>	:=	Genuine time
<1>	:=	Substituted time

7.2.6.19 Three octet binary time

CP24Time2a := CP24{milliseconds,minutes, RES1,invalid}

This binary time is defined in 6.8 of IEC 60870-5-4. It is used for the time tag of an INFORMATION OBJECT. The octets 4 up to 7 are discarded.

The RES1-bit may be used in the monitor direction to indicate whether the time tag was added to the information object when it was acquired by the RTU (genuine time) or the time tag was substituted by intermediate equipment such as concentrator stations or by the controlling station itself (substituted time).

RES1 := GEN (genuine time)

<0>	:=	Genuine time
<1>	:=	Substituted time

7.2.6.20 Two octet binary time

CP16Time2a := UI16[1..16]<0..59 999 ms>

This is used for an elapsed time such as “Relay operating time” or “Relay duration time”.

7.2.6.21 Cause of initialization

COI	:=	CP8{UI7[1..7],BS1[8]}	(Type 1.1)
UI7[1..7]<0..127>			
<0>	:=	local power switch on	
<1>	:=	local manual reset	
<2>	:=	remote reset	
<3..31>	:=	reserved for standard definitions of this companion standard (compatible range)	
<32..127>	:=	reserved for special use (private range)	
BS1[8]<0..1>			(Type 6)
<0>	:=	initialization with unchanged local parameters	
<1>	:=	initialization after change of local parameters	

7.2.6.22 Qualifier of interrogation

QOI	:=	UI8[1..8]<0..255>	(Type 1.1)
<0>	:=	not used	
<1..19>	:=	reserved for standard definitions of this companion standard (compatible range)	
<20>	:=	Station interrogation (global)	
<21>	:=	Interrogation of group 1	
<22>	:=	Interrogation of group 2	
<23>	:=	Interrogation of group 3	
<24>	:=	Interrogation of group 4	
<25>	:=	Interrogation of group 5	
<26>	:=	Interrogation of group 6	
<27>	:=	Interrogation of group 7	
<28>	:=	Interrogation of group 8	
<29>	:=	Interrogation of group 9	
<30>	:=	Interrogation of group 10	
<31>	:=	Interrogation of group 11	

<32> := Interrogation of group 12
<33> := Interrogation of group 13
<34> := Interrogation of group 14
<35> := Interrogation of group 15
<36> := Interrogation of group 16
<37..63> := reserved for standard definitions of this companion standard (compatible range)
<64..255> := reserved for special use (private range)

7.2.6.23 Qualifier of counter interrogation command

QCC := CP8{RQT,FRZ}
RQT = Request := UI6[1..6]<0..63> (Type 1.1)
<0> := no counter requested (not used)
<1> := request counter group 1
<2> := request counter group 2
<3> := request counter group 3
<4> := request counter group 4
<5> := general request counter
<6..31> := reserved for standard definitions of this companion standard (compatible range)
<32..63> := reserved for special use (private range)

FRZ = Freeze := UI2[7..8]<0..3> (Type 1.1)
<0> := read (no freeze or reset)
<1> := counter freeze without reset (value frozen represents integrated total)
<2> := counter freeze with reset (value frozen represents incremental information)
<3> := counter reset

The action specified by the FRZ code is applied only to the group specified by the RQT code.

7.2.6.24 Qualifier of parameter of measured values

QPM := CP8{KPA,LPC,POP}
KPA = kind of parameter := UI6[1..6]<0..63> (Type 1.1)
<0> := not used
<1> := threshold value
<2> := smoothing factor (filter time constant)
<3> := low limit for transmission of measured values
<4> := high limit for transmission of measured values
<5..31> := reserved for standard definitions of this companion standard (compatible range)
<32..63> := reserved for special use (private range)
LPC = local parameter change := BS1[7]<0..1> (Type 6)
<0> := no change
<1> := change
POP = parameter operation := BS1[8]<0..1> (Type 6)
<0> := in operation
<1> := not in operation

LPC and POP are not used in this standard and set to zero.

NOTE LPC and POP are defined for a possible extension of parameter loading from one to more than one parameters as it is defined in 6.10 of IEC 60870-5-5. This standard defines only loading of single parameters (see 7.4.9 of this standard).

The local parameters, which are fixed defined by default values in the controlled stations, are normally reported to the controlling station by a station interrogation procedure. If the parameters are transmitted separately from the station interrogation <20>, one of the groups 1 <21> to 16 <36> may be used.

Threshold value is the minimum change of value required to cause a new transmission of a measured value.

Limit for transmission is the value which, if exceeded, causes the transmission of a measured value.

Each parameter has to be defined by an unambiguous INFORMATION OBJECT ADDRESS per system.

7.2.6.25 Qualifier of parameter activation

QPA	:=	UI8[1..8]<0..255>	(Type 1.1)
<0>	:=	not used	
<1> [4]	:=	act/deact of the previously loaded parameters (object address = 0)	
<2> [4]	:=	act/deact of the parameter of the addressed object	
<3>	:=	act/deact of persistent cyclic or periodic transmission of the addressed object	
<4..127>	:=	reserved for standard definitions of this companion standard (compatible range)	
<128..255>	:=	reserved for special use (private range)	

Act/deact is defined in the CAUSE OF TRANSMISSION.

7.2.6.26 Qualifier of command

QOC	:=	CP6{QU, S/E}	
QU	:=	UI5[3..7]<0..31>	(Type 1.1)
<0>	:=	no additional definition [5]	
<1>	:=	short pulse duration (circuit-breaker), duration determined by a system parameter in the outstation	
<2>	:=	long pulse duration, duration determined by a system parameter in the outstation	
<3>	:=	persistent output	
<4..8>	:=	reserved for standard definitions of this companion standard (compatible range)	
<9..15>	:=	reserved for the selection of other predefined functions [6]	
<16..31>	:=	reserved for special use (private range)	
S/E	:=	BS1[8]<0..1>	(Type 6)
<0>	:=	execute	
<1>	:=	select	

7.2.6.27 Qualifier of reset process command

QRP	:=	UI8[1..8]<0..255>	(Type 1.1)
<0>	:=	not used	
<1>	:=	general reset of process	

---

[4] Not used in this companion standard (reserved for extension of parameter loading functions).

[5] May be used when the attributes (for example pulse duration, etc.) of the addressed control function are fixed (predefined) in the controlled station and not selected by the controlling station.

[6] May be used to control functions with fixed attributes, which are predefined in the controlled station.

<2> := reset of pending information with time tag of the event buffer
<3..127> := reserved for standard definitions of this companion standard (compatible range)
<128..255> := reserved for special use (private range)

7.2.6.28 File ready qualifier

FRQ := CP8{UI7[1..7],BS1[8]}
UI7[1..7]<0..127> (Type 1.1)
<0> := default
<1..63> := reserved for standard definitions of this companion standard (compatible range)
<64..127> := reserved for special use (private range)
BS1[8]<0..1> (Type 6)
<0> := positive confirm of select, request, deactivate or delete
<1> := negative confirm of select, request, deactivate or delete

7.2.6.29 Section ready qualifier

SRQ := CP8{UI7[1..7],BS1[8]}
UI7[1..7]<0..127> (Type 1.1)
<0> := default
<1..63> := reserved for standard definitions of this companion standard (compatible range)
<64..127> := reserved for special use (private range)
BS1[8]<0..1> (Type 6)
<0> := section ready to load
<1> := section not ready to load

7.2.6.30 Select and call qualifier

SCQ := CP8{UI4[1..4],UI4[5..8]}
UI4[1..4]<0..15> (Type 1.1)
<0> := default
<1> := select file
<2> := request file
<3> := deactivate file
<4> := delete file
<5> := select section
<6> := request section
<7> := deactivate section
<8..10> := reserved for standard definitions of this companion standard (compatible range)
<11..15> := reserved for special use (private range)

UI4[5..8]<0..15> (Type 1.1)

<0>	:=	default
<1>	:=	requested memory space not available
<2>	:=	checksum failed
<3>	:=	unexpected communication service
<4>	:=	unexpected name of file
<5>	:=	unexpected name of section
<6..10>	:=	reserved for standard definitions of this companion standard (compatible range)
<11..15>	:=	reserved for special use (private range)

7.2.6.31 Last section or segment qualifier

LSQ := UI8[1..8]<0..255> (Type 1.1)

<0>	:=	not used
<1>	:=	file transfer without deactivation
<2>	:=	file transfer with deactivation
<3>	:=	section transfer without deactivation
<4>	:=	section transfer with deactivation
<5..127>	:=	reserved for standard definitions of this companion standard (compatible range)
<128..255>	:=	reserved for special use (private range)

7.2.6.32 Acknowledge file or section qualifier

AFQ := CP8{UI4[1..4],UI4[5..8]}

UI4[1..4]<0..15> (Type 1.1)

<0>	:=	not used
<1>	:=	positive acknowledge of file transfer
<2>	:=	negative acknowledge of file transfer
<3>	:=	positive acknowledge of section transfer
<4>	:=	negative acknowledge of section transfer
<5..10>	:=	reserved for standard definitions of this companion standard (compatible range)
<11..15>	:=	reserved for special use (private range)

UI4[5..8]<0..15> (Type 1.1)

<0>	:=	default
<1>	:=	requested memory space not available
<2>	:=	checksum failed
<3>	:=	unexpected communication service
<4>	:=	unexpected name of file
<5>	:=	unexpected name of section
<6..10>	:=	reserved for standard definitions of this companion standard (compatible range)
<11..15>	:=	reserved for special use (private range)

7.2.6.33 Name of file

NOF := UI16[1..16]<0..65535> (Type 1.1)

<0>	:=	default
<1..65535>	:=	name of file

7.2.6.34 Name of section

NOS		:= UI8[1..8]<0..255>	(Type 1.1)
	<0>	:= default	
	<1..255>	:= name of section	

7.2.6.35 Length of file or section

LOF		:= UI24[1..24]<0..16777215>	(Type 1.1)
	<0>	:= not used	
	<1..16777215>	:= number of octets of the complete file or section	

7.2.6.36 Length of segment

LOS		:= UI8[1..8]<0..255>	(Type 1.1)
	<0>	:= not used	
	<1..n>	:= number of octets of the segment	

The maximum number of n ranges between 234 (maximum length of link field, DATA UNIT IDENTIFIER AND INFORMATION OBJECT ADDRESSes) and 240 (minimum length of link field, DATA UNIT IDENTIFIER AND INFORMATION OBJECT ADDRESSes).

7.2.6.37 Checksum

CHS		:= UI8[1..8]<0..255>	(Type 1.1)
	<0..255>	:= arithmetic sum disregarding overflows (sum modulo 256) over all octets of a section (when used in a last segment PDU) or of a complete file (when used in a last section PDU)	

7.2.6.38 Status of file

SOF		:= CP8{STATUS,LFD,FOR,FA}	
STATUS		:= UI5[1..5]<0..32>	(Type 1.1)
	<0>	:= default	
	<1..15>	:= reserved for standard definitions of this companion standard (compatible range)	
	<16..32>	:= reserved for special use (private range)	
LFD		:= BS1[6]<0..1>	(Type 6)
	<0>	:= additional file of the directory follows	
	<1>	:= last file of the directory	
FOR		:= BS1[7]<0..1>	(Type 6)
	<0>	:= name defines file	
	<1>	:= name defines subdirectory	
FA		:= BS1[8]<0..1>	(Type 6)
	<0>	:= file waits for transfer	
	<1>	:= transfer of this file is active	

7.2.6.39 Qualifier of set-point command

QOS		:= CP8{QL, S/E}	
QL		:= UI7[1..7]<0..127>	(Type 1.1)
	<0>	:= default	
	<1..63>	:= reserved for standard definitions of this companion standard (compatible range)	
	<64..127>	:= reserved for special use (private range)	

S/E	:= BS1[8]<0..1>	(Type 6)
<0>	:= execute	
<1>	:= select	

7.2.6.40 Status and status change detection

SCD	:= CP32{ST, CD}	
ST	:= BS16[1..16]	(Type 6)
BS16[n]	:= STn = status bit in bit position n	
STn<0>	:= OFF	
STn<1>	:= ON	
CD	:= BS16[17..32]	(Type 6)
BS16[n]	:= CDn = status change detection bit in bit position n+16	
CDn<0>	:= no status change was detected since last reported	
CDn<1>	:= at least one status change was detected since last reported	

A change detect has occurred if the monitored status point has completed at least one transition cycle since the last reporting of this information. A transition cycle is a 0-1-0 or a 1-0-1 sequence.

7.3 Definition and presentation of the specific ASDUs

In the following, all ASDUs defined in this companion standard are specified. Further ASDUs with TYPE IDENTIFICATION numbers in the range of 1 up to 127 may be defined by additional standards in the future. ASDUs with TYPE IDENTIFICATION numbers 128 up to 255 are available for private use by users of this standard (see 7.2.1.1). They require specification by agreement between the system user and the vendor. The use of the standardized range <1..127> or in addition, the private range <128..255> can be specified by a fixed parameter per system. If the standardized range only is defined, TYPE IDENTIFICATION numbers > 127 are discarded by controlling stations (monitor direction) or mirrored with CAUSE OF TRANSMISSION = 44 by controlled stations (control direction).

A specific application may select either a set of ASDUs with the time tag CP24Time2a, or a set of ASDUs with the time tag CP56Time2a. A mixture of ASDUs from both ASDUs with time tag CP24Time2a and CP56Time2a is not defined, with the exception of using TYPE IDENT 103 C_CS_NA_1 and TYPE IDENT 126 F_DR_TA_1.

The LPDUs of the link are defined in IEC 60870-5-2. These definitions are not repeated in this section.

7.3.1 ASDUs for process information in monitor direction

7.3.1.1 TYPE IDENT 1: M_SP_NA_1
Single-point information without time tag

Sequence of information objects (SQ = 0)

0	0	0	0	0	0	0	1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0	Number i of objects							VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3								CAUSE OF TRANSMISSION	
Defined in 7.2.4								COMMON ADDRESS OF ASDU	
Defined in 7.2.5								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT 1
IV	NT	SB	BL	0	0	0	SPI	SIQ = Single-point information with quality descriptor, defined in 7.2.6.1	
Defined in 7.2.5								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT i
IV	NT	SB	BL	0	0	0	SPI	SIQ = Single-point information with quality descriptor, defined in 7.2.6.1	

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Figure 22 – ASDU: M_SP_NA_1 Single-point information without time tag

M_SP_NA_1 := CP{Data unit identifier,i(Information object address,SIQ)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)

0 | 0 | 0 | 0 | 0 | 0 | 0 | 1		TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
1 | Number j of elements		VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3		CAUSE OF TRANSMISSION	
Defined in 7.2.4		COMMON ADDRESS OF ASDU	
Defined in 7.2.5		INFORMATION OBJECT ADDRESS A	INFORMATION OBJECT
IV | NT | SB | BL | 0 | 0 | 0 | SPI	1	SIQ = Single-point information with quality descriptor, defined in 7.2.6.1 Belongs to information object address A	
IV | NT | SB | BL | 0 | 0 | 0 | SPI	j	SIQ = Single-point information with quality descriptor, defined in 7.2.6.1 Belongs to information object address A+j–1	

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Figure 23 – ASDU: M_SP_NA_1 Sequence of single-point information without time tag

M_SP_NA_1 := CP{Data unit identifier,Information object address,j(SIQ)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 1 := M_SP_NA_1

CAUSE OF TRANSMISSION

<2> := background scan
<3> := spontaneous
<5> := requested
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by station interrogation
<21> := interrogated by group 1 interrogation
<22> := interrogated by group 2 interrogation
up to
<36> := interrogated by group 16 interrogation

7.3.1.2 TYPE IDENT 2: M_SP_TA_1
Single-point information with time tag

Sequence of information objects (SQ = 0)

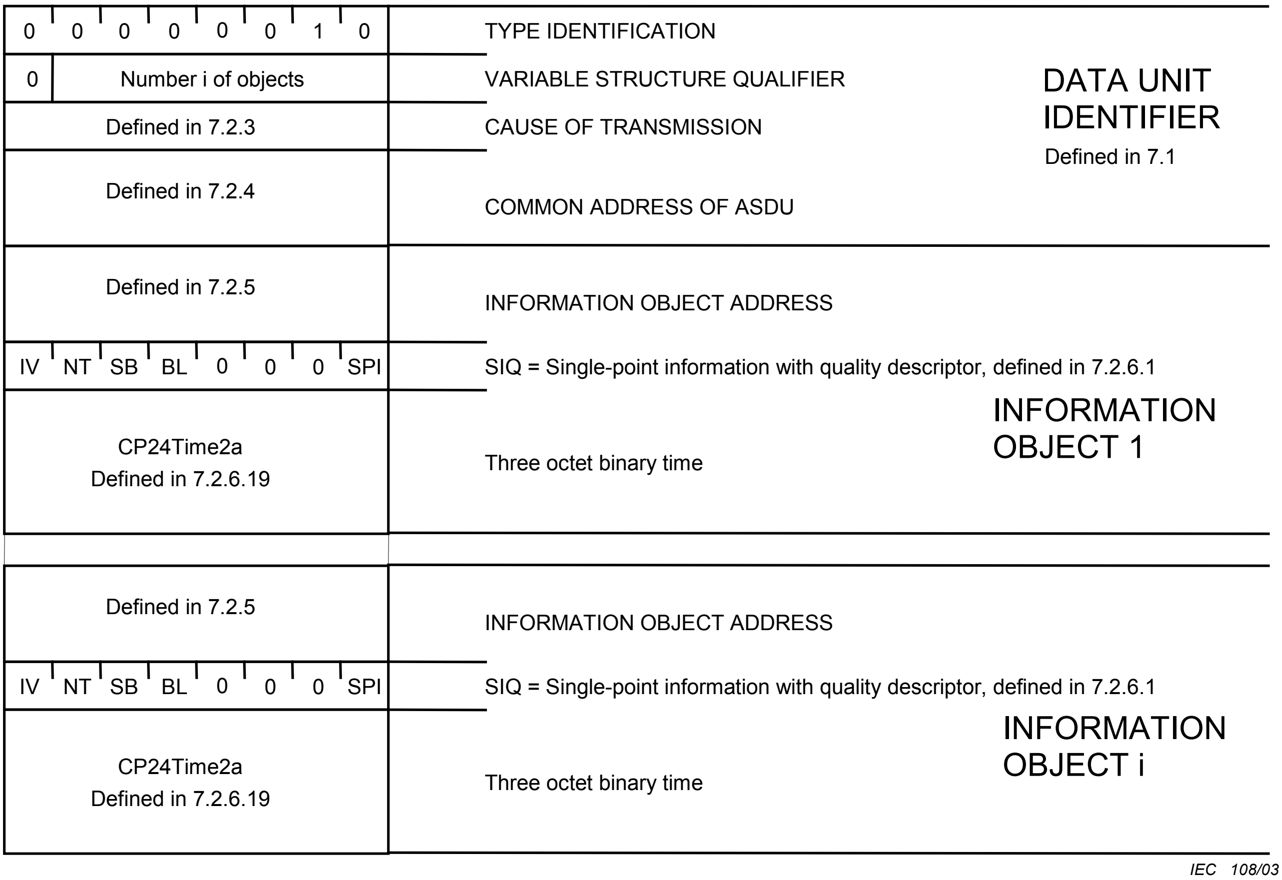

Figure 24 – ASDU: M_SP_TA_1 Single-point information with time tag

M_SP_TA_1 := CP{Data unit identifier,i(Information object address,SIQ,CP24Time2a)}
i := number of objects defined in the variable structure qualifier

Since each single-point information has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

CAUSES OF TRANSMISSION used with
TYPE IDENT 2 := M_SP_TA_1

CAUSE OF TRANSMISSION

<3> := spontaneous
<5> := requested
<11> := return information caused by a remote command
<12> := return information caused by a local command

7.3.1.3 TYPE IDENT 3: M_DP_NA_1
Double-point information without time tag

Sequence of information objects (SQ = 0)

0 0 0 0 0 0 1 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 | Number i of objects	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT 1
IV NT SB BL 0 0 | DPI	DIQ = Double-point information with quality descriptor, defined in 7.2.6.2	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT i
IV NT SB BL 0 0 | DPI	DIQ = Double-point information with quality descriptor, defined in 7.2.6.2	

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Figure 25 – ASDU: M_DP_NA_1 Double-point information without time tag

M_DP_NA_1 := CP{Data unit identifier,i(Information object address,DIQ)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)

0 0 0 0 0 0 1 1		TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
1 | Number j of elements		VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3		CAUSE OF TRANSMISSION	
Defined in 7.2.4		COMMON ADDRESS OF ASDU	
Defined in 7.2.5		INFORMATION OBJECT ADDRESS A	INFORMATION OBJECT
IV NT SB BL 0 0 | DPI	1	DIQ = Double-point information with quality descriptor, defined in 7.2.6.2 Belongs to information object address A	
IV NT SB BL 0 0 | DPI	j	DIQ = Double-point information with quality descriptor, defined in 7.2.6.2 Belongs to information object address A+j–1	

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Figure 26 – ASDU: M_DP_NA_1 Sequence of double-point information without time tag

M_DP_NA_1 := CP{Data unit identifier,Information object address,j(DIQ)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 3 := M_DP_NA_1

CAUSE OF TRANSMISSION

<2> := background scan
<3> := spontaneous
<5> := requested
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by station interrogation
<21> := interrogated by group 1 interrogation
<22> := interrogated by group 2 interrogation
up to
<36> := interrogated by group 16 interrogation

7.3.1.4 TYPE IDENT 4: M_DP_TA_1 Double-point information with time tag

Sequence of information objects (SQ = 0)

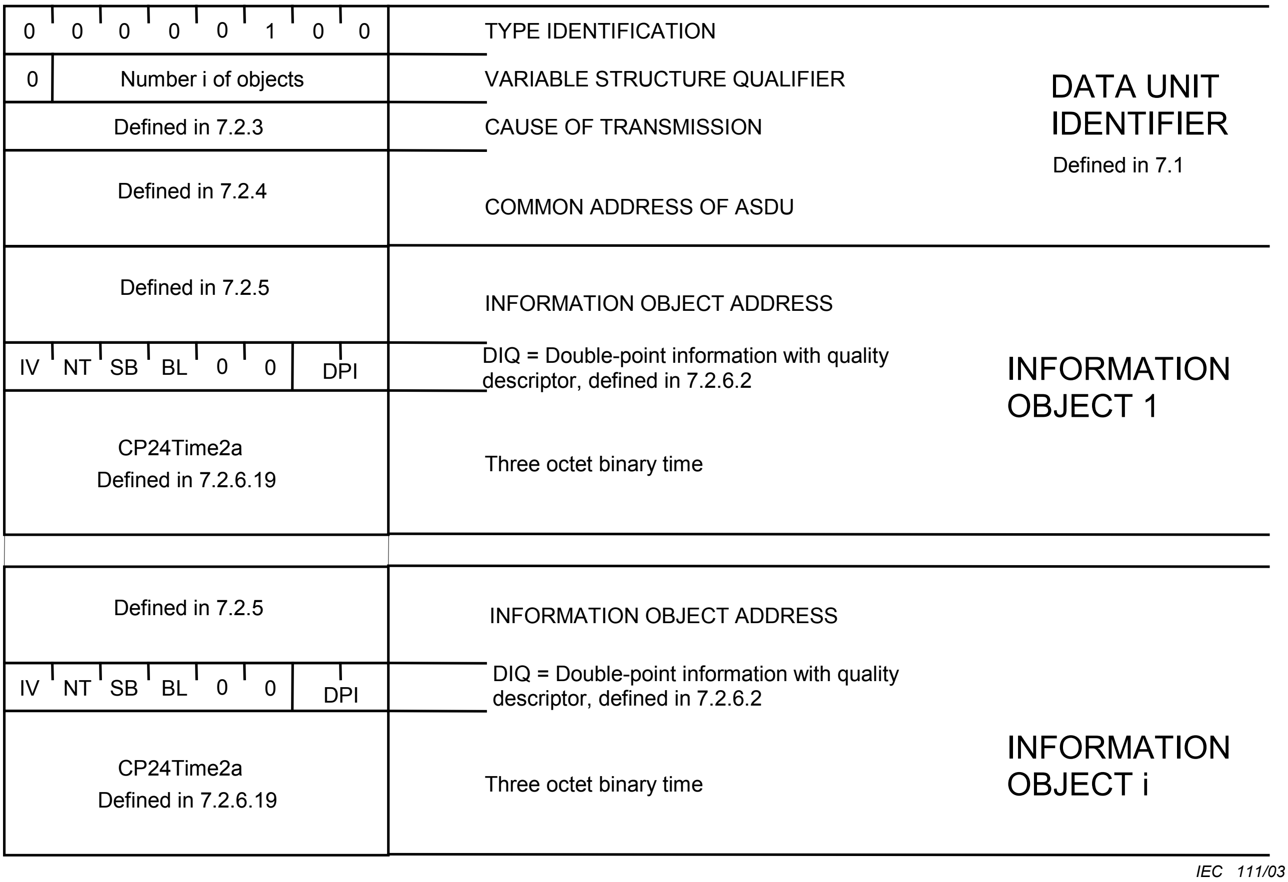


Figure 27 – ASDU: M_DP_TA_1 Double-point information with time tag

M_DP_TA_1 := CP{Data unit identifier,i(Information object address,DIQ,CP24Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 4 := M_DP_TA_1

CAUSE OF TRANSMISSION

<3> := spontaneous
<5> := requested
<11> := return information caused by a remote command
<12> := return information caused by a local command

Since each double-point information has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.5 TYPE IDENT 5: M_ST_NA_1
Step position information

Sequence of information objects (SQ = 0)

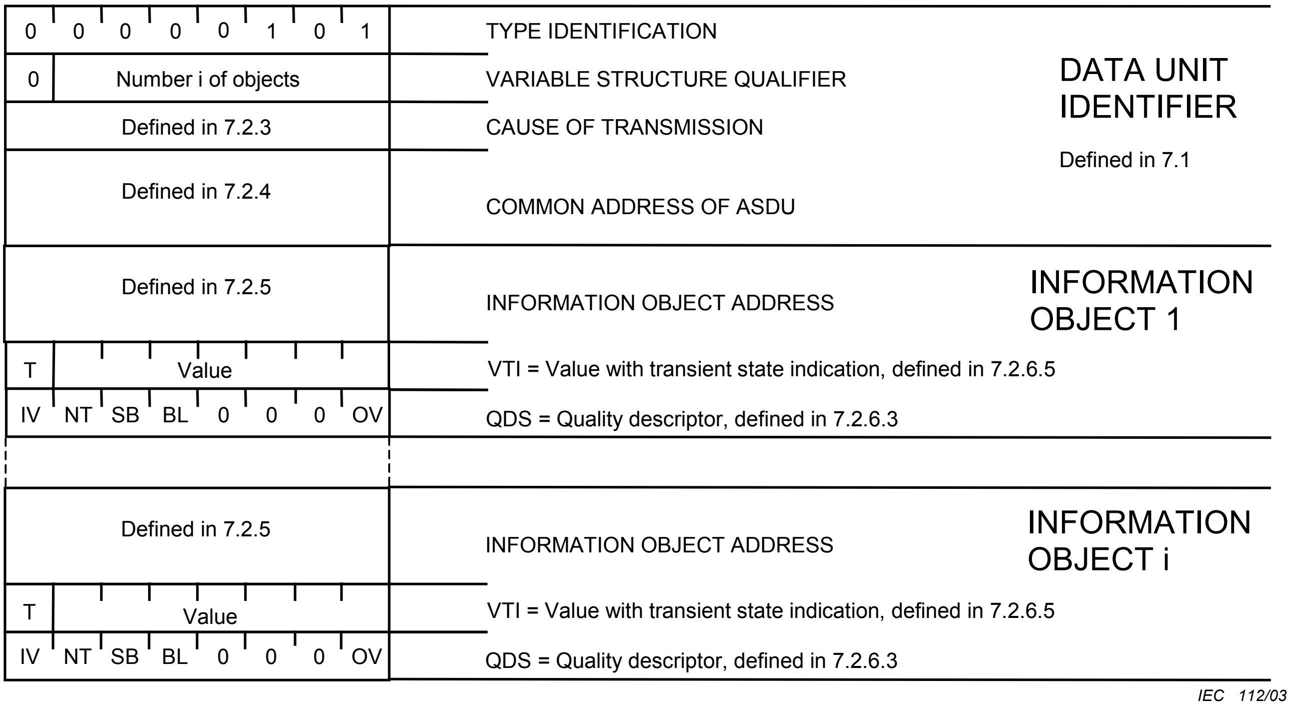


Figure 28 – ASDU: M_ST_NA_1 Step position information

M_ST_NA_1 := CP{Data unit identifier,i(Information object address,VTI,QDS)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)

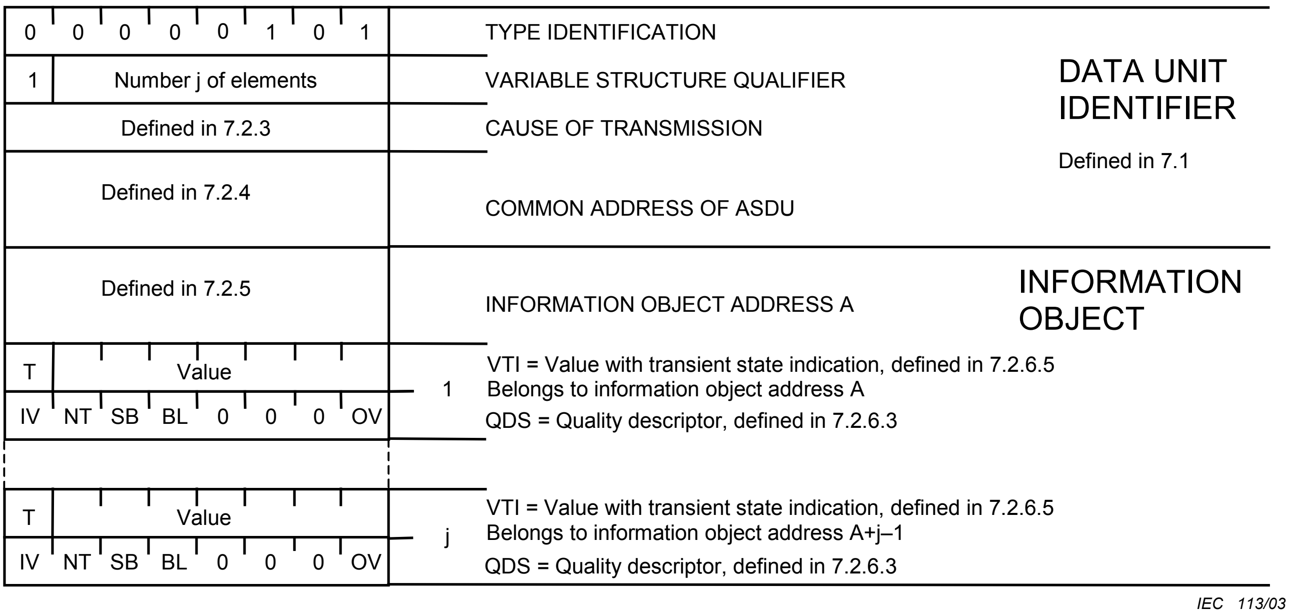


Figure 29 – ASDU: M_ST_NA_1 Sequence of step position information

M_ST_NA_1 := CP{Data unit identifier,Information object address,j(VTI,QDS)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 5 := M_ST_NA_1

CAUSE OF TRANSMISSION

<2>	:=	background scan
<3>	:=	spontaneous
<5>	:=	requested
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command
<20>	:=	interrogated by station interrogation
<21>	:=	interrogated by group 1 interrogation
<22>	:=	interrogated by group 2 interrogation
up to		
<36>	:=	interrogated by group 16 interrogation

7.3.1.6 TYPE IDENT 6: M_ST_TA_1
Step position information with time tag

Sequence of information objects (SQ = 0)

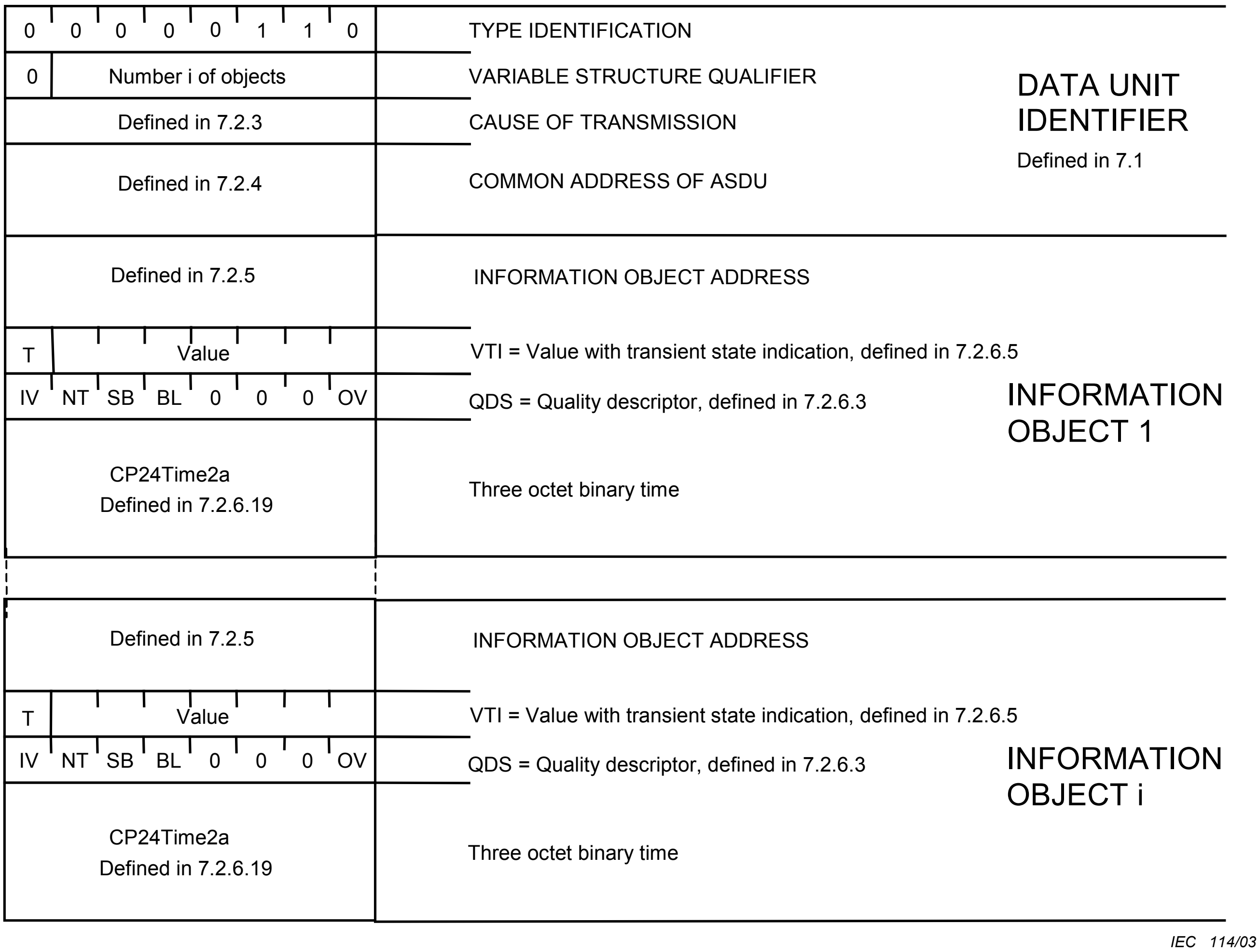


Figure 30 – ASDU: M_ST_TA_1 Step position information with time tag

M_ST_TA_1 := CP{Data unit identifier,i(Information object address,VTI,QDS,CP24Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 6 := M_ST_TA_1

CAUSE OF TRANSMISSION
- <3> := spontaneous
- <5> := requested
- <11> := return information caused by a remote command
- <12> := return information caused by a local command

Since each step position information has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.7 TYPE IDENT 7: M_BO_NA_1
Bitstring of 32 bit

Sequence of information objects (SQ = 0)

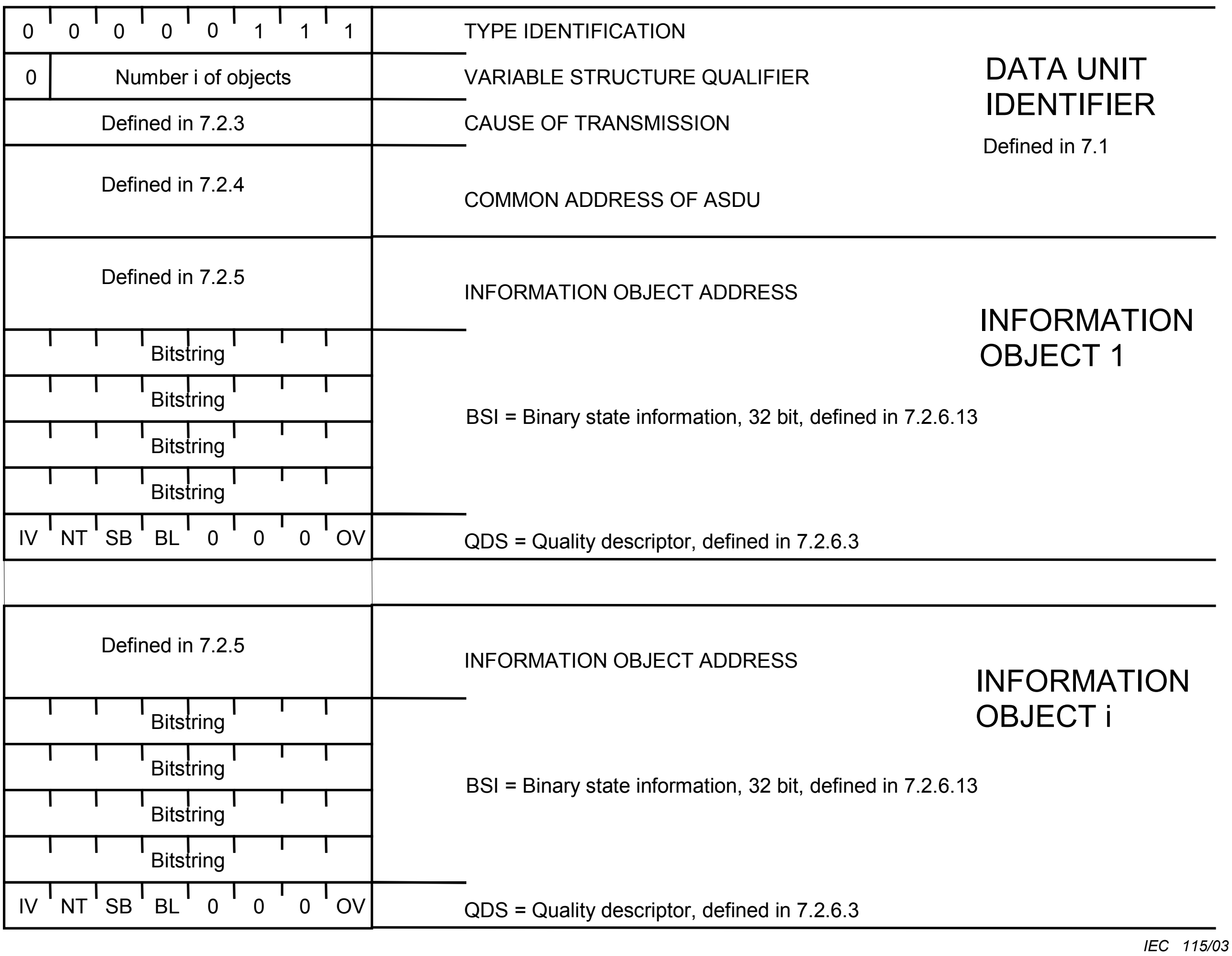


Figure 31 – ASDU: M_BO_NA_1 Bitstring of 32 bit

M_BO_NA_1 := CP{Data unit identifier,i(Information object address,BSI,QDS)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)

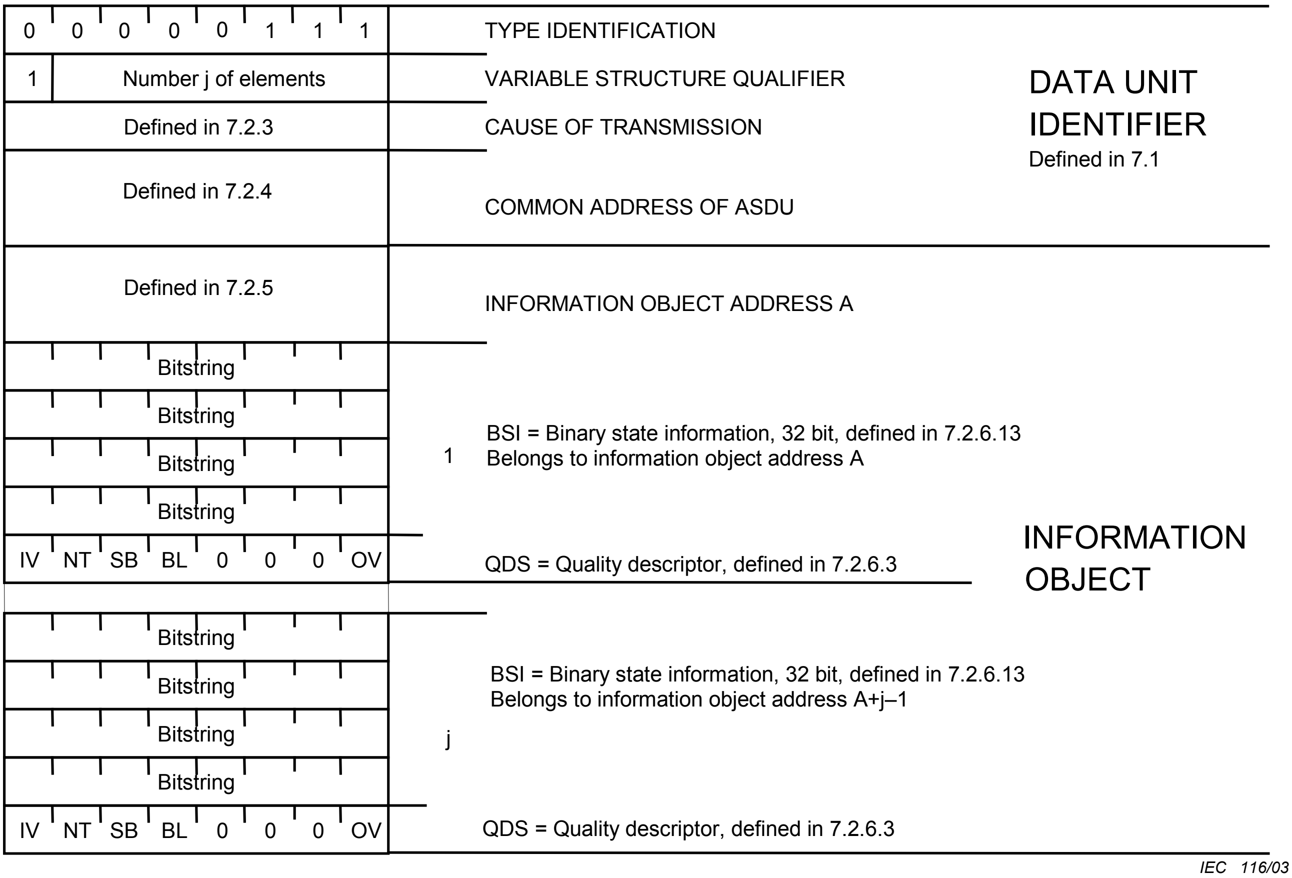


Figure 32 – ASDU: M_BO_NA_1 Sequence of bitstrings of 32 bit

M_BO_NA_1 := CP{Data unit identifier,Information object address,j(BSI,QDS)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 7 := M_BO_NA_1

CAUSE OF TRANSMISSION

<2>	:=	background scan
<3>	:=	spontaneous
<5>	:=	requested
<20>	:=	interrogated by station interrogation
<21>	:=	interrogated by group 1 interrogation
<22>	:=	interrogated by group 2 interrogation
up to		
<36>	:=	interrogated by group 16 interrogation

7.3.1.8 TYPE IDENT 8: M_BO_TA_1
Bitstring of 32 bit with time tag

Sequence of information objects (SQ = 0)

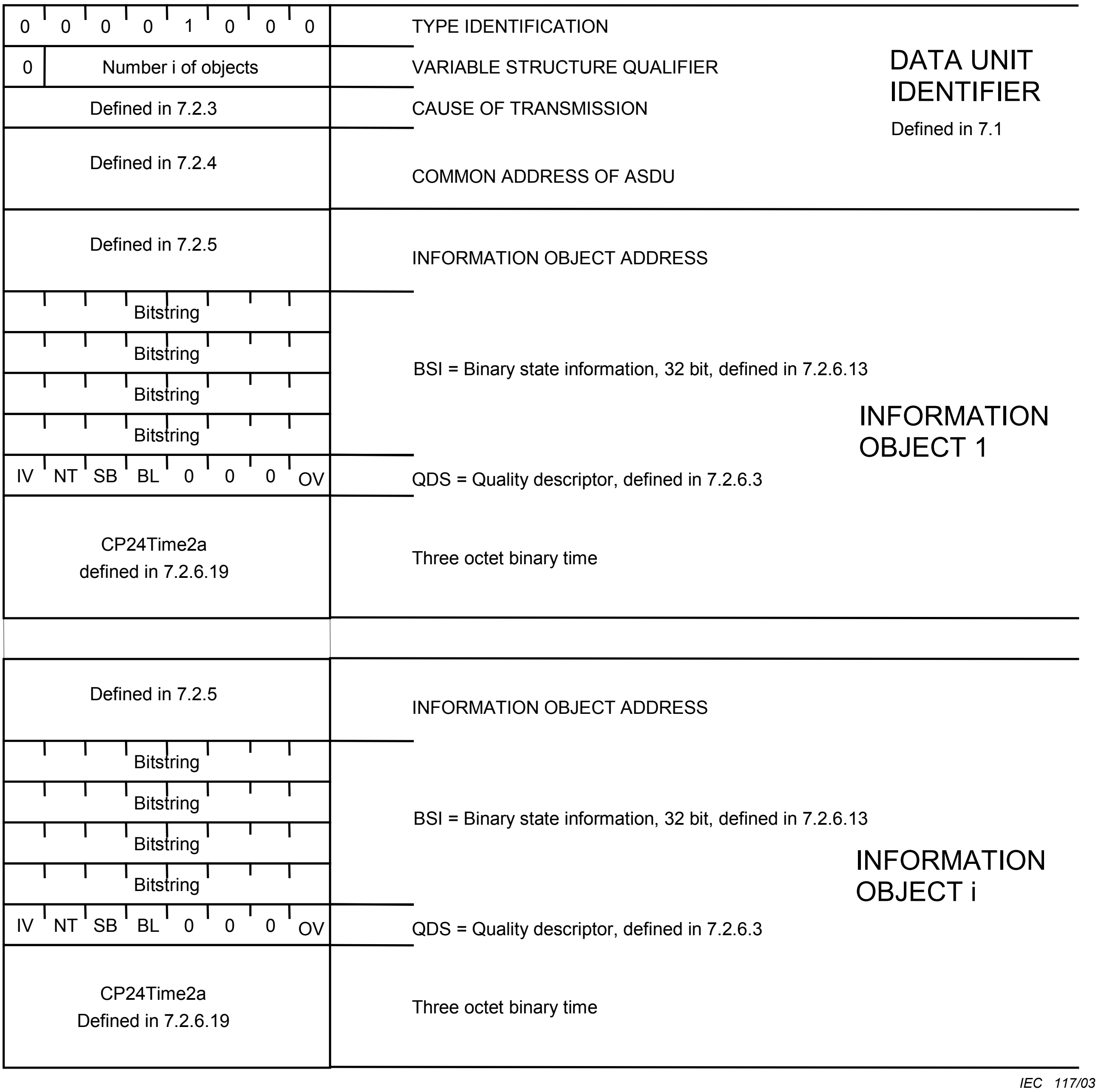


Figure 33 – ASDU: M_BO_TA_1 Bitstring of 32 bit

M_BO_TA_1 := CP{Data unit identifier,i(Information object address,BSI,QDS,CP24Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 8 := M_BO_TA_1

CAUSE OF TRANSMISSION
<3> := spontaneous
<5> := requested

Since each bitstring has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.9 TYPE IDENT 9: M_ME_NA_1
Measured value, normalized value

Sequence of information objects (SQ = 0)

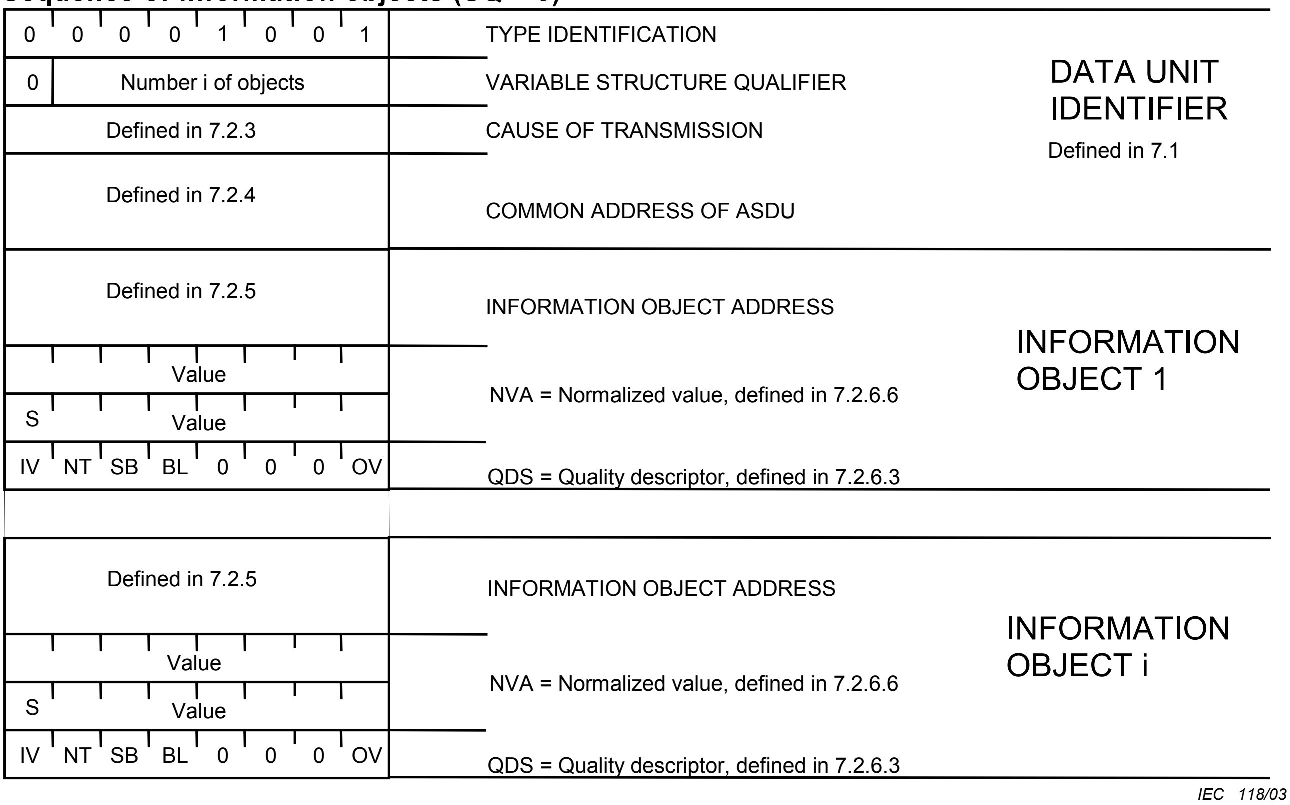


Figure 34 – ASDU: M_ME_NA_1 Measured value, normalized value

M_ME_NA_1 := CP{Data unit identifier,i(Information object address,NVA,QDS)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)

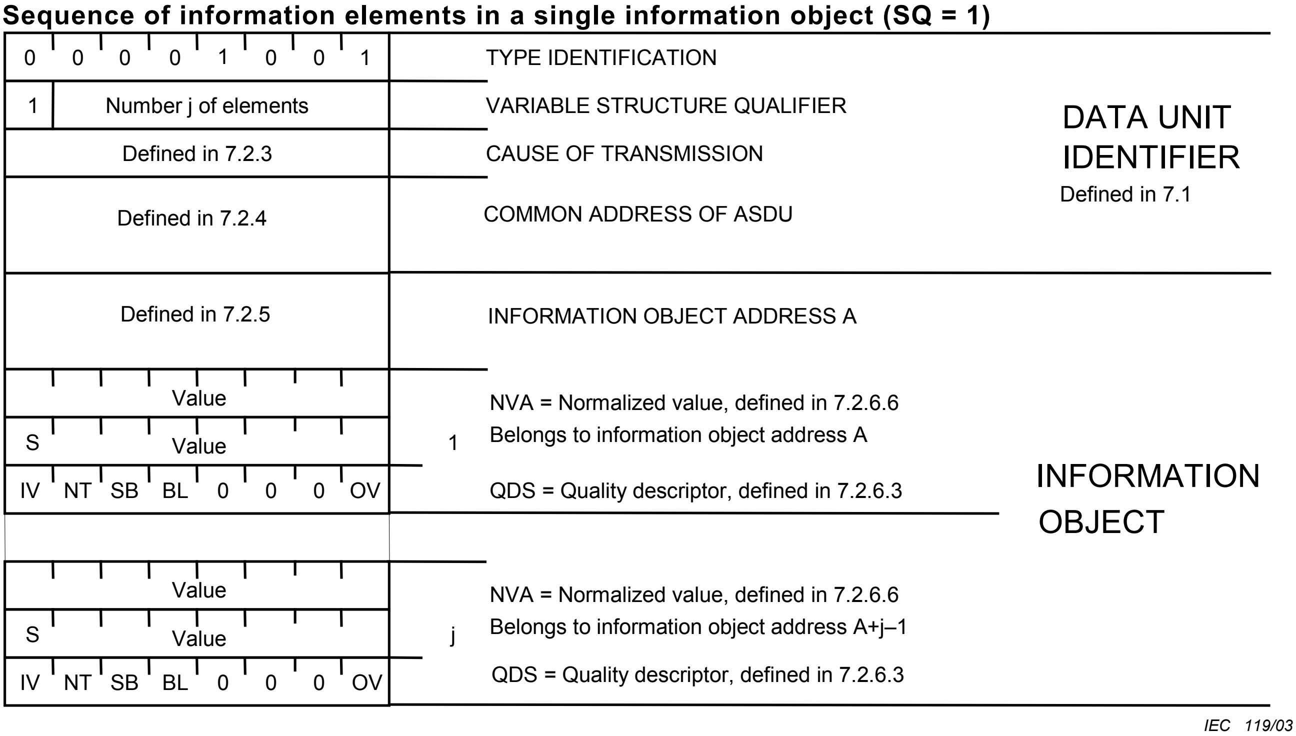


Figure 35 – ASDU: M_ME_NA_1 Sequence of measured values, normalized values

M_ME_NA_1 := CP{Data unit identifier,Information object address,j(NVA,QDS)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 9 := M_ME_NA_1

CAUSE OF TRANSMISSION

<1>	:=	periodic/cyclic
<2>	:=	background scan
<3>	:=	spontaneous
<5>	:=	requested
<20>	:=	interrogated by station interrogation
<21>	:=	interrogated by group 1 interrogation
<22>	:=	interrogated by group 2 interrogation
up to		
<36>	:=	interrogated by group 16 interrogation

7.3.1.10 TYPE IDENT 10: M_ME_TA_1
Measured value, normalized value with time tag

Sequence of information objects (SQ = 0)

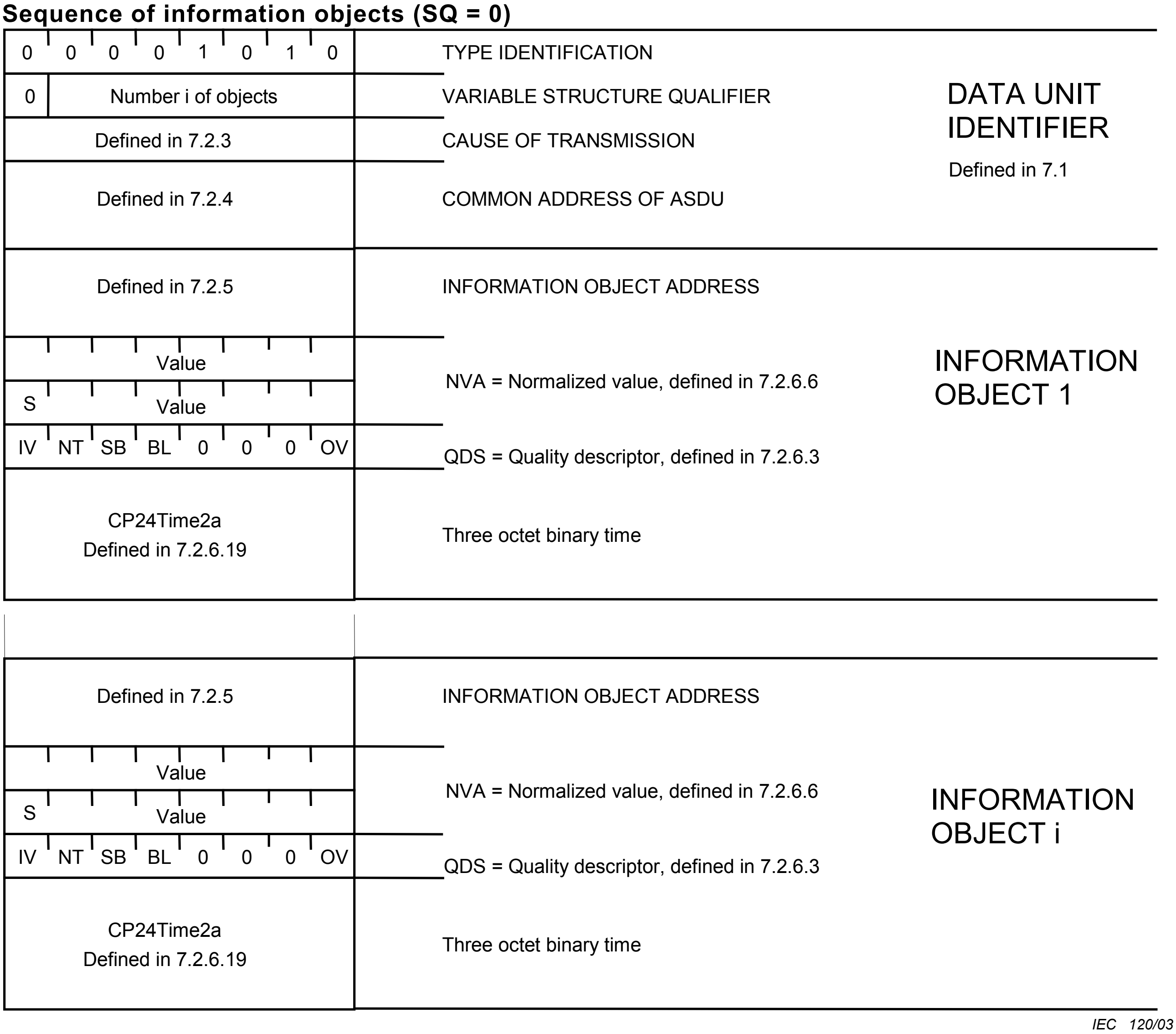


Figure 36 – ASDU: M_ME_TA_1 Measured value, normalized value with time tag

M_ME_TA_1 := CP{Data unit identifier,i(Information object address,NVA,QDS, CP24Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 10 := M_ME_TA_1

CAUSE OF TRANSMISSION
<3> := spontaneous
<5> := requested

Since each measured value has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.11 TYPE IDENT 11: M_ME_NB_1
Measured value, scaled value

Sequence of information objects (SQ = 0)

0	0	0	0	1	0	1	1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0	Number i of objects							VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3								CAUSE OF TRANSMISSION	
Defined in 7.2.4								COMMON ADDRESS OF ASDU	
Defined in 7.2.5								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT 1
Value								SVA = Scaled value, defined in 7.2.6.7	
S	Value								
IV	NT	SB	BL	0	0	0	OV	QDS = Quality descriptor, defined in 7.2.6.3	
Defined in 7.2.5								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT i
Value								SVA = Scaled value, defined in 7.2.6.7	
S	Value								
IV	NT	SB	BL	0	0	0	OV	QDS = Quality descriptor, defined in 7.2.6.3	

IEC 121/03

Figure 37 – ASDU: M_ME_NB_1 Measured value, scaled value

M_ME_NB_1 := CP{Data unit identifier,i(Information object address,SVA,QDS)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)

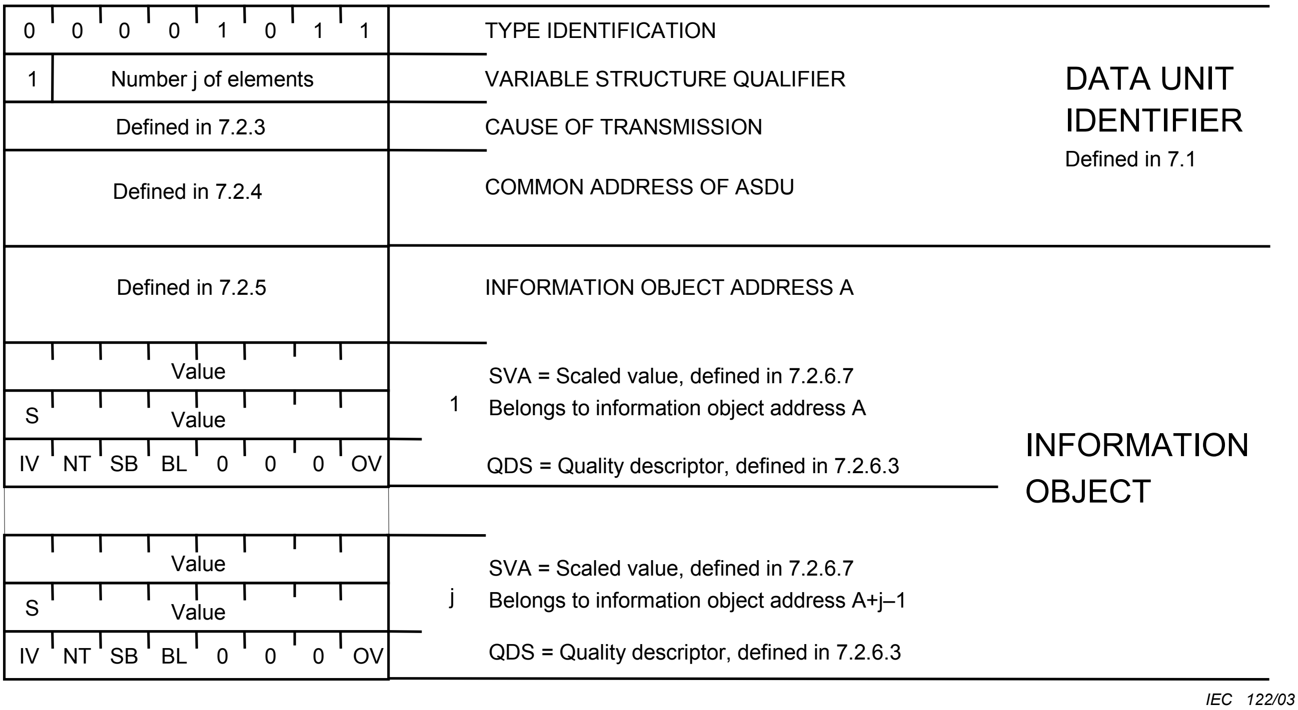


Figure 38 – ASDU: M_ME_NB_1 Sequence of measured values, scaled values

M_ME_NB_1 := CP{Data unit identifier,Information object address,j(SVA,QDS)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 11 := M_ME_NB_1

CAUSE OF TRANSMISSION

<1> := periodic/cyclic
<2> := background scan
<3> := spontaneous
<5> := requested
<20> := interrogated by station interrogation
<21> := interrogated by group 1 interrogation
<22> := interrogated by group 2 interrogation
up to
<36> := interrogated by group 16 interrogation

7.3.1.12 TYPE IDENT 12: M_ME_TB_1
Measured value, scaled value with time tag

Sequence of information objects (SQ = 0)

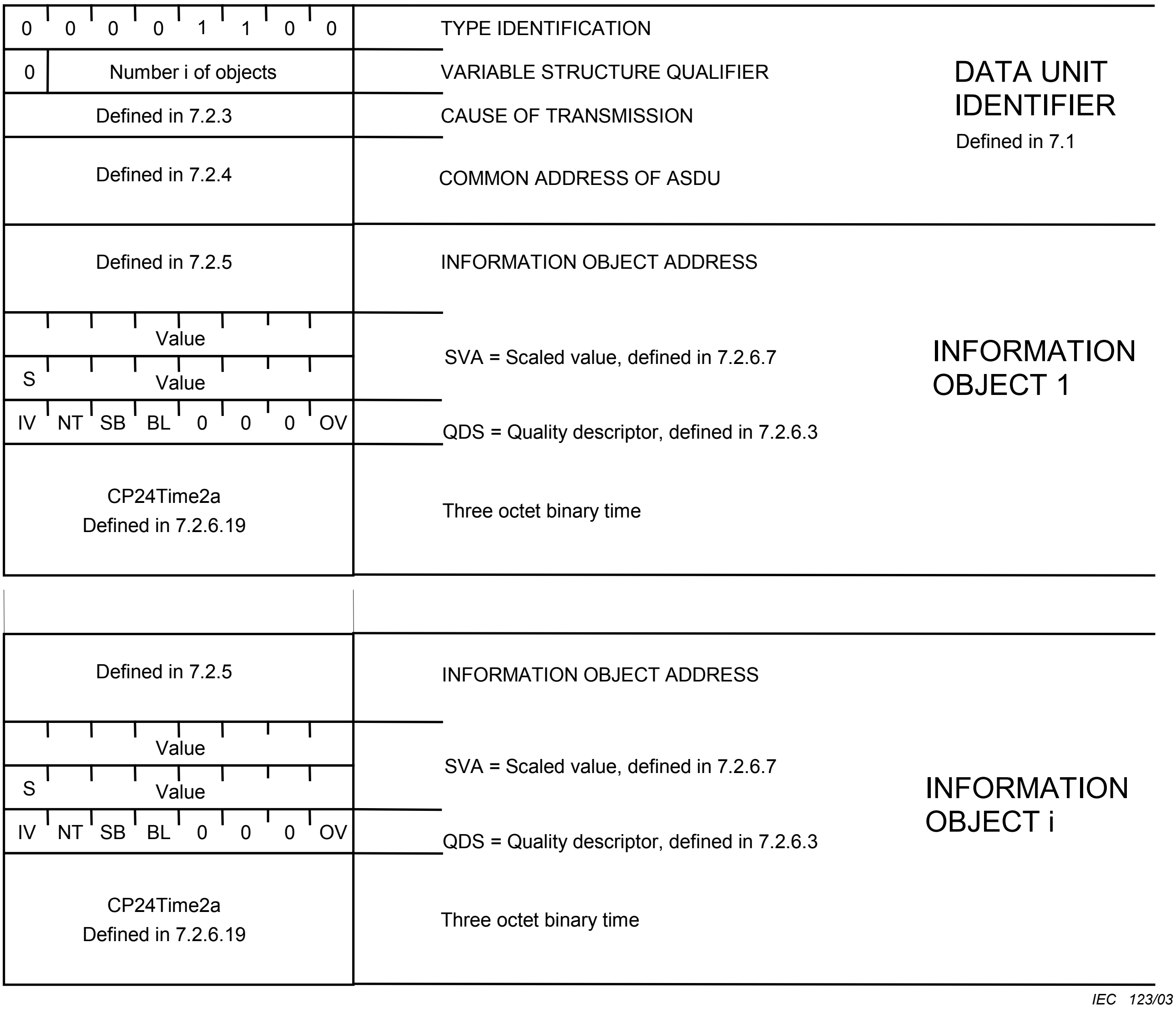


Figure 39 – ASDU: M_ME_TB_1 Measured value, scaled value with time tag

M_ME_TB_1 := CP{Data unit identifier,i(Information object address,SVA,QDS, CP24Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 12 := M_ME_TB_1

CAUSE OF TRANSMISSION
<3> := spontaneous
<5> := requested

Since each measured value has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.13 TYPE IDENT 13: M_ME_NC_1
Measured value, short floating point number

Sequence of information objects (SQ = 0)

0 0 0 0 1 1 0 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 | Number i of objects	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT 1
Fraction	IEEE STD 754 = Short floating point number, defined in 7.2.6.8	
Fraction		
E Fraction		
S Exponent		
IV NT SB BL 0 0 0 OV	QDS = Quality descriptor, defined in 7.2.6.3	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT i
Fraction	IEEE STD 754 = Short floating point number, defined in 7.2.6.8	
Fraction		
E Fraction		
S Exponent		
IV NT SB BL 0 0 0 OV	QDS = Quality descriptor, defined in 7.2.6.3	

IEC 124/03

Figure 40 – ASDU: M_ME_NC_1 Measured value, short floating point number

M_ME_NC_1 := CP{Data unit identifier,i(Information object address,
IEEE STD 754,QDS)}

i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)

0 0 0 0 1 1 0 1		TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
1 | Number j of elements		VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3		CAUSE OF TRANSMISSION	
Defined in 7.2.4		COMMON ADDRESS OF ASDU	
Defined in 7.2.5		INFORMATION OBJECT ADDRESS A	INFORMATION OBJECT
Fraction	1	IEEE STD 754 = Short floating point number, defined in 7.2.6.8 Belongs to information object address A	
Fraction			
E Fraction			
S Exponent			
IV NT SB BL 0 0 0 OV		QDS = Quality descriptor, defined in 7.2.6.3	
Fraction	j	IEEE STD 754 = Short floating point number, defined in 7.2.6.8 Belongs to information object address A+j–1	
Fraction			
E Fraction			
S Exponent			
IV NT SB BL 0 0 0 OV		QDS = Quality descriptor, defined in 7.2.6.3	

IEC 125/03

Figure 41 – ASDU: M_ME_NC_1 Sequence of measured values, short floating point number

M_ME_NC_1 := CP{Data unit identifier,Information object address,j(IEEE STD 754,QDS)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 13 := M_ME_NC_1

CAUSE OF TRANSMISSION

<1> :=periodic/cyclic
<2> :=background scan
<3> :=spontaneous
<5> :=requested
<20> :=interrogated by station interrogation
<21> :=interrogated by group 1 interrogation
<22> :=interrogated by group 2 interrogation
up to
<36> :=interrogated by group 16 interrogation

7.3.1.14 TYPE IDENT 14: M_ME_TC_1
Measured value, short floating point number with time tag

Sequence of information objects (SQ = 0)

0 0 0 0 1 1 1 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 | Number i of objects	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT 1
Fraction	IEEE STD 754 = Short floating point number, defined in 7.2.6.8	
Fraction		
E Fraction		
S Exponent		
IV NT SB BL 0 0 0 OV	QDS = Quality descriptor, defined in 7.2.6.3	
CP24Time2a Defined in 7.2.6.19	Three octet binary time	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT i
Fraction	IEEE STD 754 = Short floating point number, defined in 7.2.6.8	
Fraction		
E Fraction		
S Exponent		
IV NT SB BL 0 0 0 OV	QDS = Quality descriptor, defined in 7.2.6.3	
CP24Time2a Defined in 7.2.6.19	Three octet binary time	

IEC 126/03

Figure 42 – ASDU: M_ME_TC_1 Measured value, short floating point number with time tag

M_ME_TC_1:= CP{Data unit identifier,i(Information object address,IEEE STD 754,QDS, CP24Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 14 := M_ME_TC_1

CAUSE OF TRANSMISSION
<3> := spontaneous
<5> := requested

Since each measured value has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.15 TYPE IDENT 15: M_IT_NA_1
Integrated totals

Sequence of information objects (SQ = 0)

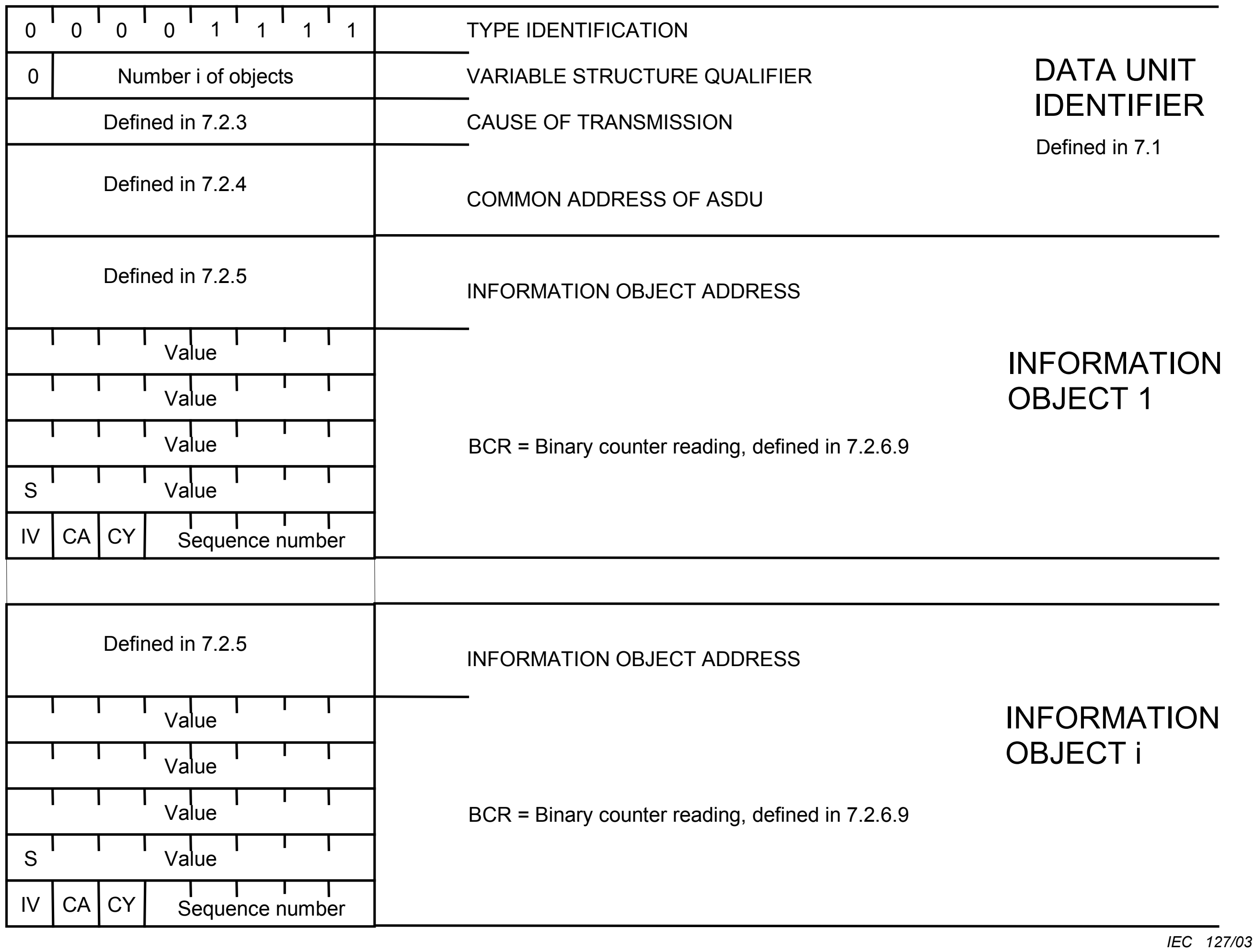
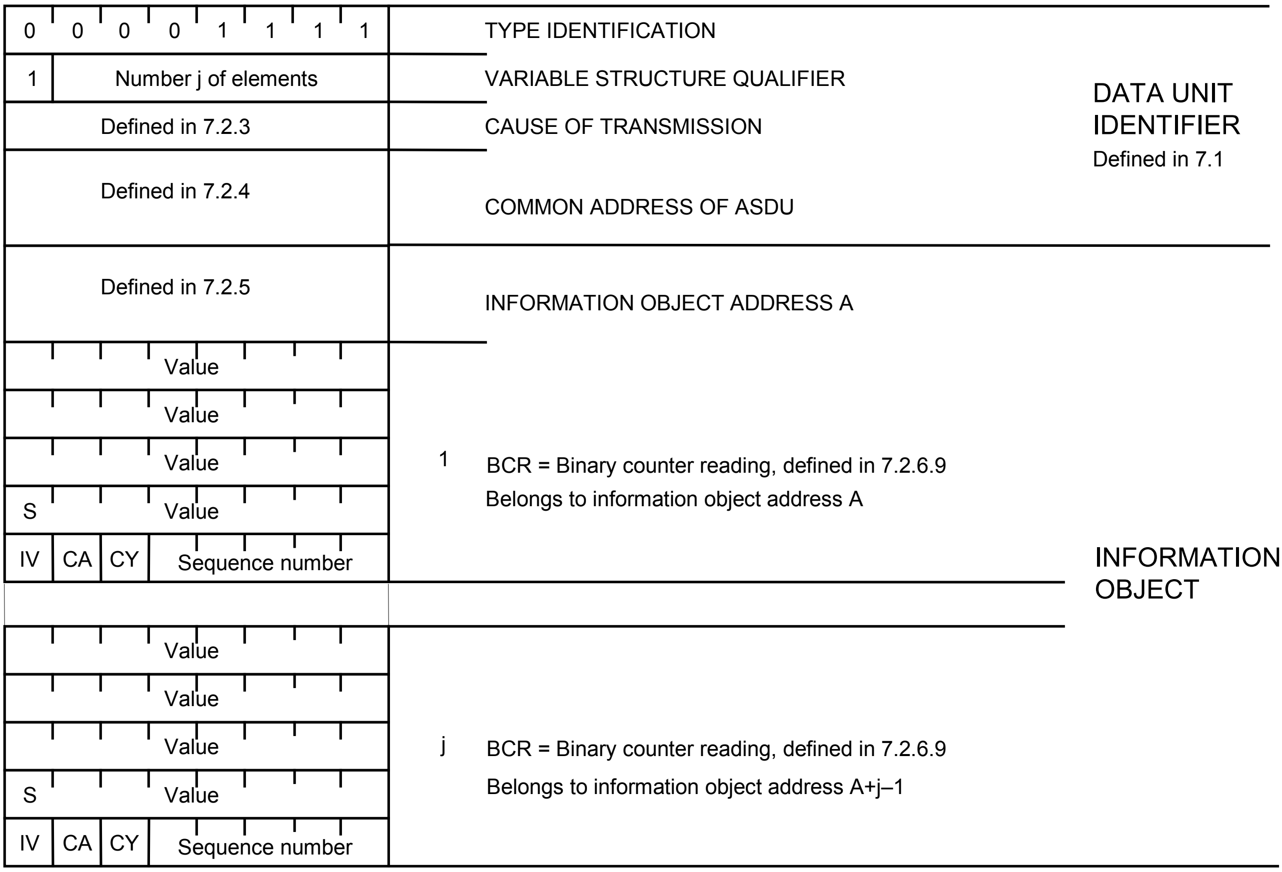


Figure 43 – ASDU: M_IT_NA_1 Integrated totals

M_IT_NA_1 := CP{Data unit identifier,i(Information object address,BCR)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)



IEC 128/03

Figure 44 – ASDU: M_IT_NA_1 Sequence of integrated totals

M_IT_NA_1 := CP{Data unit identifier,Information object address,j(BCR)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 15 := M_IT_NA_1

CAUSES OF TRANSMISSION

<3>	:=spontaneous
<37>	:=requested by general counter request
<38>	:=requested by group 1 counter request
<39>	:=requested by group 2 counter request
<40>	:=requested by group 3 counter request
<41>	:=requested by group 4 counter request

7.3.1.16 TYPE IDENT 16: M_IT_TA_1
Integrated totals with time tag

Sequence of information objects (SQ = 0)

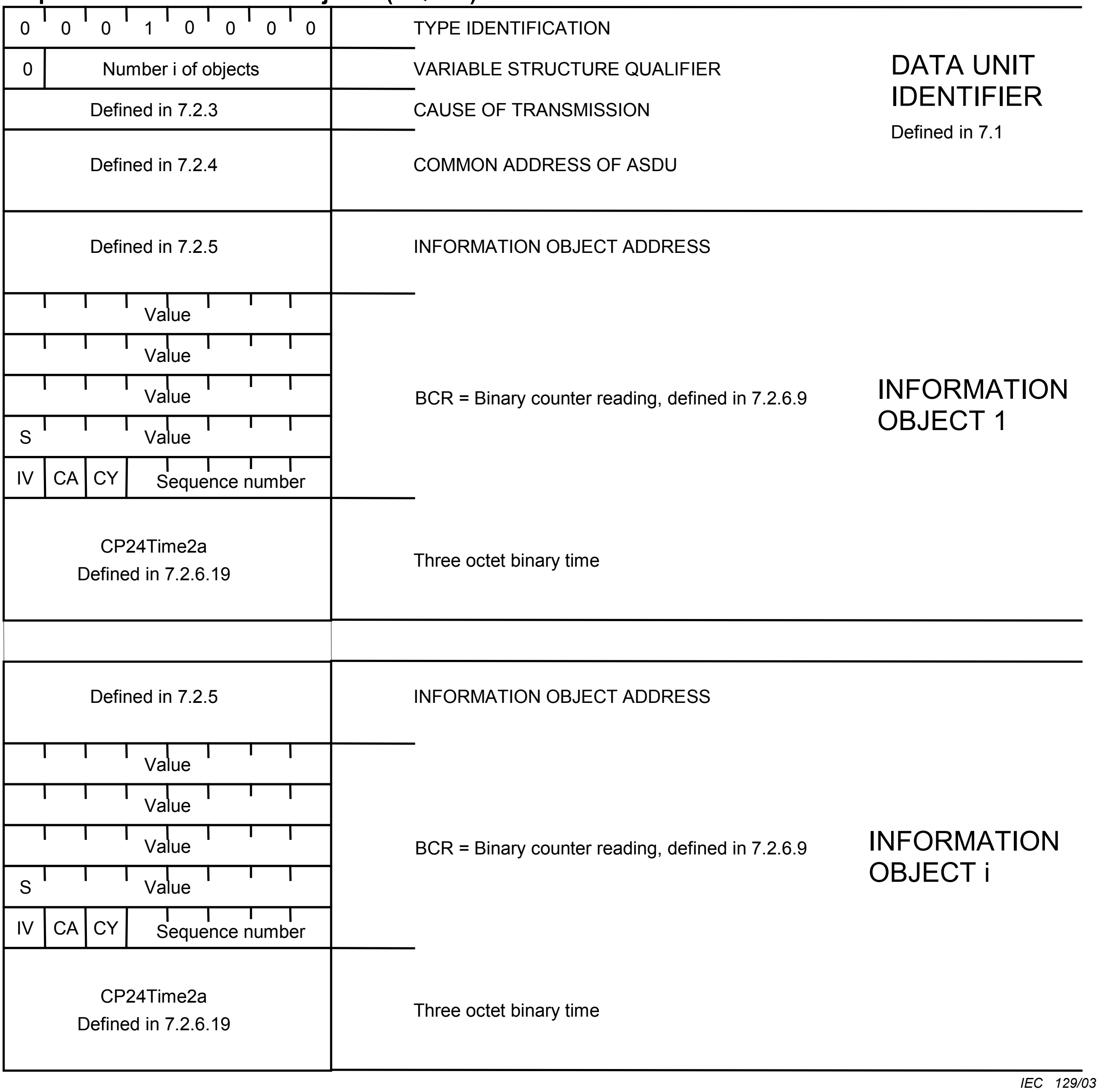


Figure 45 – ASDU: M_IT_TA_1 Integrated totals with time tag

M_IT_TA_1 := CP{Data unit identifier,i(Information object address,BCR,CP24Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 16 := M_IT_TA_1

CAUSE OF TRANSMISSION

<3>	:=	spontaneous
<37>	:=	requested by general counter request
<38>	:=	requested by group 1 counter request
<39>	:=	requested by group 2 counter request
<40>	:=	requested by group 3 counter request
<41>	:=	requested by group 4 counter request

Since each integrated total has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.17 TYPE IDENT 17: M_EP_TA_1
Event of protection equipment with time tag

Sequence of information objects (SQ = 0)

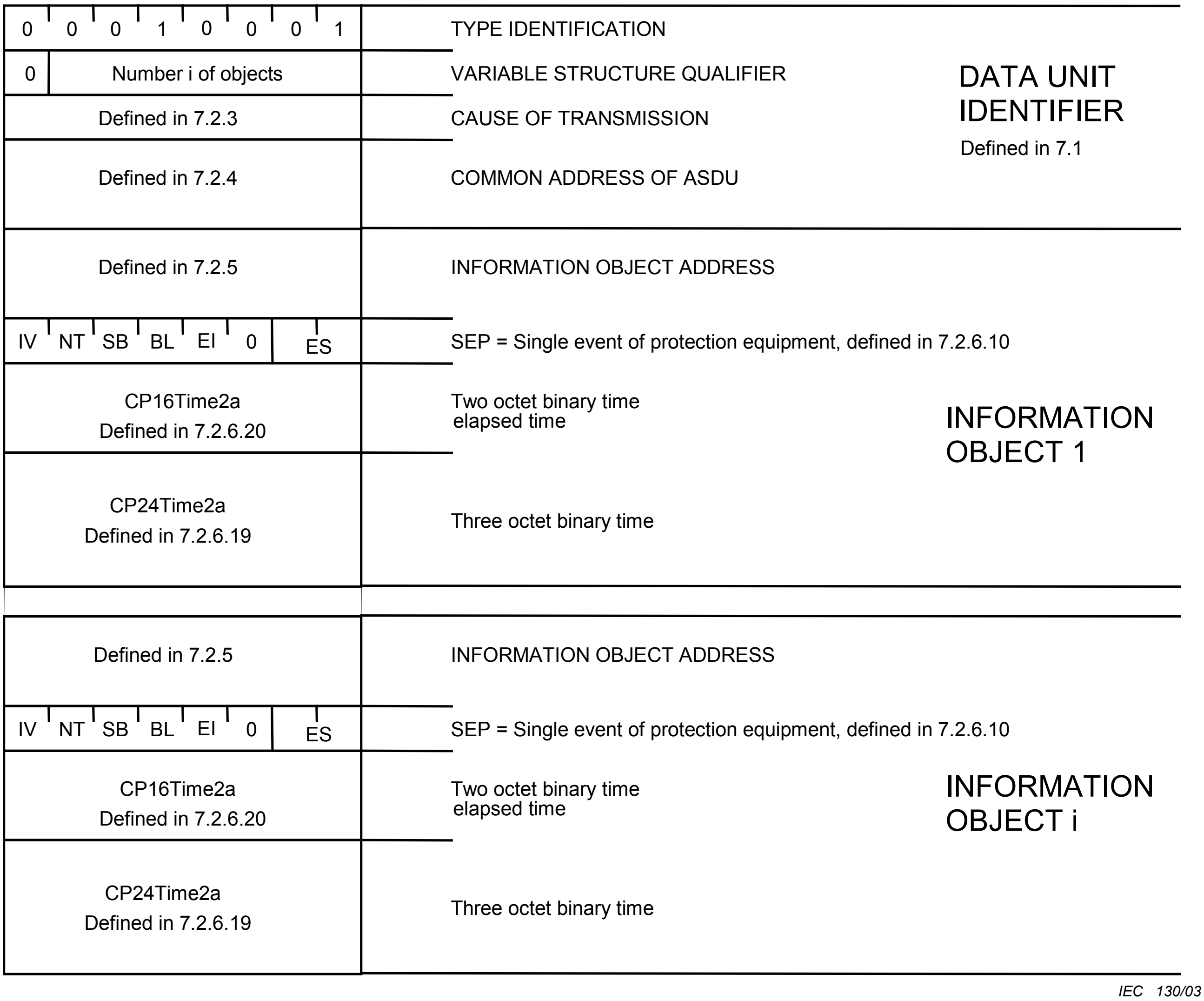


Figure 46 – ASDU: M_EP_TA_1 Event of protection equipment with time tag

M_EP_TA_1 := CP{Data unit identifier,i(Information object address,SEP,CP16Time2a, CP24Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 17 := M_EP_TA_1

CAUSE OF TRANSMISSION
<3> := spontaneous

Since each event of protection equipment has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.18 TYPE IDENT 18: M_EP_TB_1
Packed start events of protection equipment with time tag

Single information object (SQ = 0)

0 0 0 1 0 0 1 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
0 0 SRD SIE SL3 SL2 SL1 GS	SPE = Start event of protection equipment, defined in 7.2.6.11	
IV NT SB BL EI 0 0 0	QDP = Quality descriptor for events of protection equipment, defined in 7.2.6.4	
CP16Time2a Defined in 7.2.6.20	Relay duration time	
CP24Time2a Defined in 7.2.6.19	Three octet binary time	

IEC 131/03

Figure 47 – ASDU: M_EP_TB_1 Packed start events of protection equipment with time tag

M_EP_TB_1 := CP{Data unit identifier,Information object address,SPE,QDP, CP16Time2a,CP24Time2a}

CAUSES OF TRANSMISSION used with
TYPE IDENT 18 := M_EP_TB_1

CAUSE OF TRANSMISSION
<3> := spontaneous

7.3.1.19 TYPE IDENT 19: M_EP_TC_1
Packed output circuit information of protection equipment with time tag

Single information object (SQ = 0)

0 0 0 1 0 0 1 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
0 0 0 0 CL3 CL2 CL1 GC	OCI = Output circuit information of protection equipment, defined in 7.2.6.12	
IV NT SB BL EI 0 0 0	QDP = Quality descriptor of protection equipment, defined in 7.2.6.4	
CP16Time2a Defined in 7.2.6.20	Relay operating time	
CP24Time2a Defined in 7.2.6.19	Three octet binary time	

IEC 132/03

Figure 48 – ASDU: M_EP_TC_1 Packed output circuit information of protection equipment with time tag

M_EP_TC_1 := CP{Data unit identifier,Information object address,OCI,QDP, CP16Time2a,CP24Time2a}

CAUSES OF TRANSMISSION used with

TYPE IDENT 19 := M_EP_TC_1

CAUSE OF TRANSMISSION

<3> := spontaneous

7.3.1.20 TYPE IDENT 20: M_PS_NA_1
Packed single-point information with status change detection

Sequence of information objects (SQ = 0)

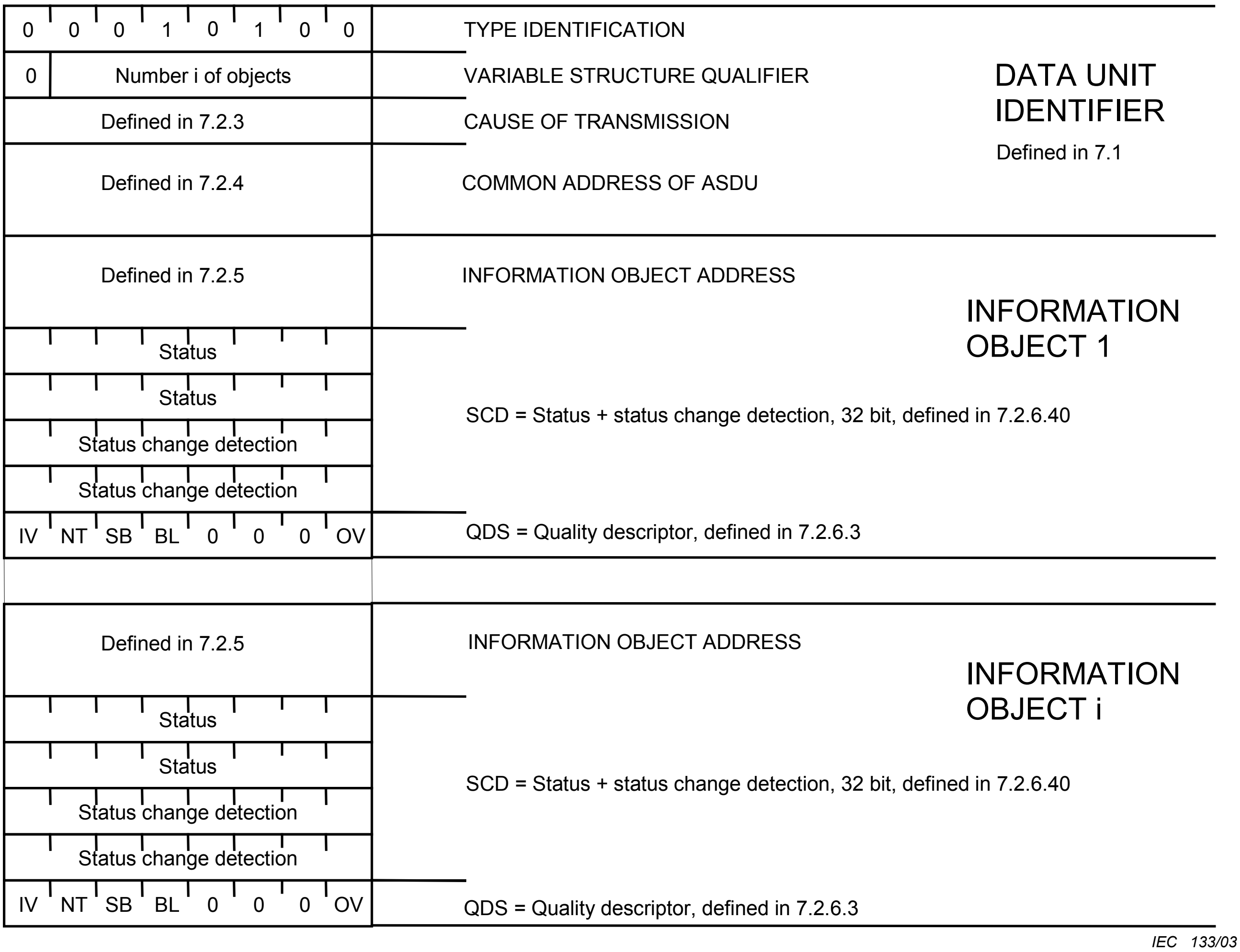


Figure 49 – ASDU: M_PS_NA_1 Packed single-point information with status change detection

M_PS_NA_1 := CP{Data unit identifier,i(Information object address,SCD,QDS)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)

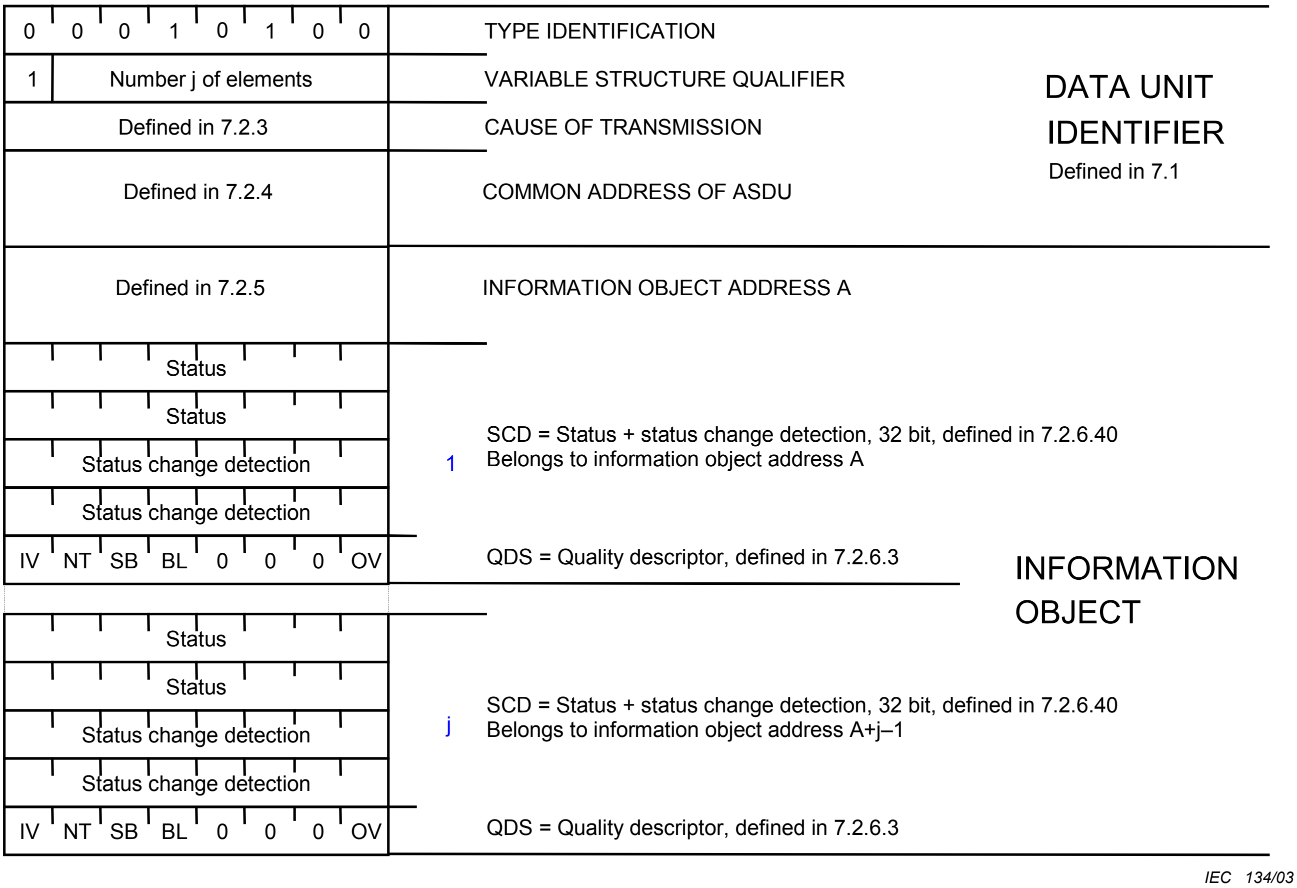


Figure 50 – ASDU: M_PS_NA_1 Sequence of packed single-point information with status change detection

M_PS_NA_1 := CP{Data unit identifier,Information object address,j(SCD,QDS)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 20 := M_PS_NA_1

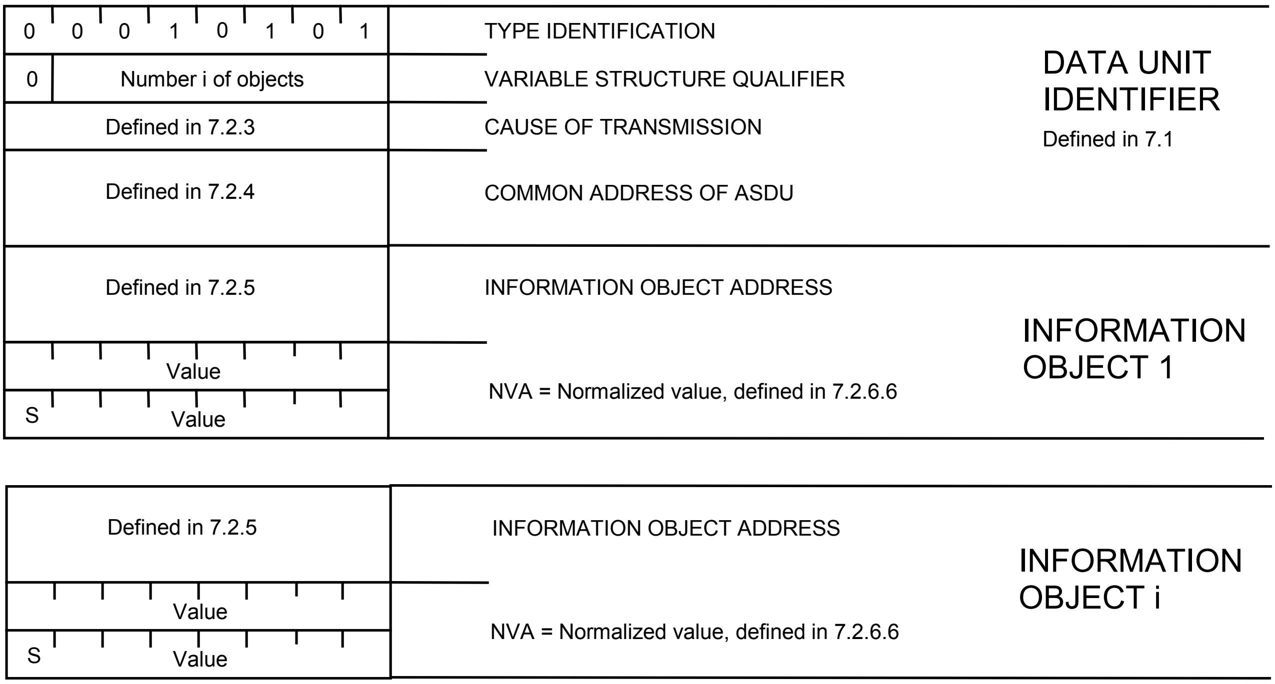
CAUSE OF TRANSMISSION

<2>	:=	background scan
<3>	:=	spontaneous
<5>	:=	requested
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command
<20>	:=	interrogated by station interrogation
<21>	:=	interrogated by group 1 interrogation
<22>	:=	interrogated by group 2 interrogation
up to		
<36>	:=	interrogated by group 16 interrogation

The information object address defines the LSB of the first status byte. The following bits are identified by numbers incrementing continuously by +1 from this offset.

7.3.1.21 TYPE IDENT 21: M_ME_ND_1
Measured value, normalized value without quality descriptor

Sequence of information objects (SQ = 0)

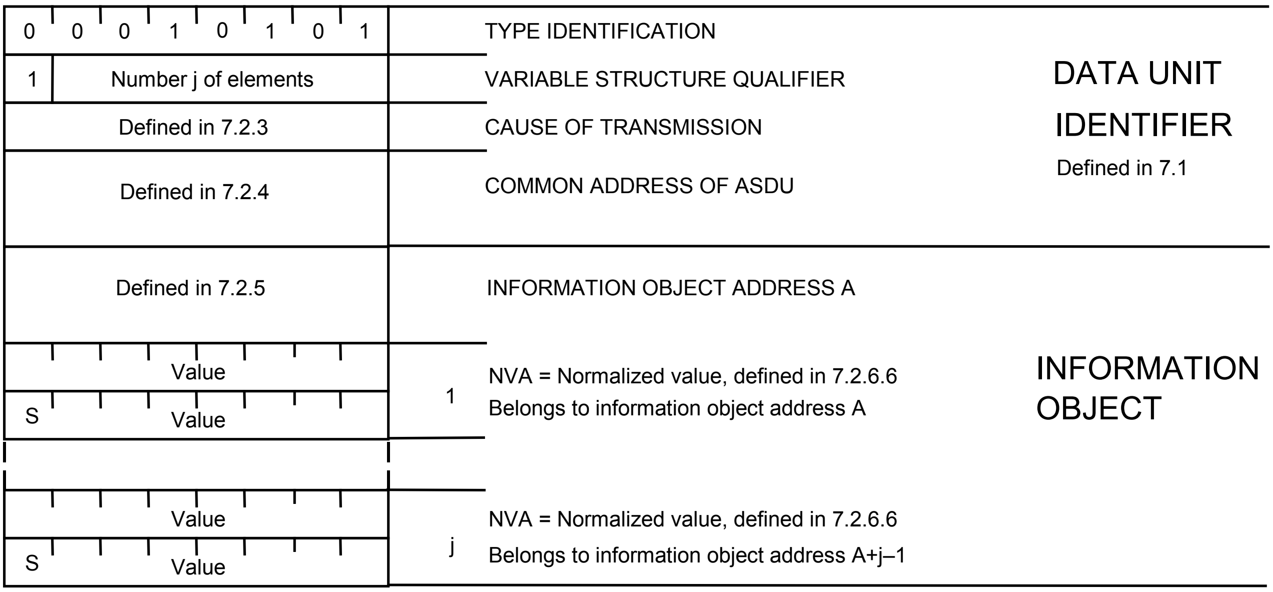


IEC 135/03

Figure 51 – ASDU: M_ME_ND_1
Measured value, normalized value without quality descriptor

M_ME_ND_1 := CP{Data unit identifier,i(Information object address,NVA)}
i := number of objects defined in the variable structure qualifier

Sequence of information elements in a single information object (SQ = 1)



IEC 136/03

Figure 52 – ASDU: M_ME_ND_1 Sequence of measured values, normalized values without quality descriptor

M_ME_ND_1 := CP{Data unit identifier,Information object address,j(NVA)}
j := number of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 21 := M_ME_ND_1

CAUSE OF TRANSMISSION

<1>	:=	periodic/cyclic
<2>	:=	background scan
<3>	:=	spontaneous
<5>	:=	requested
<20>	:=	interrogated by station interrogation
<21>	:=	interrogated by group 1 interrogation
<22>	:=	interrogated by group 2 interrogation
up to		
<36>	:=	interrogated by group 16 interrogation

7.3.1.22 TYPE IDENT 30: M_SP_TB_1

Single-point information with time tag CP56Time2a

Sequence of information objects (SQ = 0)

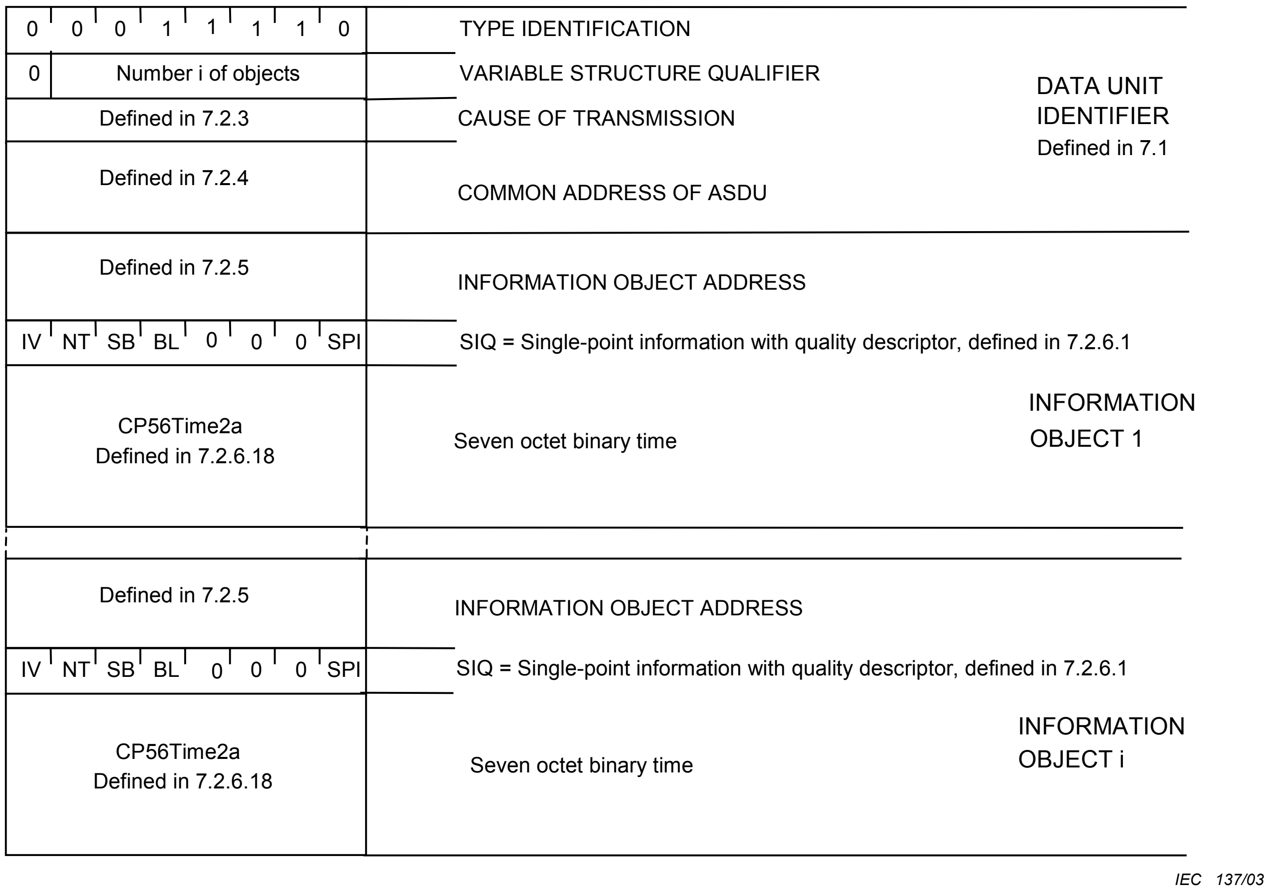


Figure 53 – ASDU: M_SP_TB_1
Single-point information with time tag CP56Time2a

M_SP_TB_1 := CP{Data unit identifier,i(Information object address,SIQ,CP56Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 30 := M_SP_TB_1

CAUSE OF TRANSMISSION

<3> := spontaneous
<5> := requested
<11> := return information caused by a remote command
<12> := return information caused by a local command

Since each single-point information has its individual time tag, this type of ASDU does not exist as a sequence of information elements (SQ = 1).

7.3.1.23 TYPE IDENT 31: M_DP_TB_1
Double-point information with time tag CP56Time2a

Sequence of information objects (SQ = 0)

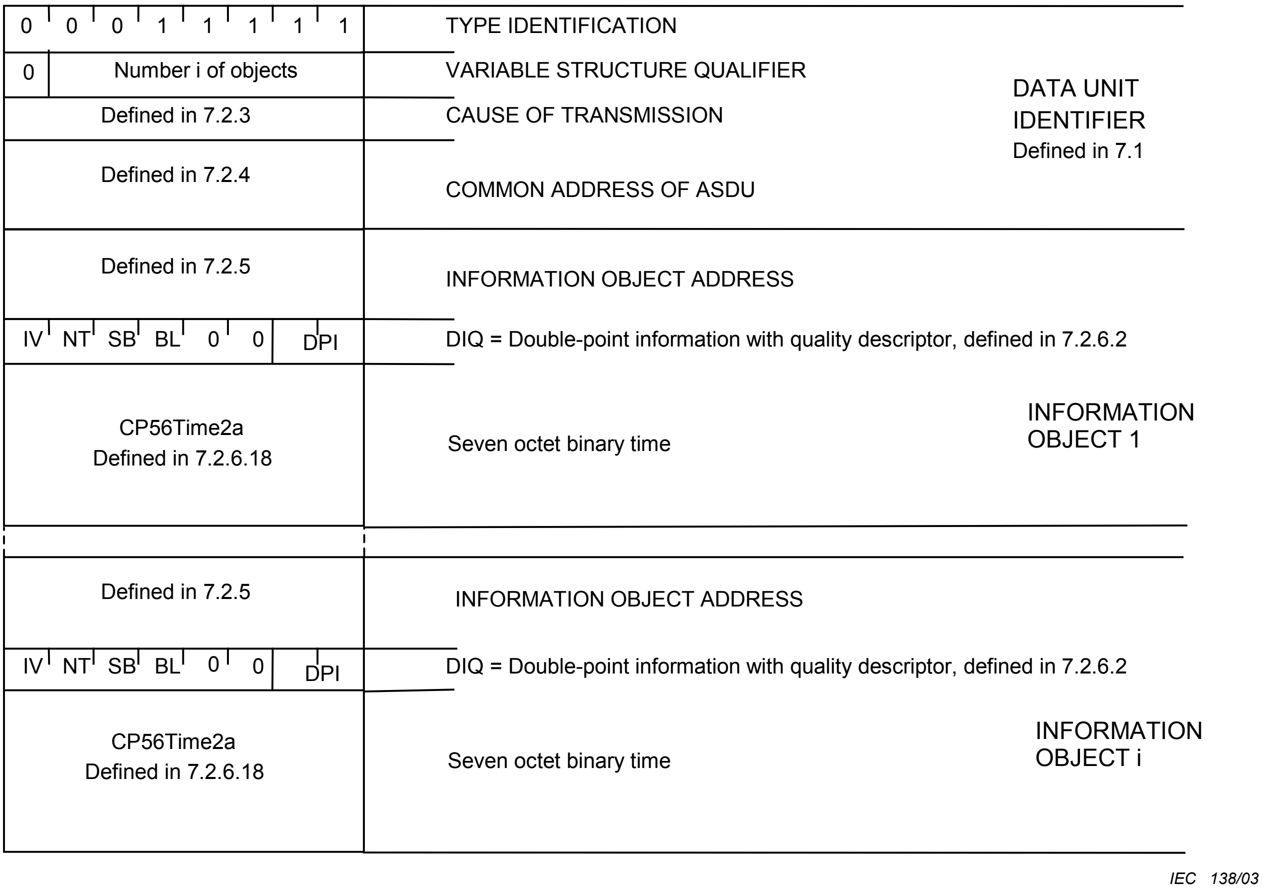


Figure 54 – ASDU: M_DP_TB_1
Double-point information with time tag CP56Time2a

M_DP_TB_1 := CP{Data unit identifier,i(Information object address,DIQ,CP56Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 31 := M_DP_TB_1

CAUSE OF TRANSMISSION
<3> := spontaneous
<5> := requested
<11> := return information caused by a remote command
<12> := return information caused by a local command

Since each double-point information has its individual time tag, this type of ASDU does not exist as a sequence of information elements (SQ = 1).

7.3.1.24 TYPE IDENT 32: M_ST_TB_1
Step position information with time tag CP56Time2a

Sequence of information objects (SQ = 0)

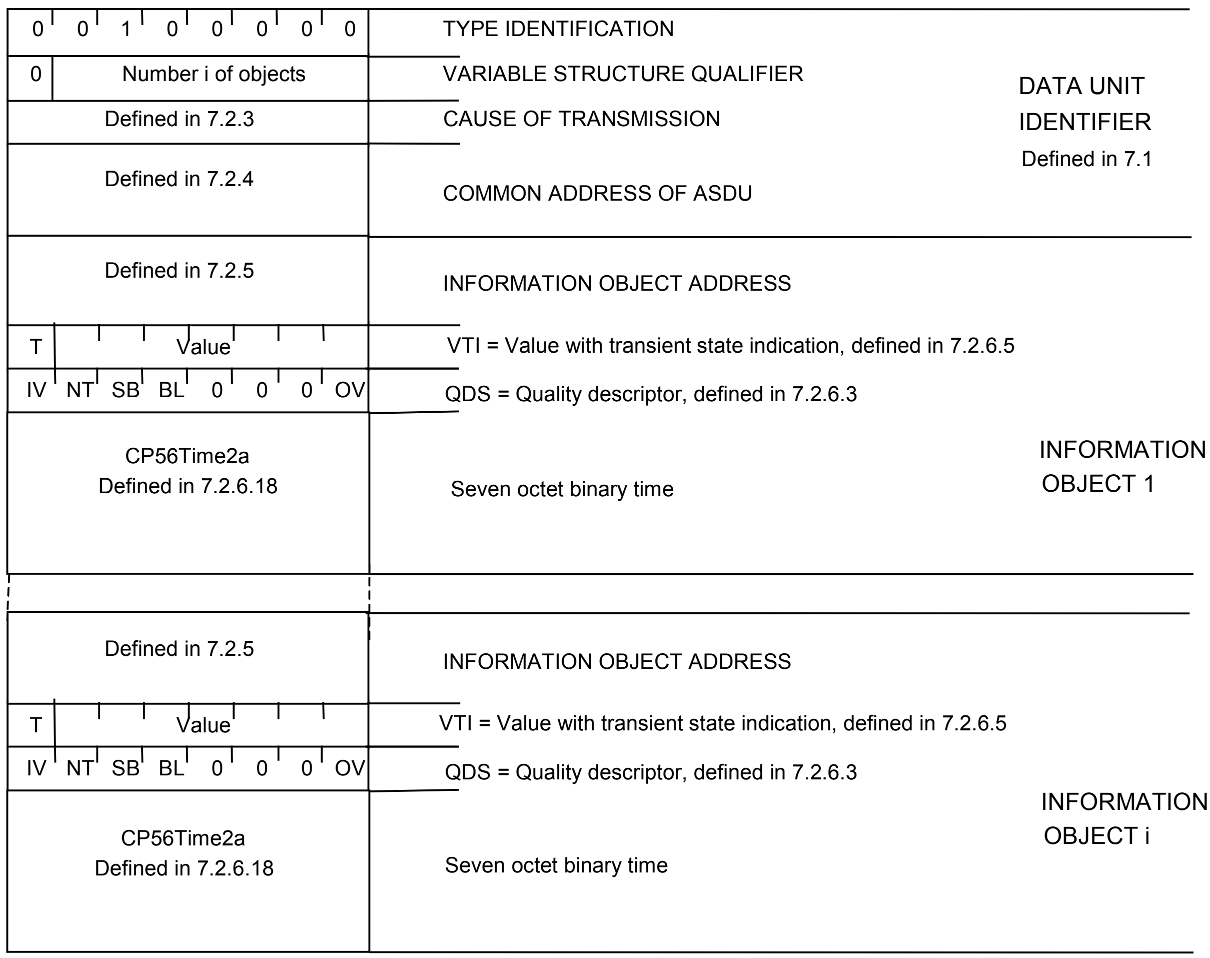


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Figure 55 – ASDU: M_ST_TB_1
Step position information with time tag CP56Time2a

M_ST_TB_1 := CP{Data unit identifier,i(Information object address,VTI,QDS,CP56Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 32 := M_ST_TB_1

CAUSE OF TRANSMISSION

<3>	:=	spontaneous
<5>	:=	requested
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command

Since each step position information has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.25 TYPE IDENT 33: M_BO_TB_1
Bitstring of 32 bits with time tag CP56Time2a

Sequence of information objects (SQ = 0)

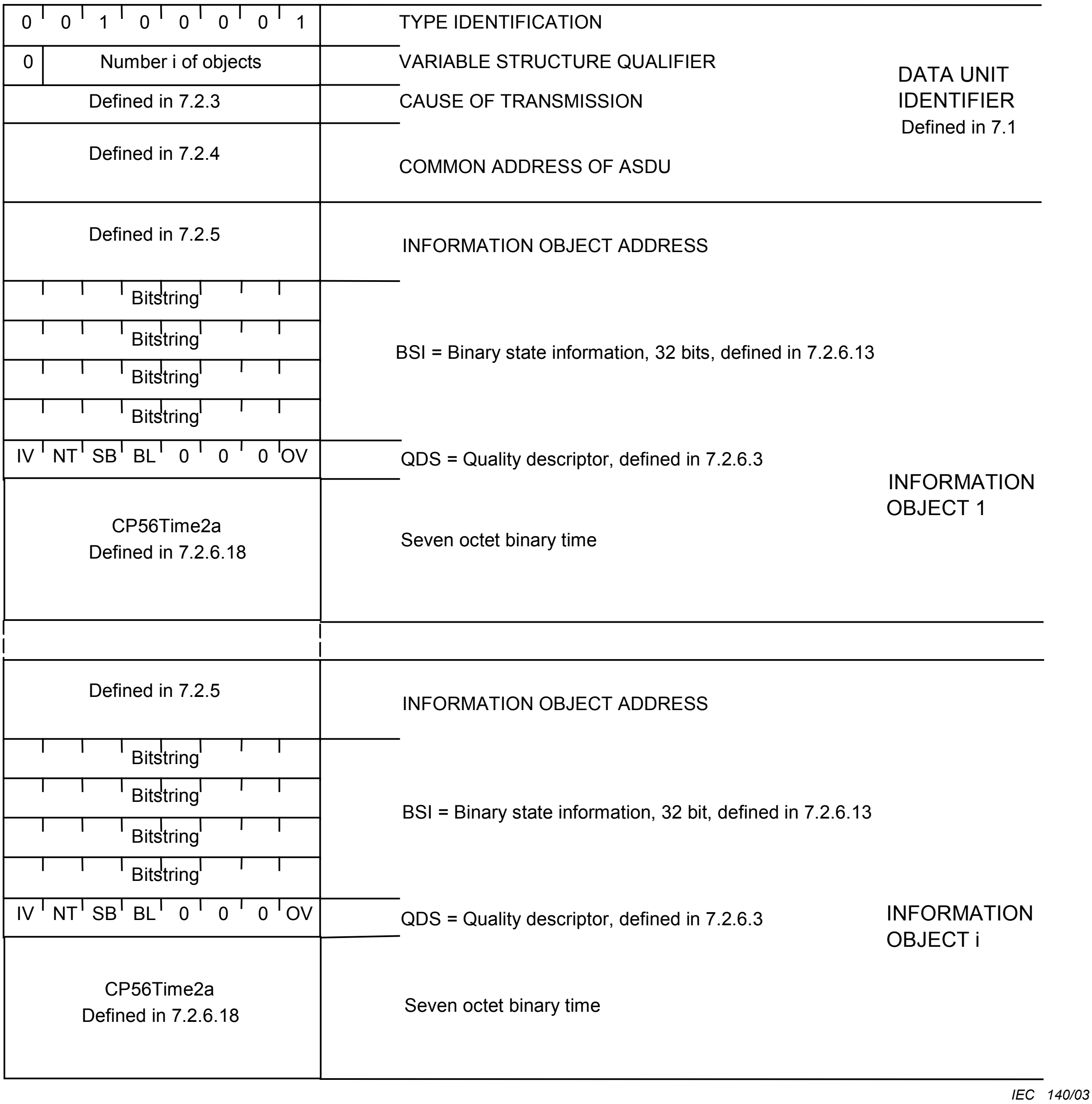

Figure 56 – ASDU: M_BO_TB_1
Bitstring of 32 bits with time tag CP56Time2a

M_BO_TB_1 := CP{Data unit identifier,i(Information object address,BSI,QDS, CP56Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 33 := M_BO_TB_1

CAUSE OF TRANSMISSION
<3> := spontaneous
<5> := requested

Since each bitstring has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.26 TYPE IDENT 34: M_ME_TD_1
Measured value, normalized value with time tag CP56Time2a

Sequence of information objects (SQ = 0)

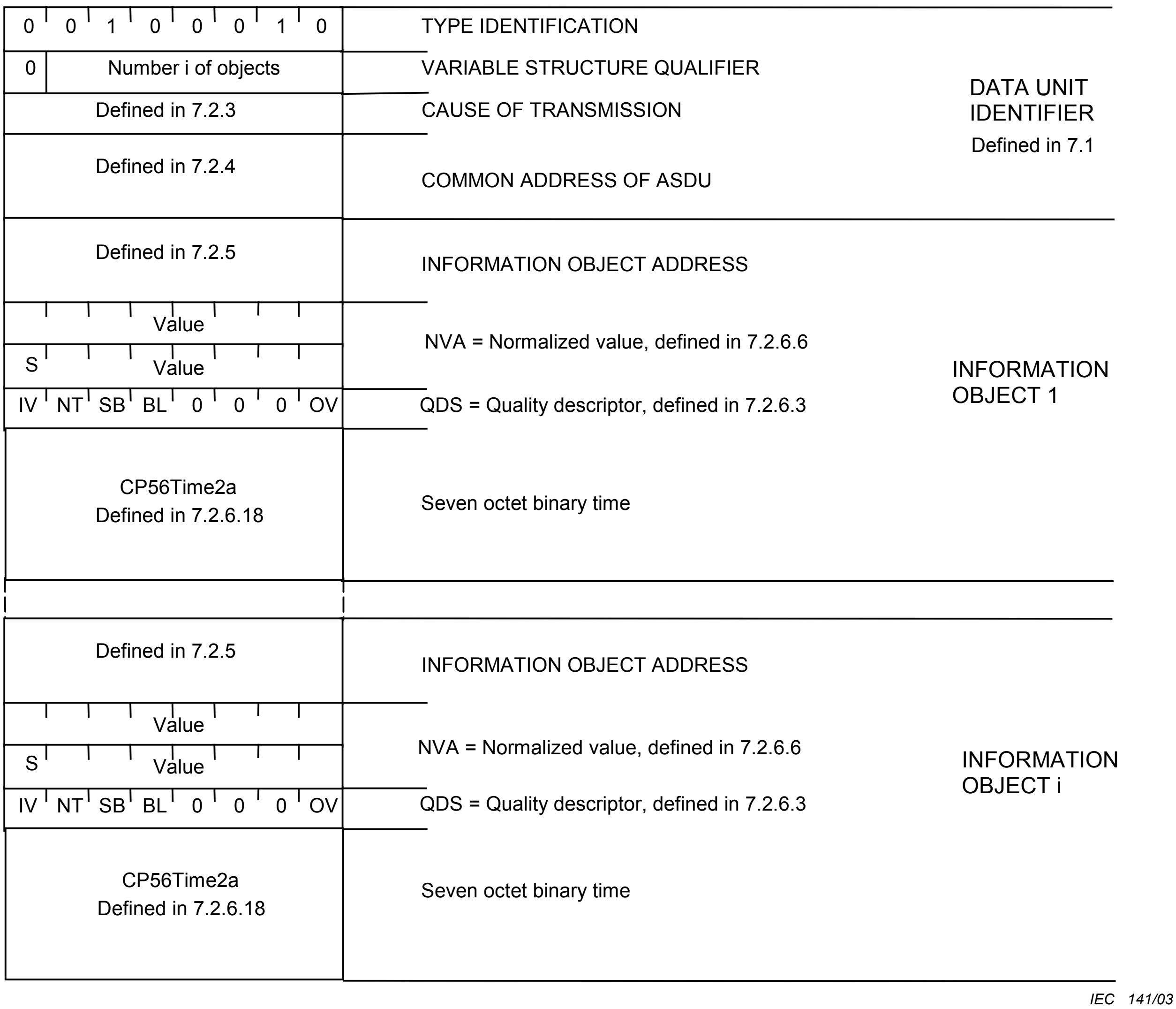

Figure 57 – ASDU: M_ME_TD_1
Measured value, normalized value with time tag CP56Time2a

M_ME_TD_1:= CP{Data unit identifier,i(Information object address,NVA,QDS,
CP56Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 34 := M_ME_TD_1

CAUSE OF TRANSMISSION
<3> := spontaneous
<5> := requested

Since each measured value has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.27 TYPE IDENT 35: M_ME_TE_1
Measured value, scaled value with time tag CP56Time2a

Sequence of information objects (SQ = 0)

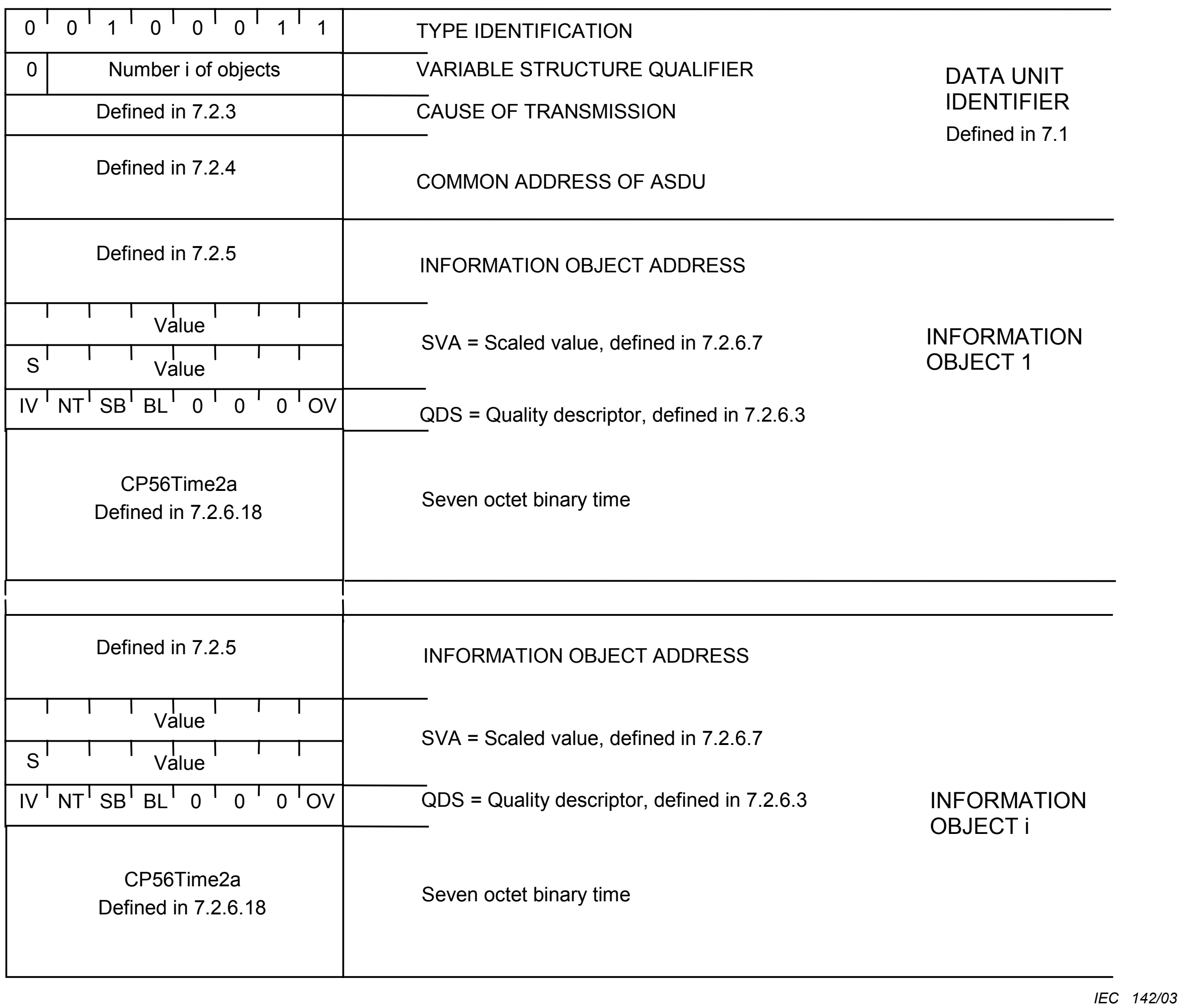

Figure 58 – ASDU: M_ME_TE_1
Measured value, scaled value with time tag CP56Time2a

M_ME_TE_1 := CP{Data unit identifier,i(Information object address,SVA,QDS, CP56Time2a)}

i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 35 := M_ME_TE_1

CAUSE OF TRANSMISSION

<3> := spontaneous

<5> := requested

Since each measured value has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.28 TYPE IDENT 36: M_ME_TF_1
Measured value, short floating point number with time tag CP56Time2a

Sequence of information objects (SQ = 0)

0 0 1 0 0 1 0 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 | Number i of objects	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT 1
Fraction	IEEE STD 754 = Short floating point number, defined in 7.2.6.8	
Fraction		
E Fraction		
S Exponent		
IV NT SB BL 0 0 0 OV	QDS = Quality descriptor, defined in 7.2.6.3	
CP56Time2a Defined in 7.2.6.18	Seven octet binary time	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT i
Fraction	IEEE STD 754 = Short floating point number, defined in 7.2.6.8	
Fraction		
E Fraction		
S Exponent		
IV NT SB BL 0 0 0 OV	QDS = Quality descriptor, defined in 7.2.6.3	
CP56Time2a Defined in 7.2.6.18	Seven octet binary time	

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Figure 59 – ASDU: M_ME_TF_1
Measured value, short floating point number with time tag CP56Time2a

M_ME_TF_1 := CP{Data unit identifier,i(Information object address,IEEE STD 754, QDS,CP56Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 36 := M_ME_TF_1

CAUSE OF TRANSMISSION
<3> := spontaneous
<5> := requested

Since each measured value has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.29 TYPE IDENT 37: M_IT_TB_1
Integrated totals with time tag CP56Time2a

Sequence of information objects (SQ = 0)

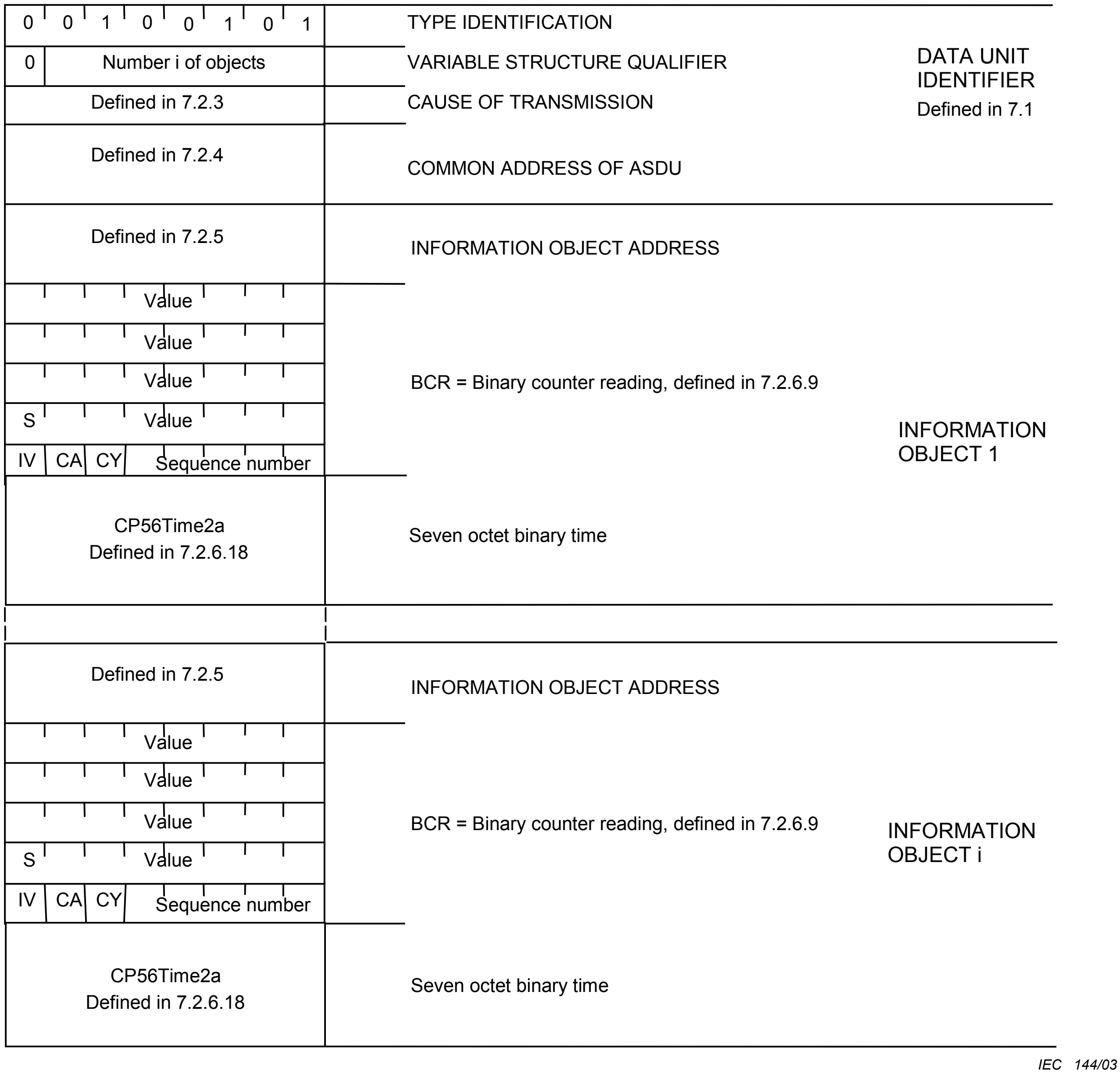

Figure 60 – ASDU: M_IT_TB_1
Integrated totals with time tag CP56Time2a

M_IT_TB_1 := CP{Data unit identifier,i(Information object address,BCR,CP56Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 37 := M_IT_TB_1

CAUSE OF TRANSMISSION

<3> := spontaneous
<37> := requested by general counter request
<38> := requested by group 1 counter request
<39> := requested by group 2 counter request
<40> := requested by group 3 counter request
<41> := requested by group 4 counter request

Since each integrated total has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.30 TYPE IDENT 38: M_EP_TD_1
Event of protection equipment with time tag CP56Time2a

Sequence of information objects (SQ = 0)

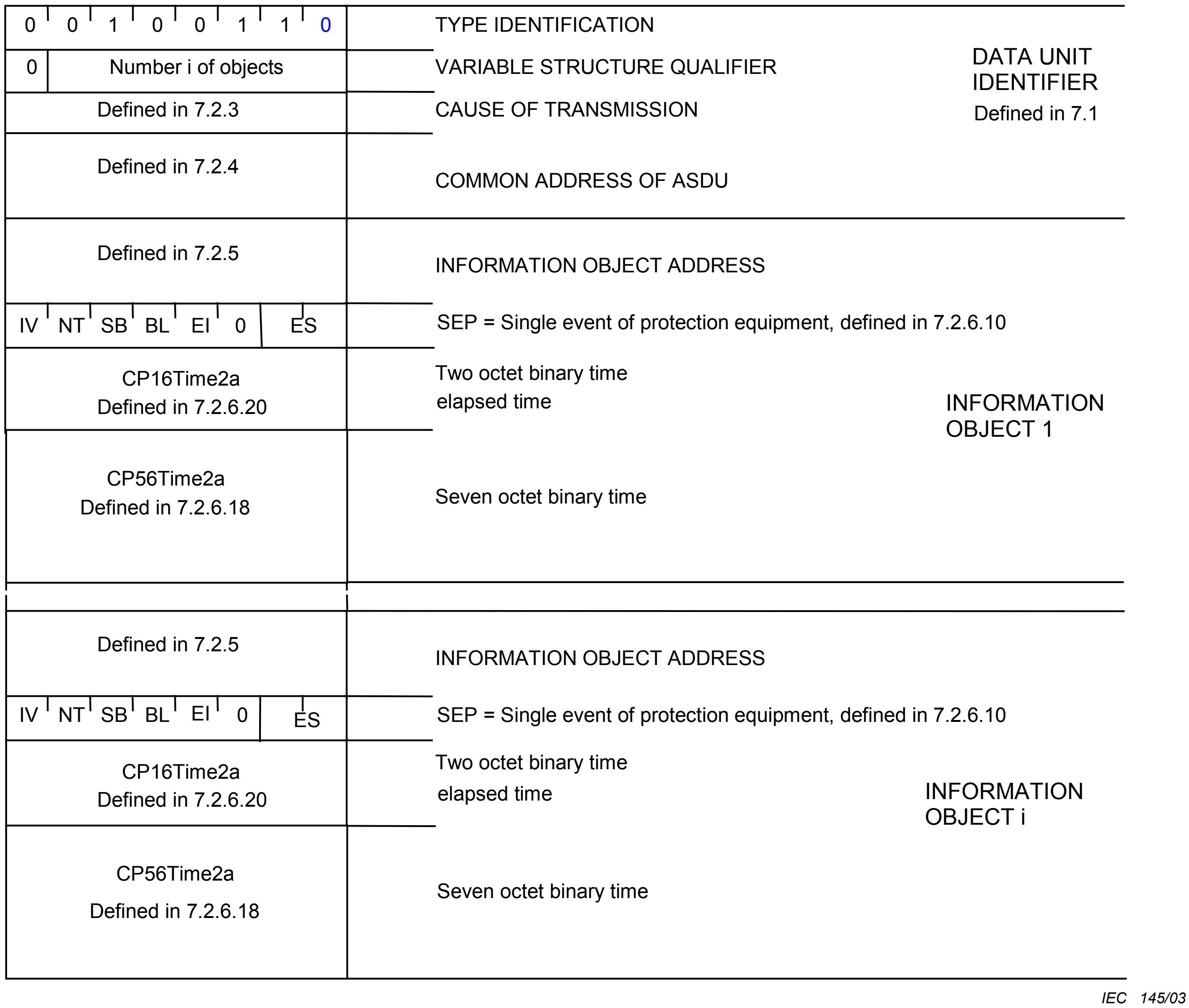

Figure 61 – ASDU: M_EP_TD_1
Event of protection equipment with time tag CP56Time2a

M_EP_TD_1 := CP{Data unit identifier,i(Information object address,SEP,CP16Time2a, CP56Time2a)}
i := number of objects defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with

TYPE IDENT 38 := M_EP_TD_1

CAUSE OF TRANSMISSION

<3>:= spontaneous

Since each event of protection equipment has its individual time tag, this type of ASDU does not exist as a sequence of information elements.

7.3.1.31 TYPE IDENT 39: M_EP_TE_1
Packed start events of protection equipment with time tag CP56Time2a

Single information object (SQ = 0)

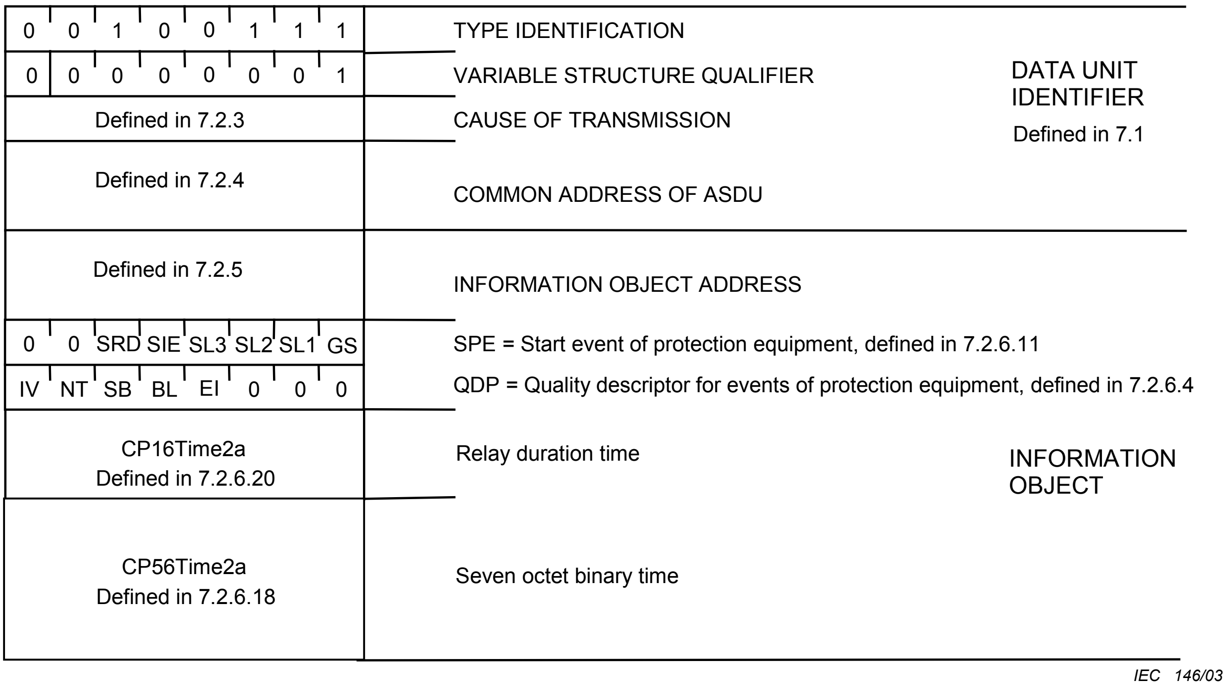

Figure 62 – ASDU: M_EP_TE_1
Packed start events of protection equipment with time tag CP56Time2a

M_EP_TE_1 := CP{Data unit identifier,Information object address,SPE,QDP,
CP16Time2a,CP56Time2a}

CAUSES OF TRANSMISSION used with

TYPE IDENT 39 := M_EP_TE_1

CAUSE OF TRANSMISSION

<3> := spontaneous

7.3.1.32 TYPE IDENT 40: M_EP_TF_1
Packed output circuit information of protection equipment with time tag CP56Time2a

Single information object (SQ = 0)

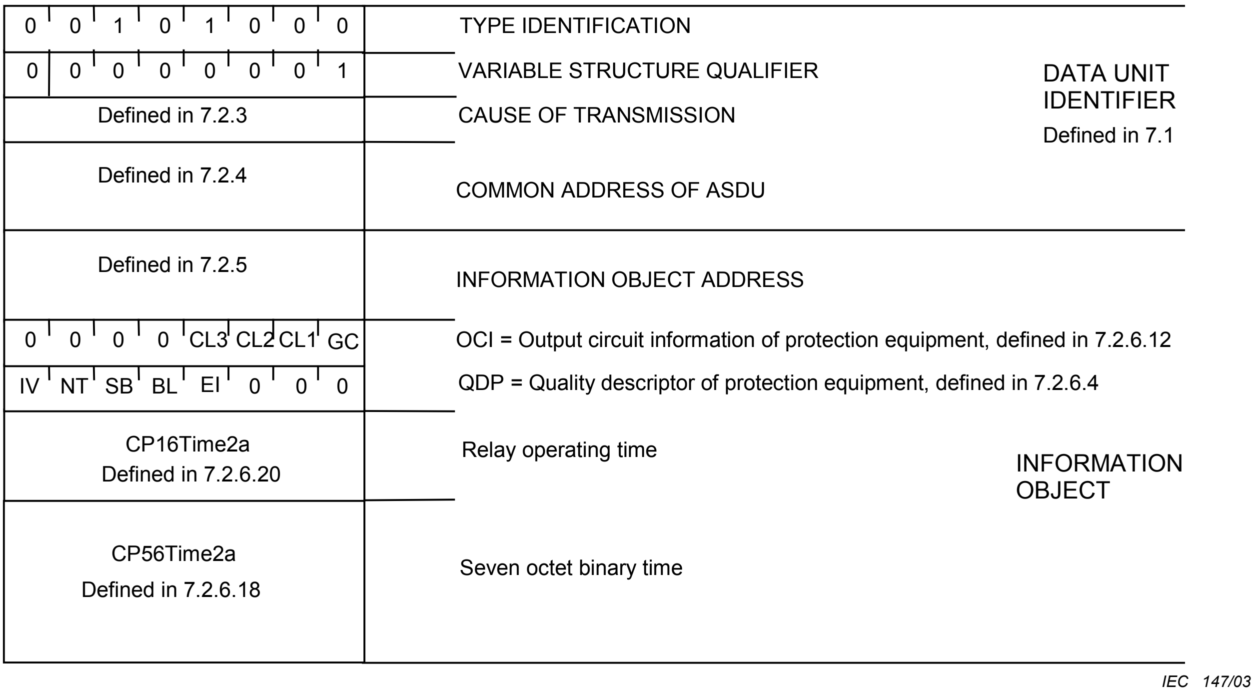

Figure 63 – ASDU: M_EP_TF_1
Packed output circuit information of protection equipment with time tag CP56Time2a

M_EP_TF_1 := CP{Data unit identifier,Information object address,OCI,QDP, CP16Time2a,CP56Time2a}

CAUSES OF TRANSMISSION used with

TYPE IDENT 40 := M_EP_TF_1

CAUSE OF TRANSMISSION
<3> := spontaneous

7.3.2 ASDUs for process information in control direction

7.3.2.1 TYPE IDENT 45: C_SC_NA_1
Single command

Single information object (SQ = 0)

0 0 1 0 1 1 0 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 | 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
S/E | QU | 0 | SCS	SCO = Single command, defined in 7.2.6.15	

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Figure 64 – ASDU: C_SC_NA_1 Single command

C_SC_NA_1 := CP{Data unit identifier,Information object address,SCO}

CAUSES OF TRANSMISSION used with

TYPE IDENT 45 := C_SC_NA_1

CAUSE OF TRANSMISSION

in control direction:

<6> := activation
<8> := deactivation

in monitor direction:

<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.2.2 TYPE IDENT 46: C_DC_NA_1
Double command

Single information object (SQ = 0)

0 0 1 0 1 1 1 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 | 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
S/E | QU | DCS	DCO = Double command, defined in 7.2.6.16	

IEC 149/03

Figure 65 – ASDU: C_DC_NA_1 Double command

C_DC_NA_1 := CP{Data unit identifier,Information object address,DCO}

CAUSES OF TRANSMISSION used with

TYPE IDENT 46 := C_DC_NA_1

CAUSE OF TRANSMISSION

in control direction:

<6> := activation
<8> := deactivation

in monitor direction:

<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.2.3 TYPE IDENT 47: C_RC_NA_1 Regulating step command

Single information object (SQ = 0)

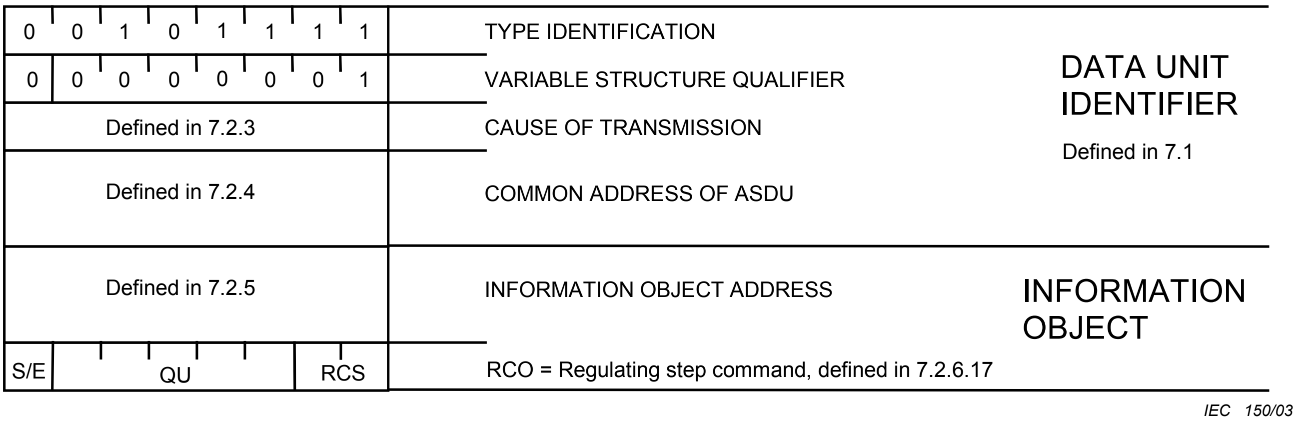


Figure 66 – ASDU: C_RC_NA_1 Regulating step command

C_RC_NA_1 := CP{Data unit identifier,Information object address,RCO}

CAUSES OF TRANSMISSION used with

TYPE IDENT 47 := C_RC_NA_1

CAUSE OF TRANSMISSION

in control direction:

<6> := activation
<8> := deactivation

in monitor direction:

<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.2.4 TYPE IDENT 48: C_SE_NA_1
Set-point command, normalized value

Single information object (SQ = 0)

0 0 1 1 0 0 0 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 | 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
Value	NVA = Normalized value, defined in 7.2.6.6	
S | Value		
S/E | QL	QOS = Qualifier of set-point command, defined in 7.2.6.39	

IEC 151/03

Figure 67 – ASDU: C_SE_NA_1 Set-point command, normalized value

C_SE_NA_1 := CP{Data unit identifier,Information object address,NVA,QOS}

CAUSES OF TRANSMISSION used with

TYPE IDENT 48 := C_SE_NA_1

CAUSE OF TRANSMISSION

in control direction:

<6> := activation
<8> := deactivation

in monitor direction:

<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination (opt)
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.2.5 TYPE IDENT 49: C_SE_NB_1
Set-point command, scaled value

Single information object (SQ = 0)

0 0 1 1 0 0 0 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 | 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
Value	SVA = Scaled value, defined in 7.2.6.7	
S | Value		
S/E | QL	QOS = Qualifier of set-point command, defined in 7.2.6.39	

IEC 152/03

Figure 68 – ASDU: C_SE_NB_1 Set-point command, scaled value

C_SE_NB_1 := CP{Data unit identifier,Information object address,SVA,QOS}

CAUSES OF TRANSMISSION used with
TYPE IDENT 49 := C_SE_NB_1

CAUSE OF TRANSMISSION

in control direction:
<6> := activation
<8> := deactivation

in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination (opt)
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.2.6 TYPE IDENT 50: C_SE_NC_1
Set-point command, short floating point number

Single information object (SQ = 0)

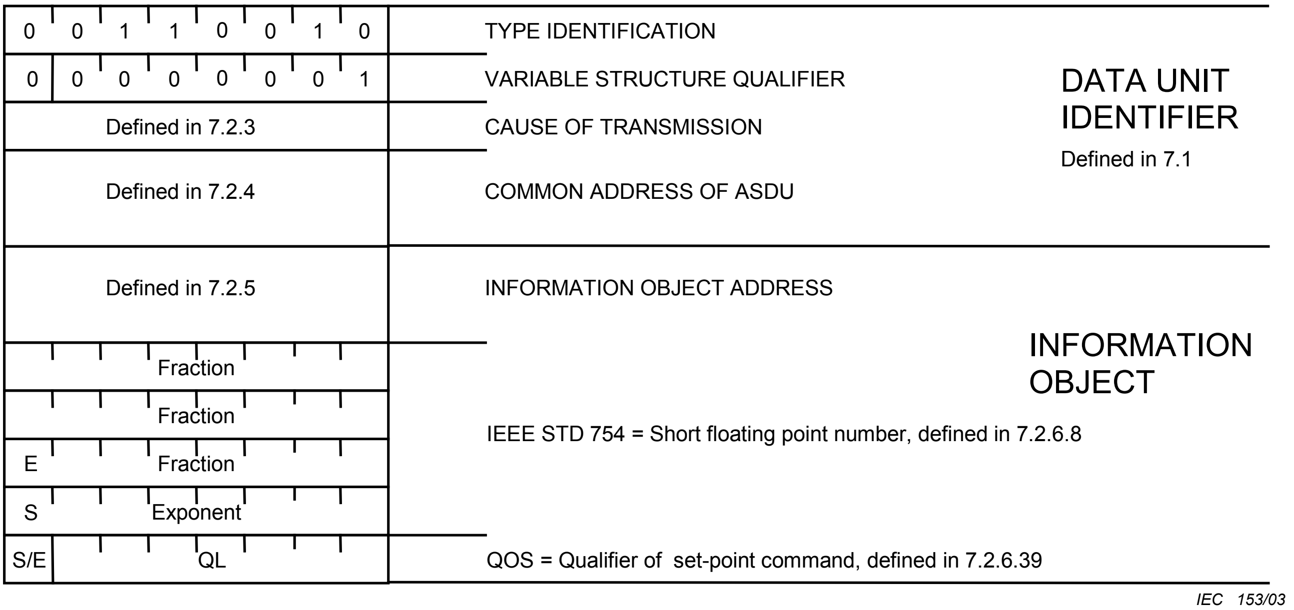


Figure 69 – ASDU: C_SE_NC_1 Set-point command, short floating point number

C_SE_NC_1 := CP{Data unit identifier,Information object address,IEEE STD 754,QOS}

CAUSES OF TRANSMISSION used with
TYPE IDENT 50 := C_SE_NC_1

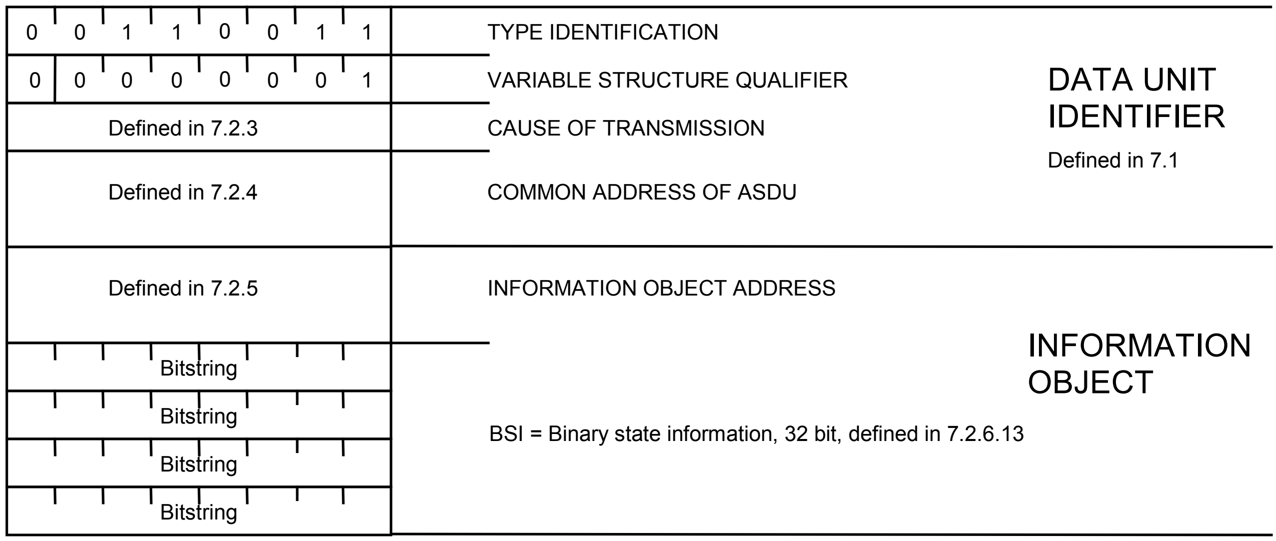
CAUSE OF TRANSMISSION

in control direction:
<6> := activation
<8> := deactivation

in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination (opt)
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.2.7 TYPE IDENT 51: C_BO_NA_1
Bitstring of 32 bit

Single information object (SQ = 0)



IEC 154/03

Figure 70 – ASDU: C_BO_NA_1 Bitstring of 32 bit

C_BO_NA_1 := CP{Data unit identifier,Information object address,BSI}

CAUSES OF TRANSMISSION used with
TYPE IDENT 51 := C_BO_NA_1

CAUSE OF TRANSMISSION

in control direction:
<6> := activation
<8> := deactivation

in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination (opt)
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.3 ASDUs for system information in monitor direction

7.3.3.1 TYPE IDENT 70: **M_EI_NA_1**
End of initialization

Single information object (SQ = 0)

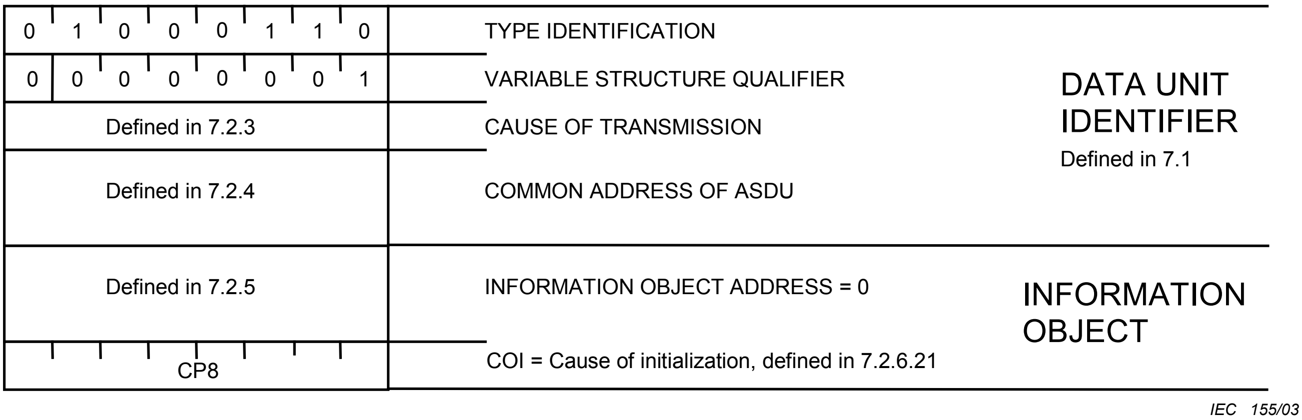


Figure 71 – ASDU: M_EI_NA_1 End of initialization

M_EI_NA_1 := CP{Data unit identifier,Information object address,COI}

CAUSES OF TRANSMISSION used with
TYPE IDENT 70 := M_EI_NA_1

CAUSE OF TRANSMISSION
<4> := initialized

7.3.4 ASDUs for system information in control direction

7.3.4.1 TYPE IDENT 100: C_IC_NA_1
Interrogation command

Single information object (SQ = 0)

0 1 1 0 0 1 0 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS = 0	INFORMATION OBJECT
UI8	QOI = Qualifier of interrogation, defined in 7.2.6.22	

IEC 156/03

Figure 72 – ASDU: C_IC_NA_1 Interrogation command

C_IC_NA_1 := CP{Data unit identifier,Information object address,QOI}

CAUSES OF TRANSMISSION used with
TYPE IDENT 100 := C_IC_NA_1

CAUSE OF TRANSMISSION

in control direction:
- <6> := activation
- <8> := deactivation

in monitor direction:
- <7> := activation confirmation
- <9> := deactivation confirmation
- <10> := activation termination
- <44> := unknown type identification
- <45> := unknown cause of transmission
- <46> := unknown common address of ASDU
- <47> := unknown information object address

7.3.4.2 TYPE IDENT 101: C_CI_NA_1
Counter interrogation command

Single information object (SQ = 0)

0 1 1 0 0 1 0 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS = 0	INFORMATION OBJECT
CP8	QCC = Qualifier of counter interrogation command, defined in 7.2.6.23	

IEC 157/03

Figure 73 – ASDU: C_CI_NA_1 Counter interrogation command

C_CI_NA_1 := CP{Data unit identifier,Information object address,QCC}

CAUSES OF TRANSMISSION used with
TYPE IDENT 101 := C_CI_NA_1

CAUSE OF TRANSMISSION

in control direction:
<6> := activation
<8> := deactivation

in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.4.3 TYPE IDENT 102: C_RD_NA_1
Read command

Single information object (SQ = 0)

0	1	1	0	0	1	1	0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0	0	0	0	0	0	0	1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3								CAUSE OF TRANSMISSION	
Defined in 7.2.4								COMMON ADDRESS OF ASDU	
Defined in 7.2.5								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT

IEC 158/03

Figure 74 – ASDU: C_RD_NA_1 Read command

C_RD_NA_1 := CP{Data unit identifier,Information object address}

CAUSES OF TRANSMISSION used with
TYPE IDENT 102 := C_RD_NA_1

CAUSE OF TRANSMISSION

in control direction:
<5> := request

in monitor direction:
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.4.4 TYPE IDENT 103: C_CS_NA_1
Clock synchronization command

Single information object (SQ = 0)

0 1 1 0 0 1 1 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS = 0	INFORMATION OBJECT
CP56Time2a Defined in 7.2.6.18	Seven octet binary time (date and clock time in milliseconds up to years)	

IEC 159/03

Figure 75 – ASDU: C_CS_NA_1 Clock synchronization command

C_CS_NA_1 := CP{Data unit identifier,Information object address,CP56Time2a}

CAUSES OF TRANSMISSION used with
TYPE IDENT 103 := C_CS_NA_1

CAUSE OF TRANSMISSION

in control direction:
<6> := activation

in monitor direction:
<3> := spontaneous
<7> := activation confirmation
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

In addition to the procedure shown in 6.7 of IEC 60870-5-5, C_CS_NA_1 may be used in the monitor direction for spontaneous transmission of the clock time. For example to indicate the change of hour at an outstation, thus enabling messages to be stored for more than 1 h in an outstation without ambiguity.

7.3.4.5 TYPE IDENT 104: C_TS_NA_1
Test command

Single information object (SQ = 0)

0 1 1 0 1 0 0 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS = 0	INFORMATION OBJECT
1 0 1 0 1 0 1 0	FBP = Fixed test bit pattern, defined in 7.2.6.14	
0 1 0 1 0 1 0 1		

IEC 160/03

Figure 76 – ASDU: C_TS_NA_1 Test command

C_TS_NA_1 := CP{Data unit identifier,Information object address,FBP}

CAUSES OF TRANSMISSION used with
TYPE IDENT 104 := C_TS_NA_1

CAUSE OF TRANSMISSION

in control direction:

<6> := activation

in monitor direction:

<7> := activation confirmation
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.4.6 TYPE IDENT 105: C_RP_NA_1
Reset process command

Single information object (SQ = 0)

0 1 1 0 1 0 0 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS = 0	INFORMATION OBJECT
UI8	QRP = Qualifier of reset process command, defined in 7.2.6.27	

IEC 161/03

Figure 77 – ASDU: C_RP_NA_1 Reset process command

C_RP_NA_1 := CP{Data unit identifier,Information object address,QRP}

CAUSES OF TRANSMISSION used with
TYPE IDENT 105 := C_RP_NA_1

CAUSE OF TRANSMISSION

in control direction:
<6> := activation

in monitor direction:
<7> := activation confirmation
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.4.7 TYPE IDENT 106: C_CD_NA_1
Delay acquisition command

Single information object (SQ = 0)

0 1 1 0 1 0 1 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS = 0	INFORMATION OBJECT
CP16Time2a Defined in 7.2.6.20	Two octet binary time (milliseconds up to seconds)	

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Figure 78 – ASDU: C_CD_NA_1 Delay acquisition command

C_CD_NA_1 := CP{Data unit identifier,Information object address,CP16Time2a}

CAUSES OF TRANSMISSION used with
TYPE IDENT 106 := C_CD_NA_1

CAUSE OF TRANSMISSION

in control direction:
<3> := spontaneous
<6> := activation

in monitor direction:
<7> := activation confirmation
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.5 ASDUs for parameter in control direction

7.3.5.1 TYPE IDENT 110: P_ME_NA_1
Parameter of measured values, normalized value

Single information object (SQ = 0)

0 1 1 0 1 1 1 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1	
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER		
Defined in 7.2.3	CAUSE OF TRANSMISSION		
Defined in 7.2.4	COMMON ADDRESS OF ASDU		
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT	
Value	NVA = Normalized value, defined in 7.2.6.6		
S Value			
UI8	QPM = Qualifier of parameter of measured values, defined in 7.2.6.24		

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Figure 79 – ASDU: P_ME_NA_1 Parameter of measured values, normalized value

P_ME_NA_1 := CP{Data unit identifier,Information object address,NVA,QPM}

CAUSES OF TRANSMISSION used with
TYPE IDENT 110 := P_ME_NA_1

CAUSE OF TRANSMISSION

in control direction:
<6> := activation

in monitor direction:
<7> := activation confirmation
<20> := interrogated by station interrogation
<21> := interrogated by group 1 interrogation
<22> := interrogated by group 2 interrogation
up to
<36> := interrogated by group 16 interrogation
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.5.2 TYPE IDENT 111: P_ME_NB_1
Parameter of measured values, scaled value

Single information object (SQ = 0)

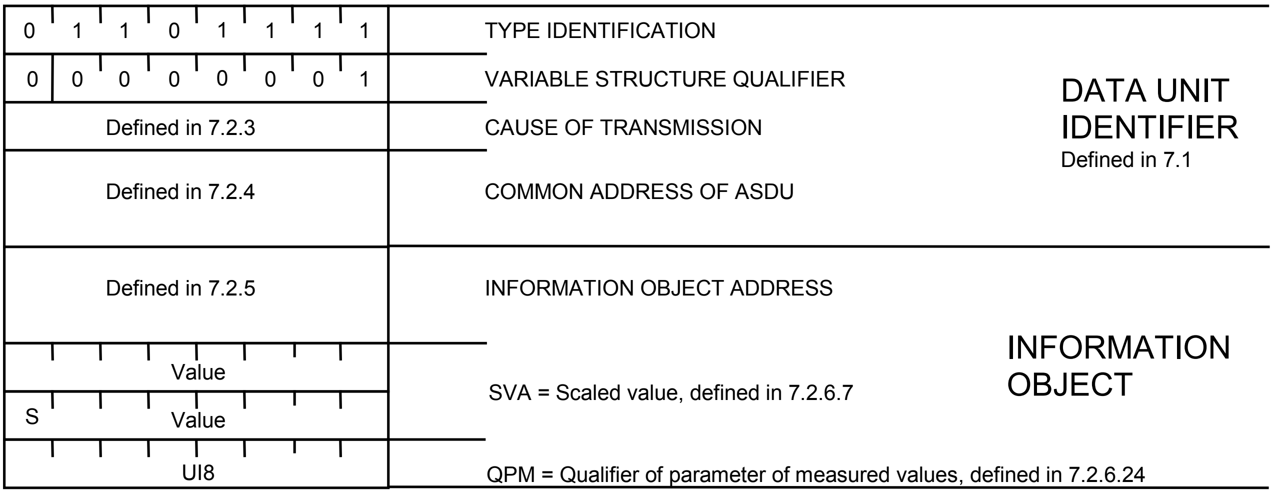

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Figure 80 – ASDU: P_ME_NB_1 Parameter of measured values, scaled value

P_ME_NB_1 := CP{Data unit identifier,Information object address,SVA,QPM}

CAUSES OF TRANSMISSION used with
TYPE IDENT 111 := P_ME_NB_1

CAUSE OF TRANSMISSION

in control direction:

<6> := activation

in monitor direction:

<7> := activation confirmation
<20> := interrogated by station interrogation
<21> := interrogated by group 1 interrogation
<22> := interrogated by group 2 interrogation
up to
<36> := interrogated by group 16 interrogation
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.5.3 TYPE IDENT 112: P_ME_NC_1
Parameter of measured values, short floating point number

Single information object (SQ = 0)

0 1 1 1 0 0 0 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
Fraction	IEEE STD 754 = Short floating point number, defined in 7.2.6.8	
Fraction		
E Fraction		
S Exponent		
CP8	QPM = Qualifier of parameter of measured values, defined in 7.2.6.24	

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Figure 81 – ASDU: P_ME_NC_1
Parameter of measured values, short floating point number

P_ME_NC_1 := CP{Data unit identifier,Information object address,IEEE STD 754,QPM}

CAUSES OF TRANSMISSION used with
TYPE IDENT 112 := P_ME_NC_1

CAUSE OF TRANSMISSION

in control direction:
<6> := activation

in monitor direction:
<7> := activation confirmation
<20> := interrogated by station interrogation
<21> := interrogated by group 1 interrogation
<22> := interrogated by group 2 interrogation
up to
<36> := interrogated by group 16 interrogation
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.5.4 TYPE IDENT 113: P_AC_NA_1
Parameter activation

Single information object (SQ = 0)

0	1	1	1	0	0	0	1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0	0	0	0	0	0	0	1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3								CAUSE OF TRANSMISSION	
Defined in 7.2.4								COMMON ADDRESS OF ASDU	
Defined in 7.2.5								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
UI8								QPA = Qualifier of parameter activation, defined in 7.2.6.25	

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Figure 82 – ASDU: P_AC_NA_1 Parameter activation

P_AC_NA_1 := CP{Data unit identifier,Information object address,QPA}

CAUSES OF TRANSMISSION used with

TYPE IDENT 113 := P_AC_NA_1

CAUSE OF TRANSMISSION

in control direction:

<6> := activation
<8> := deactivation

in monitor direction:

<7> := activation confirmation
<9> := deactivation confirmation
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.6 ASDUs for file transfer

7.3.6.1 TYPE IDENT 120: F_FR_NA_1
File ready

Single information object (SQ = 0)

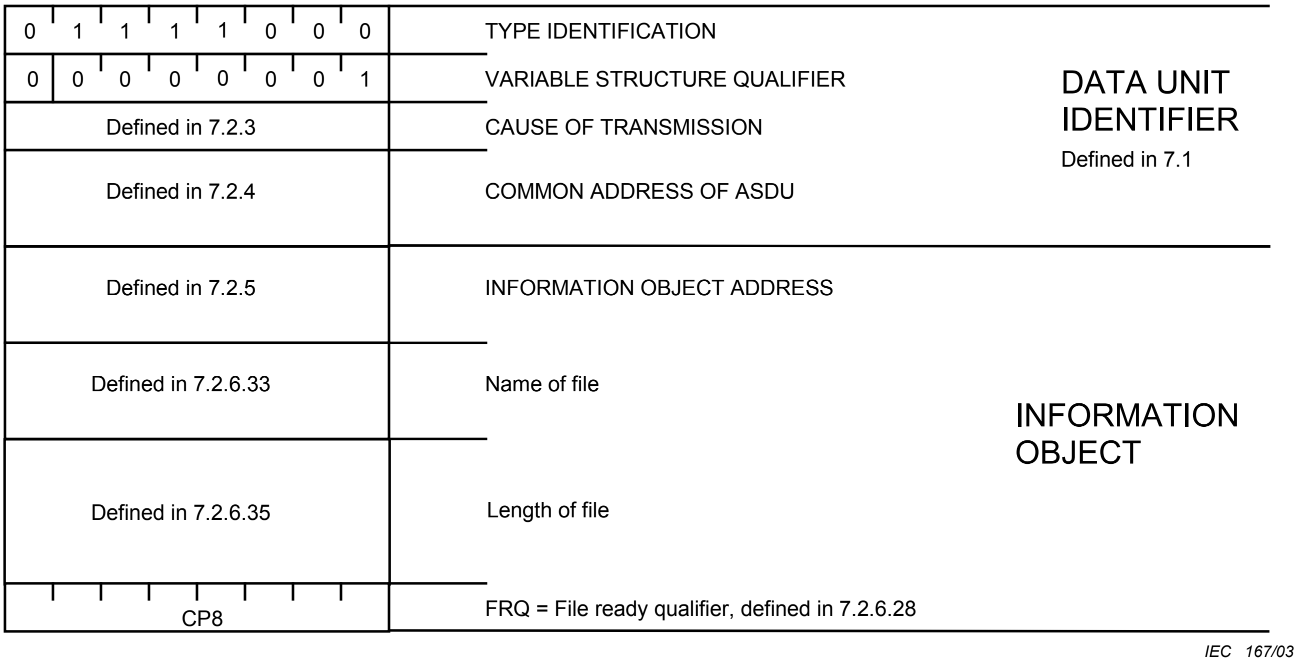

Figure 83 – ASDU: F_FR_NA_1 File ready

F_FR_NA_1 := CP{Data unit identifier,Information object address,Name of file, Length of file, FRQ}

CAUSES OF TRANSMISSION used with
TYPE IDENT 120 := F_FR_NA_1

CAUSE OF TRANSMISSION
<13> := file transfer
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.6.2 TYPE IDENT 121: F_SR_NA_1
Section ready

Single information object (SQ = 0)

0 1 1 1 1 0 0 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
Defined in 7.2.6.33	Name of file	
Defined in 7.2.6.34	Name of section	
Defined in 7.2.6.35	Length of section	
CP8	SRQ = Section ready qualifier, defined in 7.2.6.29	

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Figure 84 – ASDU: F_SR_NA_1 Section ready

F_SR_NA_1 := CP{Data unit identifier,Information object address,Name of file, Name of section,Length of section,SRQ}

CAUSES OF TRANSMISSION used with
TYPE IDENT 121 := F_SR_NA_1

CAUSE OF TRANSMISSION
<13> := file transfer
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.6.3 TYPE IDENT 122: F_SC_NA_1
Call directory, select file, call file, call section

Single information object (SQ = 0)

0 1 1 1 1 0 1 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
Defined in 7.2.6.33	Name of file	
Defined in 7.2.6.34	Name of section	
CP8	SCQ = Select and call qualifier, defined in 7.2.6.30	

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Figure 85 – ASDU: F_SC_NA_1 Call directory, select file, call file, call section

F_SC_NA_1 := CP{Data unit identifier,Information object address,Name of file, Name of section,SCQ}

CAUSES OF TRANSMISSION used with
TYPE IDENT 122 := F_SC_NA_1

CAUSE OF TRANSMISSION

<5>	:=	request (only for Call Directory)
<13>	:=	file transfer (all except for Call Directory)
<44>	:=	unknown type identification
<45>	:=	unknown cause of transmission
<46>	:=	unknown common address of ASDU
<47>	:=	unknown information object address

7.3.6.4 TYPE IDENT 123: F_LS_NA_1
Last section, last segment

Single information object (SQ = 0)

0 1 1 1 1 0 1 1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
Defined in 7.2.6.33	Name of file	
Defined in 7.2.6.34	Name of section	
UI8	LSQ = Last section or segment qualifier, defined in 7.2.6.31	
UI8	CHS = Checksum, defined in 7.2.6.37	

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Figure 86 – ASDU: F_LS_NA_1 Last section, last segment

F_LS_NA_1 := CP{Data unit identifier,Information object address,Name of file,Name of section,LSQ,Checksum}

CAUSES OF TRANSMISSION used with
TYPE IDENT 123 := F_LS_NA_1

CAUSE OF TRANSMISSION
<13> := file transfer
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

7.3.6.5 TYPE IDENT 124: F_AF_NA_1
ACK file, ACK section

Single information object (SQ = 0)

0 1 1 1 1 1 0 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0 0 0 0 0 0 0 1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
Defined in 7.2.6.33	Name of file	
Defined in 7.2.6.34	Name of section	
UI8	AFQ = ACK file or section qualifier, defined in 7.2.6.32	

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Figure 87 – ASDU: F_AF_NA_1 ACK file, ACK section

F_AF_NA_1 := CP{Data unit identifier,Information object address,Name of file,Name of section, AFQ}

CAUSES OF TRANSMISSION used with
TYPE IDENT 124 := F_AF_NA_1

CAUSE OF TRANSMISSION
- <13> := file transfer
- <44> := unknown type identification
- <45> := unknown cause of transmission
- <46> := unknown common address of ASDU
- <47> := unknown information object address

7.3.6.6 TYPE IDENT 125: F_SG_NA_1 Segment

Single information object (SQ = 0)

0	1	1	1	1	1	0	1	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
0	0	0	0	0	0	0	1	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3								CAUSE OF TRANSMISSION	
Defined in 7.2.4								COMMON ADDRESS OF ASDU	
Defined in 7.2.5								INFORMATION OBJECT ADDRESS	INFORMATION OBJECT
Defined in 7.2.6.33								Name of file	
Defined in 7.2.6.34								Name of section	
UI8								LOS = Length of segment, defined in 7.2.6.36	
Octet 1								Segment	
Octet n									

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Figure 88 – ASDU: F_SG_NA_1 Segment

F_SG_NA_1 := CP{Data unit identifier,Information object address,Name of file,Name of section,Length of segment,Segment}

CAUSES OF TRANSMISSION used with
TYPE IDENT 125 := F_SG_NA_1

CAUSE OF TRANSMISSION
- <13> := file transfer
- <44> := unknown type identification
- <45> := unknown cause of transmission
- <46> := unknown common address of ASDU
- <47> := unknown information object address

7.3.6.7 TYPE IDENT 126: F_DR_TA_1 Directory

Sequence of information elements in a single information object (SQ = 1)

0 1 1 1 1 1 1 0	TYPE IDENTIFICATION	DATA UNIT IDENTIFIER Defined in 7.1
1 Number j of elements	VARIABLE STRUCTURE QUALIFIER	
Defined in 7.2.3	CAUSE OF TRANSMISSION	
Defined in 7.2.4	COMMON ADDRESS OF ASDU	
Defined in 7.2.5	INFORMATION OBJECT ADDRESS A	INFORMATION OBJECT
Defined in 7.2.6.33	Name of file or subdirectory	File 1 Belongs to information object address A
Defined in 7.2.6.35	Length of file	
Defined in 7.2.6.38	SOF = Status of file, defined in 7.2.6.38	
CP56Time2a Defined in 7.2.6.18	Seven octet binary time (Date and clock time in milliseconds up to years) Creation time of the file	
⋮		
Defined in 7.2.6.33	Name of file or subdirectory	File j Belongs to information object address A+j–1
Defined in 7.2.6.35	Length of file	
Defined in 7.2.6.38	SOF = Status of file, defined in 7.2.6.38	
CP56Time2a Defined in 7.2.6.18	Seven octet binary time (Date and clock time in milliseconds up to years) Creation time of the file	

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Figure 89 – ASDU: F_DR_TA_1 Directory

F_DR_TA_1 := CP{Data unit identifier,Information object address,j(Name of file,Length of file,Status of file,CP56Time2a)}

j := number of set of elements defined in the variable structure qualifier

CAUSES OF TRANSMISSION used with
TYPE IDENT 126 := F_DR_TA_1

CAUSE OF TRANSMISSION

<3> := spontaneous

<5> := requested

7.4 Selections from IEC 60870-5-5: Basic application functions

The following basic application functions, defined in IEC 60870-5-5 are used:

Station initialization (IEC 60870-5-5, 6.1)

Data acquisition by polling (IEC 60870-5-5, 6.2)

Cyclic data transmission (IEC 60870-5-5, 6.3)

Acquisition of events (IEC 60870-5-5, 6.4)

General interrogation (IEC 60870-5-5, 6.6)

Clock synchronization (IEC 60870-5-5, 6.7)

Command transmission (IEC 60870-5-5, 6.8)

Transmission of integrated totals (IEC 60870-5-5, 6.9)

Parameter loading (IEC 60870-5-5, 6.10)

Test procedure (IEC 60870-5-5, 6.11)

File transfer (IEC 60870-5-5, 6.12)

Acquisition of transmission delay (IEC 60870-5-5, 6.13)

After successful station initialization, all application functions must be available to run simultaneously.

If a controlled station has data for more than one of the following ASDU types ready for transmission at the same time, they must be sent in the following order regardless of which data was generated first. Table 16 does not define the order in which the controlling station must request the data or require that the controlled station not transmit data until another type of data becomes available. ASDU type identifications within the same row may be sent in any order. The chronological reporting requirements defined in 7.2.2.2 are valid.

Table 16 – Respond priorities of the controlled station

Request ASDU	Description	Comment
70	End of initialization	In monitor direction
45 to 69	Command transmission	Mirrored ASDUs
1 to 44 103 106	Event reporting Clock synchronization Acquisition of transmission delay	Event reporting: In monitor direction with COT = 3 Sequence of events and clock synchronization (See 6.7 of IEC 60870-5-5)
102, 104, 105, 110 to 113	Read command, test procedure, reset process, parameter loading,	
100, 101	Station interrogation, transmission of integrated totals	
9, 11, 13, 21 120 to 127	Cyclic data transmission (in monitor direction with COT = 1), file transfer	

7.4.1 Selections from station initialization

Options of IEC 60870-5-5, 6.1:

M_AA (Application layer is available) in monitoring direction is not used.

IEC 60870-5-101 defines the addressing of a whole station or just particular station sectors by the common address of the ASDU. Station sectors may exist as separate physical pieces of equipment (for example, RTU1 to 4 identical with LRU1 to 4 in Figure 90) or as logical units within one physical unit (for example, LRU5 to 5+n within RTU5 in Figure 90). In the following, both are defined as logical remote units LRU (see Figure 90).

ENDINIT is transmitted separately by each LRU after initialization when this LRU's data becomes available (see 6.1 of IEC 60870-5-5). This is also required when a common initialization procedure for several LRUs is implemented in one item of physical equipment (hardware). In both cases, each LRU has to transmit an ENDINIT containing its specific common address of ASDU.

7.4.2 Selections from data acquisition by polling

The complete function, defined in IEC 60870-5-5, 6.2, is used.

The polling procedure is supported by the link layer which requests user data of classes 1 and 2. In general, ASDUs containing the causes of transmission periodic/cyclic are assigned to be transmitted with the link layer data class 2 and all time tagged or spontaneously transmitted ASDUs are assigned to be transmitted with the link layer data class 1. Other ASDUs with other causes of transmission of low priority such as background scan may also be assigned to data class 2 and must be listed in the interoperability document.

In this case, it has to be considered that the link request of class 1 occurs at a different point of time (to or from) the link request of class 2, which may influence the correct sequence of the ASDUs delivered to the application layer of the controlling station.

In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.

When using the read command, specific information objects may be requested by interrogating their respective information object addresses. The requested information objects are returned with the cause of transmission <5> requested. Normally, these requested objects do not include the time tag.

7.4.3 Selections from cyclic data transmission

The complete function, defined in IEC 60870-5-5, 6.3, is used.

7.4.4 Selections from acquisition of events

The complete function, defined in IEC 60870-5-5, 6.4, is used.

7.4.5 Selections from station interrogation, outstation interrogation

Options of IEC 60870-5-5, 6.6:

C_IC ACTCON and C_IC ACTTERM in the monitor direction are used.

The interrogation command C_IC ACT requests the complete or a fixed defined subset of the interrogated information of a controlled station. The subset (group) is chosen by the definitions of the qualifier of interrogation QOI.

A station interrogation command requests the controlled stations to transmit the actual state of their normally spontaneously transmitted information (cause of transmission := <3>) to the controlling station with the causes of transmission <20> up to <36>. The station interrogation is used to synchronize the process information of the controlling station (network image NIM) and the controlled stations. It is also used for updating the controlling station after an initialization procedure or when the controlling station detects the loss of a link (unsuccessful repetitions of the link layer) and the link layer is available again. The response to a station interrogation should include all process information objects that are stored in the controlled station. In response to a station interrogation request, these information objects are reported in type identifications <1>, <3>, <5>, <7>, <9>, <11>, <13>, <20> or <21>. These information objects may also be reported in other responses using type identifications <1> to <14>, <20>, <21> and <30> to <36> sent with causes of transmission <1> periodic/cyclic, <2> background scan or <3> spontaneous.

The controlled station does not need to send information which is not retained in the controlling station (see 6.6 of IEC 60870-5-5), i.e. any object that is not stored in the controlled station is not returned in response to a station interrogation and shall only be reported with the cause of transmission <1> periodic/cyclic. This may be achieved by configuring the information to be sent from the controlled station in response to a station interrogation request, but this is not required behaviour for a controlled station.

Table 17 shows the ASDUs that may be transmitted in response to the station interrogation procedure including the type identifications, causes of transmission and the qualifiers of interrogation of the station interrogation command.

Table 17 – ASDUs involved in the station interrogation procedure

Direction C=control M=monitor	Type identification	Cause of transmission	Qualifier of interrogation
C	<100> C_IC_NA_1	<6> act	<20> to <36>
M	<100> C_IC_NA_1	<7> actcon	<20> to <36>
M	<1> M_SP_NA_1 <3> M_DP_NA_1 <5> M_ST_NA_1 <7> M_BO_NA_1 <9> M_ME_NA_1 <11> M_ME_NB_1 <13> M_ME_NC_1 <20> M_PS_NA_1 <21> M_ME_ND_1	<20> inrogen <21> to <36> inro 1 to inro 16	
M	<100> C_IC_NA_1	<10> actterm	<20> to <36>

A remote telecontrol unit RTU may consist of several (logical) sectors (LRUs = logical remote units). Each LRU is defined by a system-specific common address. An outstation containing only one LRU returns the station interrogation (or counter interrogation) which is directed to that LRU with ASDUs which contain the specific common address defined for this LRU. If the outstation consists of several RTUs, all LRUs (in this example LRU 1 to LRU 4) may be interrogated simultaneously via a station interrogation command (or counter interrogation command) with the common address of ASDU FF or FFFF (see Figure 91 for this procedure). In the example shown in Figure 90, LRU 1 is responsible for the initiation of the station interrogation procedure to the LRUs (LRU 2 to LRU 4) that are connected to it.

If an LRU (LRU 5+n+m+1 in Figure 90) is distributed to more than one physical controlled station (RTU 7 and 8 in Figure 90), each connected via a separate physical channel, the station interrogation (or counter interrogation command) must be sent to each physical controlled station (RTU 7 and 8), this could be done using the broadcast data link address.

The initialization of an identical general interrogation of the same source before the previous one is terminated is normally locked by the controlling station.

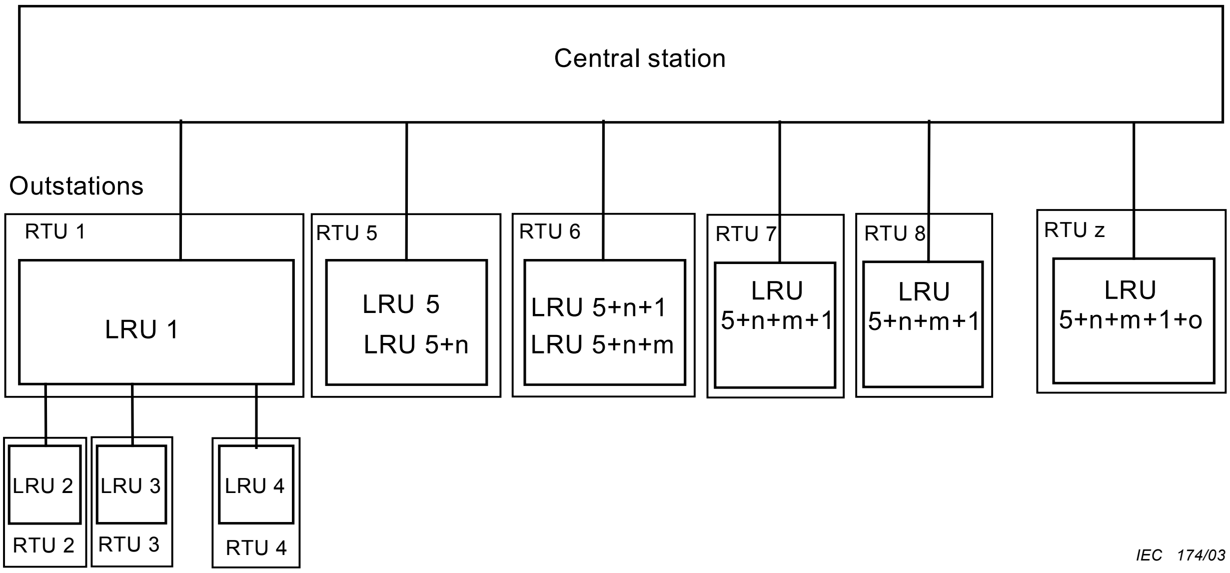

Figure 90 – Hierarchical presentation of the allocation of common addresses of ASDUs to LRUs (example)

A station interrogation request is issued to the controlled station

– if an ENDINIT is received from the controlled station, or
– if the central station observes the loss of a link (unsuccessful repetitions of the link layer) and the link layer is available again. The station interrogation command C_IC ACT is negatively acknowledged by a C_IC ACTCON when the controlled station is not ready to return the interrogated information. In this case, the station interrogation command may be repeated.

Additionally, a station interrogation may be issued to a controlled station in response to other (configurable) criteria, for example, when initiated manually.

When issuing a station interrogation command to a controlled station using the common address FF or FFFF (request of all), ACTCON, ACTTERM and the interrogated information objects are returned with the specific common addresses of the LRUs in exactly the same manner as if they were initiated by a station interrogation command issued to the specific LRU.

The LRU specific interrogation commands to the controlled stations may be transmitted in parallel, for example the response sequence ACTCON through to ACTTERM of a previously transmitted interrogation command need not to be completed prior to issuing an interrogation command to another LRU. The controlled station may respond with a negative activation confirmation to simultaneous requests of the same type to multiple addresses.

ASDUs with cause of transmission 20 to 36 are transmitted without time tags.

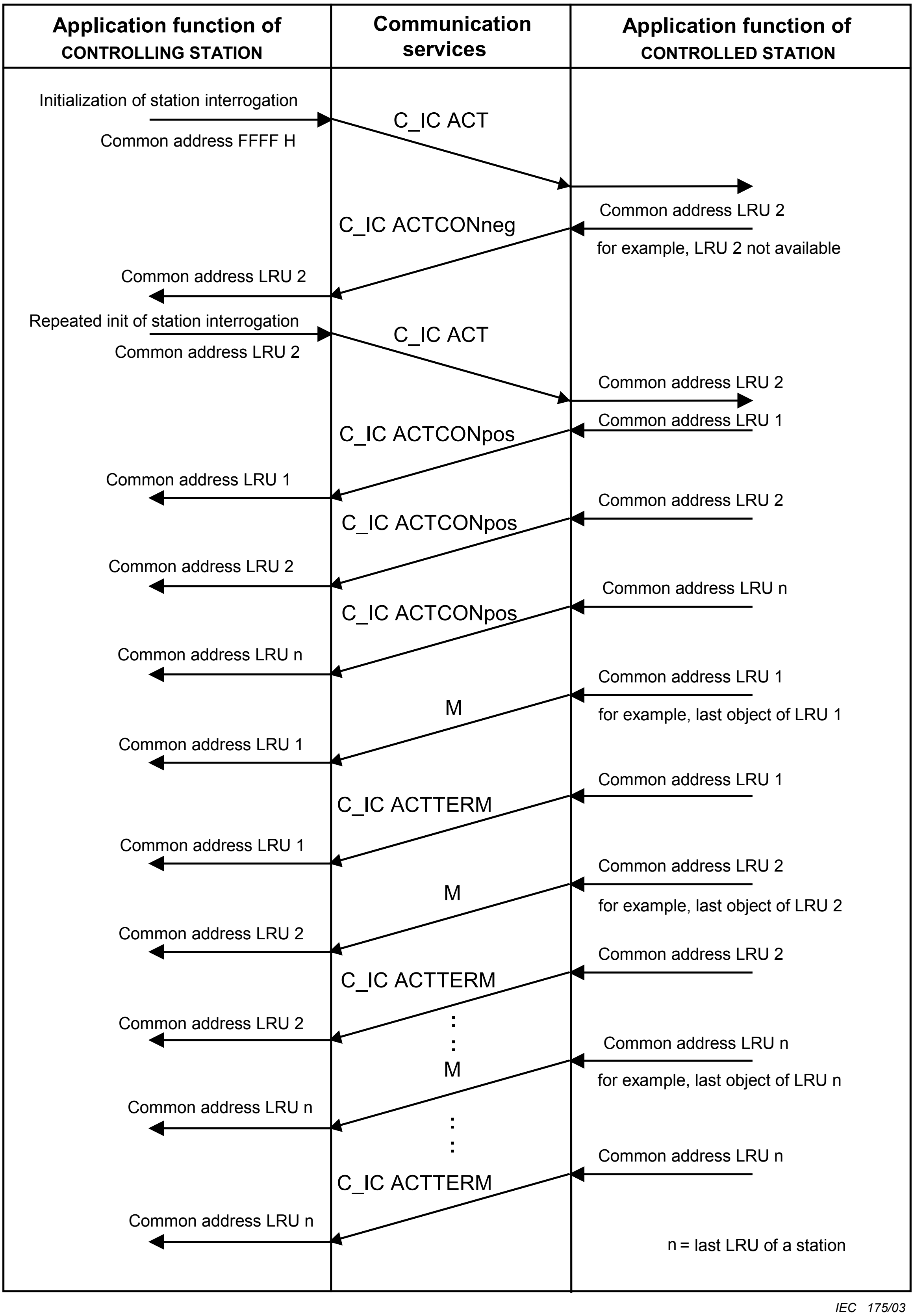

Figure 91 – Sequential procedure of station interrogation to all LRUs of a specific controlled station (example)

The sequence shown in Figure 91 is an example. The responses from one LRU may be transmitted in a close formation (C_IC ACT, C_IC ACTCONpos, M, M...C_IC ACTTERM) or may be interspersed with those of other LRUs.

7.4.6 Selections from clock synchronization

The complete function, defined in IEC 60870-5-5, 6.7, is used.

Time information is corrected exclusively by the controlled station.

The reference for the clock synchronization command is a system dependent parameter. The reference may be local time, or if a system spans over several time zones, UTC or a central time reference may be used. The summer-time bit is ignored in both controlling and controlled stations, and should be set to zero.

The invalid bit IV belongs to the information element CP56Time2a and therefore it refers to the accuracy of the transmitted time. Bit IV is set to 1 if the clock is not synchronized for a specific period of time.

7.4.7 Selections from command transmission

Options of IEC 60870-5-5, 6.8:
The select procedure is only used in case of a select and execute function. DEACT, DEACTCON is only used in case of a select and execute function.
C_SC, C_DC, C_RC ACT, ACTCON and ACTTERM are used.
C_SE ACT and ACTCON is used with direct command transmission or select and execute procedures. C_SE ACTTERM may be used optionally.
RETURN_INF for control operation commenced is not used.
RETURN_INF for control operation complete is used (if available).

S/E of the qualifier of command QOC is irrelevant in ASDUs with causes of transmission DEACT and DEACTCON.

NOTE Usually, a single command (type identification 45) is used to control an object that is monitored as a single-point (type identification 1, 2 and 30), a double command (type identification 46) is used to control an object that is monitored as double-point (type identification 3, 4 or 31) and a regulating step command (type identification 47) is used to control an object that is monitored as a step position information (type identifications 5, 6 and 32).

7.4.8 Selections from transmission of integrated totals

Options of IEC 60870-5-5, 6.9:
C_CI ACT, ACTCON, ACTTERM is used.
Both options, MEMORIZE COUNTER and MEMORIZE INCREMENT are used. The integrated totals are transmitted with CAUSE OF TRANSMISSION = SPONTANEOUS after memorizing. MEMORIZE may be executed locally (local clock). In this case, the options MEMORIZE COUNTER and MEMORIZE INCREMENT are not used.
REQUEST INTEGRATED TOTALS is used. In this case, the integrated totals are transmitted with CAUSE OF TRANSMISSION = REQUESTED BY COUNTER REQUEST.
C_CI DEACT and DEACTCON are not used.

The general counter model is shown in Figure 92. Integrated totals are values that are integrated over a specific period of time (see 6.9 of IEC 60870-5-5).

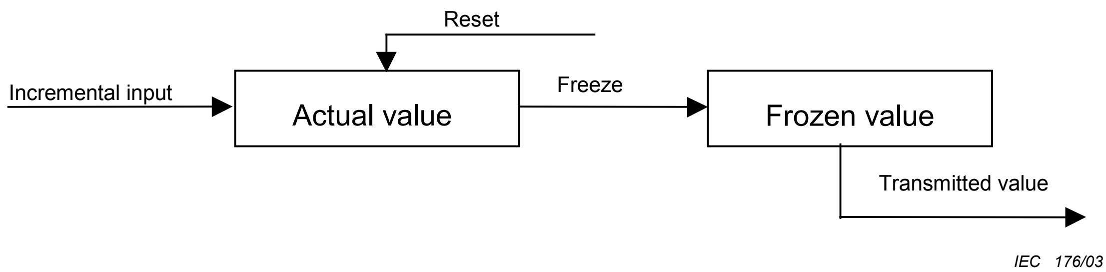

Figure 92 – General counter model

The actual values are normally integrated by counters. The actual values may be memorized (copied) periodically to frozen values by a freeze command received from a controlling station or initiated locally within the device. After freezing, the actual value is either reset to zero (acquisition of incremental information) or continues its operation without being reset (acquisition of integrated totals).

Information object addresses of integrated totals may be defined in groups. These groups may be frozen, reset or transmitted selectively. The counter interrogation command includes a qualifier field (QCC) which defines the action to be performed (FRZ), and the counter group (RQT) upon which the action shall be performed (see 7.2.6.23)

There are four modes of acquisition of integrated totals or incremental information.

Mode A: local freeze with spontaneous transmission.

Local clocks in the controlled station initiate the freeze or freeze with reset operations. The integrated totals (frozen values) are transmitted spontaneously in M_IT ASDUs after the freeze or freeze with reset operation has been performed. The controlling station does not issue counter interrogation commands (C_CI).

If the ASDU integrated totals with time tag (M_IT_TA_1) is used, a frozen counter history may be produced by this mode even when communications have failed for a period and are subsequently restored.

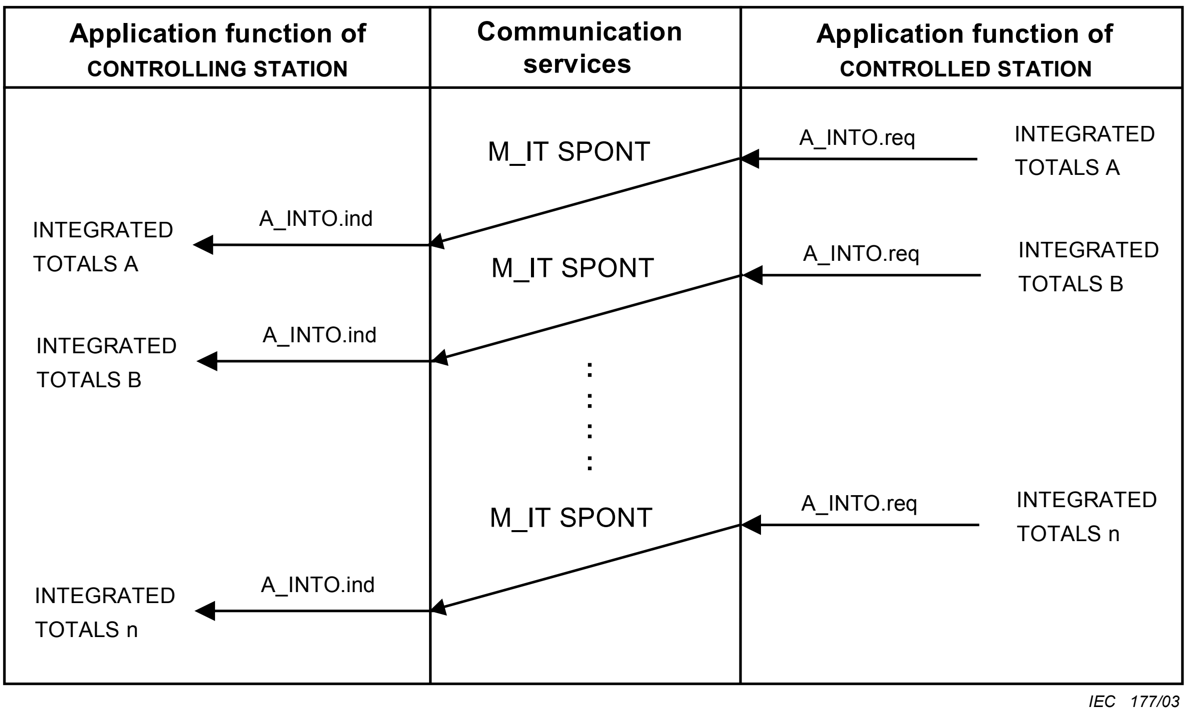

Figure 93 – Sequential procedure of spontaneously transmitted integrated totals (mode A)

Mode B: local freeze with counter interrogation

Local clocks in the controlled station initiate the freeze or freeze with reset operations. The integrated totals (frozen values) are requested by counter interrogation commands (C_CI). In this case, the freeze or freeze with reset functionality must not be used in the counter interrogation command (i.e. the command qualifier must contain FRZ = 0). Integrated totals may be requested in general or in groups 1 to 4. The assignments of the information object addresses of the integrated totals to the specific groups have to be specified in the controlled station. Requested integrated totals are transmitted with cause of transmission 37 to 41.

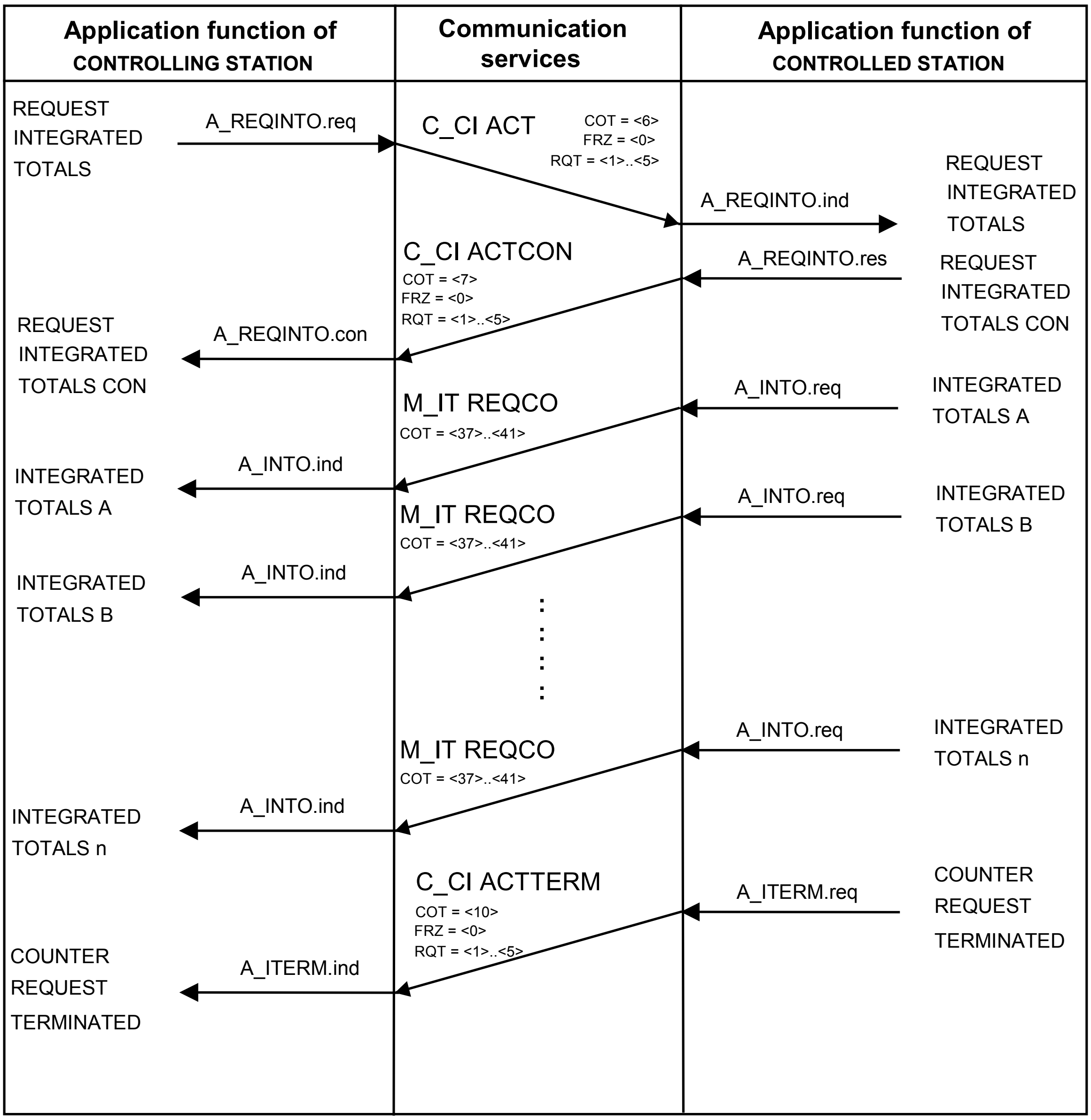

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Figure 94 – Sequential procedure of interrogation of integrated totals (mode B)

Mode C: counter interrogation commands from the controlling station initiate the freeze, freeze with reset or reset commands. A subsequent counter interrogation command is issued by the controlling station to collect the frozen values from the controlled station.

A counter interrogation command is issued periodically by the controlling station to control freeze and/or reset.

The counter interrogation command to freeze and/or reset the values may specify all counters (general counter request, RQT = <5>) or specific counter groups (RQT = <1>..<4>). The "no counters" (RQT = <0>) option is not used. The command also specifies the operation to be performed: freeze (FRZ = <1>, see Figure 95), freeze with reset (FRZ = <2>, see Figure 96) or reset (FRZ = <3>). The operation specified by FRZ is only applied to the counters specified by RQT. All other counters are unaffected. This command does not cause the counter values to be transmitted.

After this transaction is complete, a counter interrogation command to collect the frozen values is issued by the controlling station. The format of this is as described for the collection of the integrated total data in mode B.

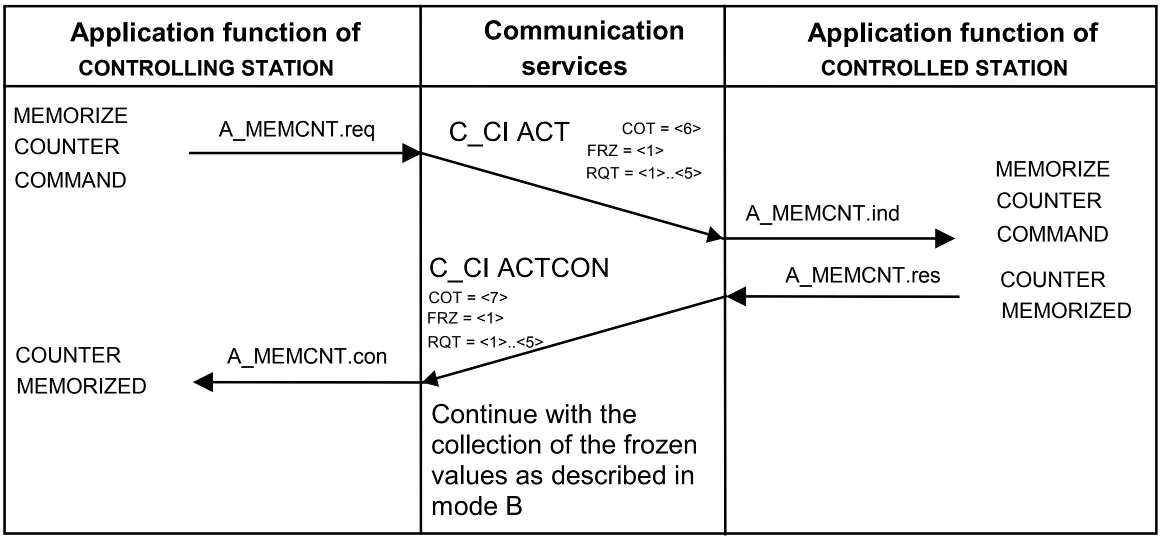

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Figure 95 – Sequential procedure of memorizing of integrated totals without reset (mode C)

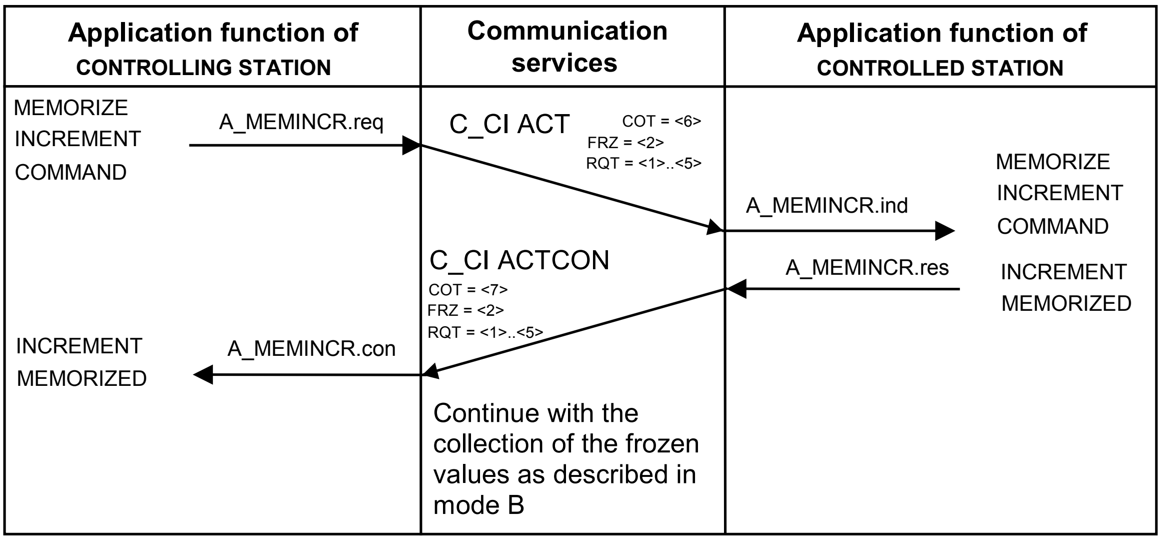

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Figure 96 – Sequential procedure of memorizing of integrated totals with reset (mode C)

Mode D: counter interrogation commands from the controlling station initiate the freeze operation, and the frozen values are reported spontaneously.

This mode is a combination of the counter command from the controlling station as specified in mode C, with spontaneous reporting of the integrated totals, as described in mode A.

7.4.9 Selections from parameter loading

Options of IEC 60870-5-5, 6.10:

P_AC ACT/ACTCON and DEACT/DEACTCON are used only in combination with

QPA := <3> = act/deact of persistent cyclic or periodic transmission of the addressed object.

P_ME SPONT for local parameter change is not used.

P_ME ACT and ACTCON are used for loading single parameters which are activated immediately after being checked for feasibility and accepted as having a valid value. In either case (positive or negative acceptance), the parameter value returned in the ASDU P_ME ACTCON is the value (new or old) of the parameter now in operation.

7.4.10 Selections from test procedure

The complete procedure, defined in IEC 60870-5-5, 6.11 is used.

7.4.11 Selections from file transfer

Options of IEC 60870-5-5, 6.12:

F_SC_NA_1 (Call directory) in the control direction is used.

F_DR_TA_1 (Directory) in monitor direction is used.

7.4.11.1 General addressing structure for file transfer

7.4.11.1.1 Introduction

In general, files are established, controlled and buffered at the part of the system where they are generated, for example, protection files are established in protection equipment, files (records) for sequences of events are established in substation automation systems, files for configuration data are established in the controlling station, etc. Files may be selected and requested by the accompanying communication partner. To avoid implementing extensive data file management functionality twice, for example in the controlling and in the controlled stations, a directory may be requested by the controlling station, which specifies the files that are available in the controlled stations. Each file (directory or subdirectory) is unambiguously defined by the combination of the common address of the ASDU and the information object address which includes the name of file as an additional information. According to this standard, a file is considered as an information object. The directory either directly specifies the information object address of the file or it references a subdirectory which then defines the real information object addresses and names of files. The information element SOF = status of file of the directory defines the distinction with FOR = 0, name defines file or FOR = 1 name defines subdirectory. Figure 97 shows an example of a possible directory. Protection files defined in IEC 60870-5-103 need to be addressed with name of file in addition to the information object address.

The time tag in a directory with FOR = 1 defines the point of time of the most recent change of the subdirectory.

The following names of files are defined:

Name of file:

<1>	:=	transparent file
<2>	:=	disturbance data of protection equipment
<3>	:=	sequences of events
<4>	:=	sequences of recorded analogue values
<5..127>	:=	reserved for further compatible definitions
<128..255>	:=	reserved for special use (private range)

The second octet of the name of the file is reserved for further compatible definitions.

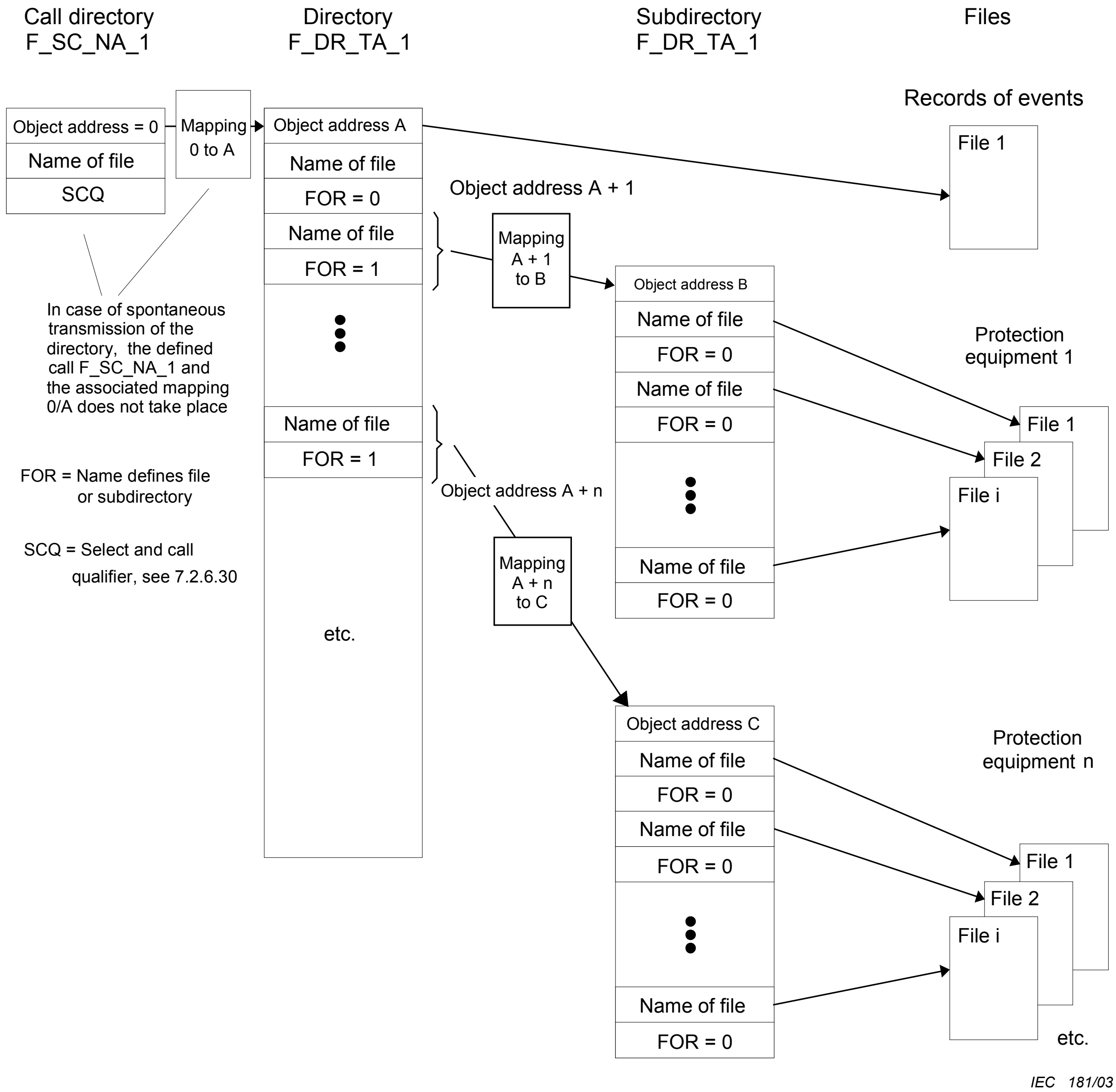

Figure 97 – Addressing of files (example)

7.4.11.1.2 Specification of directories and subdirectories

Directories and subdirectories are ordered in substation automation systems (including RTUs). Both may be requested by the controlling station or transmitted spontaneously in case of changes.

There is no requirement for multiple files to be available simultaneously in the substation automation system. They may be stored in the protection equipment and obtained upon request. However, the substation automation system must reserve the memory for at least one complete file. Deleting of files in substation automation systems is an application specific function and is not defined in this standard.

7.4.11.2 Transmission of disturbance data

This Subclause defines how disturbance data obtained from protection equipment within a substation shall be mapped onto the file transfer mechanism of this standard, when onward transmission to the controlling station is required. The format of the disturbance files used is as defined for IEC 60870-5-103 for the informative interface of protection equipment.

The differences in data units and procedures between IEC 60870-5-103 and this standard require additional definitions to permit disturbance data acquired and buffered in substation automation systems to be transmitted to the controlling system. For these definitions, see 7.4.11.2.1 to 7.4.11.2.7.

7.4.11.2.1 Definitions to the request from protection equipment

The following definitions may either be applied for the transmission of disturbance data directly from the protection equipment or from other parts of substation automation systems. In both cases, the splitting of the disturbance data files into specific sections is needed, as defined in Figure 100. From the point of view of the controlling station, both cases may be controlled in the same manner except for different time out conditions.

7.4.11.2.2 Request for files by the central station from protection equipment

When the selected file is buffered in the protection equipment at the point of time when it is selected by the controlling station, then the procedure for the transmission of disturbance data defined in IEC 60870-5-103 is initiated with the ASDU 24 (order for disturbance data transmission) which is triggered by the ASDU F_SC_NA_1 SCQ := <1> (select file) of the controlling station (see Figure 98, step 1). After that, the transmission of the selected file from the protection equipment to the substation automation system is performed (see Figure 98, step 2). After the successful termination of this procedure of the protection equipment (ASDU 31 End of transmission, TOO := <32> End of disturbance data transmission without abortion) the ASDU F_FR_NA_1 with FRQ BS1[8] := <0> (positive confirm of select) is transmitted to the controlling station. In all other cases, F_FR_NA_1 with FRQ BS1[8] := <1> (negative confirm of select) is transmitted to the controlling station. Then the request of the disturbance data file from the substation automation system followed by the transmission of the file to the controlling station may follow (see Figure 98, step 3).

The transfer time of the selected file from the protection equipment to the substation automation system has to be allowed for (for example, there must be no premature time out of the central file processing manager of the controlling station).

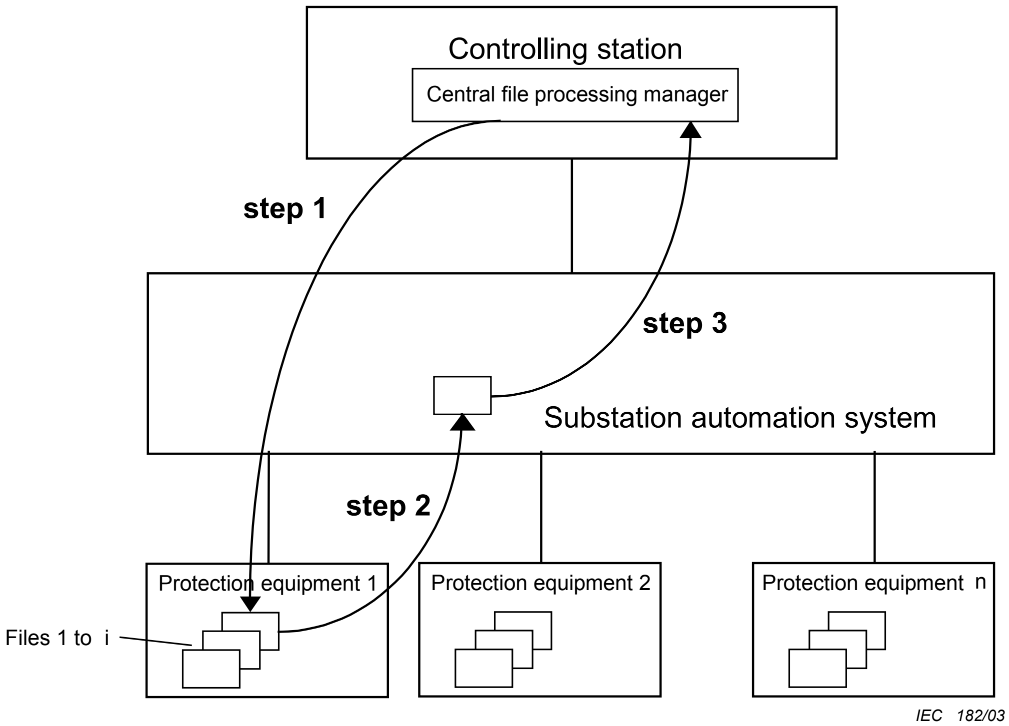

Figure 98 – Request from protection equipment

7.4.11.2.3 Request for files by the controlling station from substation automation systems

In the case where the files are available in the substation automation system, the file is selected with the ASDU F_SC_NA_1 SCQ := <1> (select file) which is confirmed positively directly with F_FR_NA_1 FRQ BS1[8] := <0> (positive confirm of select, see Figure 99, step 1). In all other cases, F_FR_NA_1 with FRQ BS1[8] := <1> (negative confirm of select) is transmitted to the controlling station. The request and transmission of the file containing disturbance data from the substation automation system to the controlling system follows (see Figure 99, step 2). The transmission to the central file processing manager of the controlling station is performed directly from the substation automation system without any files being requested from the protection equipment. In this case, the transmissions are decoupled in time and there are no direct assignments of the procedural services of IEC 60870-5-101 to those of IEC 60870-5-103.

The number of files 1 to k buffered in the substation automation system for each protection equipment may exceed the number of files 1 to i buffered in the protection equipment itself.

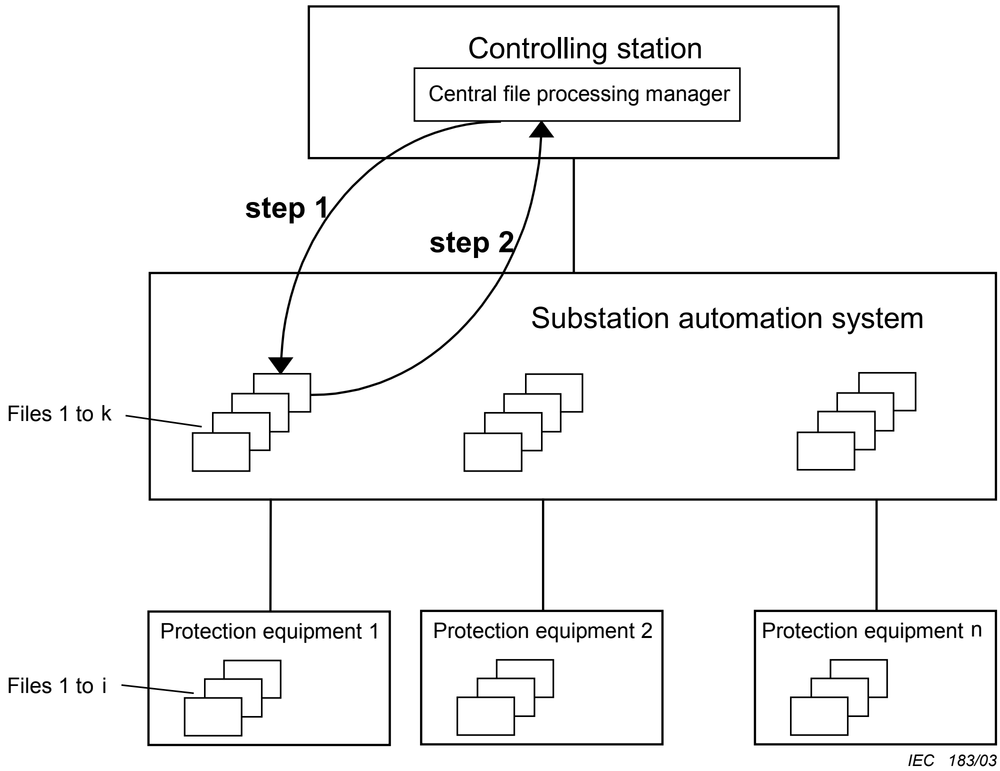

Figure 99 – Request from substation automation system

7.4.11.2.4 Structure of disturbance data files

The ASDUs and procedures as defined in IEC 60870-5-103 are structured according to disturbance, time tags and disturbance data channels. The file transfer according to this standard maintains this structure when disturbance data are transmitted. The disturbance data, generated by the protection equipment, are buffered in disturbance data files. In addition, each protection equipment establishes a list of recorded disturbances (directory). This list of recorded disturbances is mapped in a subdirectory F_DR_TA_1 (see 7.4.11.2.5).

The transmission to the controlling station is performed separately for each file.

Figure 100 shows the structure of the list of recorded disturbances of a protection equipment. Each buffered disturbance file is split into the sections 1 to n, which correspond to the sections defined in IEC 60870-5-5. Parameters, time tags and disturbance data from IEC 60870-5-103 are allocated to these sections as follows:

Section 1	parameter of disturbances 1 to k
Section 2	tags of disturbances 1 to k
Section 3	parameter of disturbance 1 to k for channel 1
Section 4	disturbance data of disturbance 1 to k for channel 1
Section 5	parameter of disturbance 1 to k for channel 2
Section 6	disturbance data of disturbance 1 to k for channel 2
etc.	

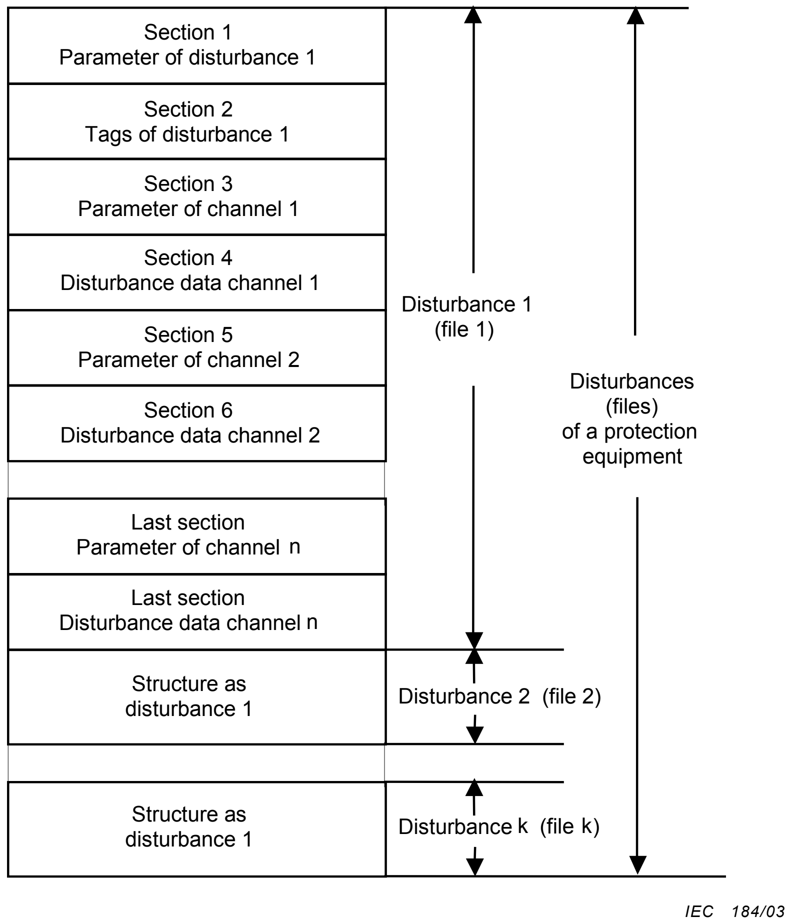

Figure 100 – Structure of disturbance data of a protection equipment

Parameters for a disturbance, time tags for a disturbance, parameters for a channel and disturbance data for a channel as defined in IEC 60870-5-103 (see Figure 101). These parameters and data are originally attached to the sections of a subdirectory of a protection equipment and transmitted in the octets 1 to n of the segment of the ASDUs F_SG_NA_1.

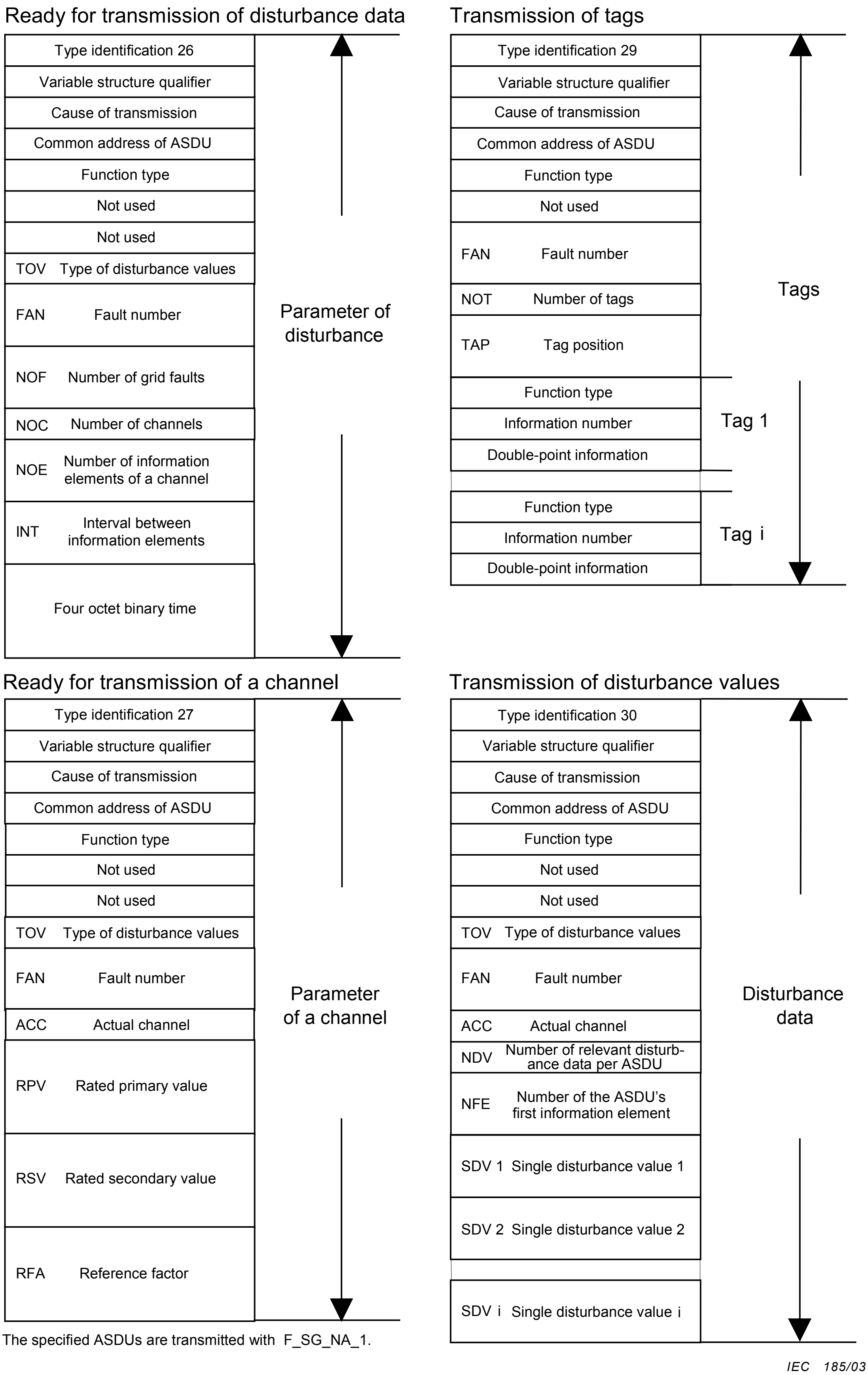

Figure 101 – Allocation of data types (ASDUs) of IEC 60870-5-103 to the sections of disturbance data files

7.4.11.2.5 Mapping of the list of recorded disturbances to the directory

The list of recorded disturbances defined in IEC 60870-5-103 is mapped on the subdirectory F_DR_TA_1 defined in this standard. Figure 102 shows the mapping of the ASDUs. The information fields type identification, information object address and status of file are not only copied from type 126 of this standard to type 23 of IEC 60870-5-103 and vice versa but mapped via mapping lists (see Table 18). The information fields' name of file to fault number and binary time tags are identically mutually copied (see Figure 102).

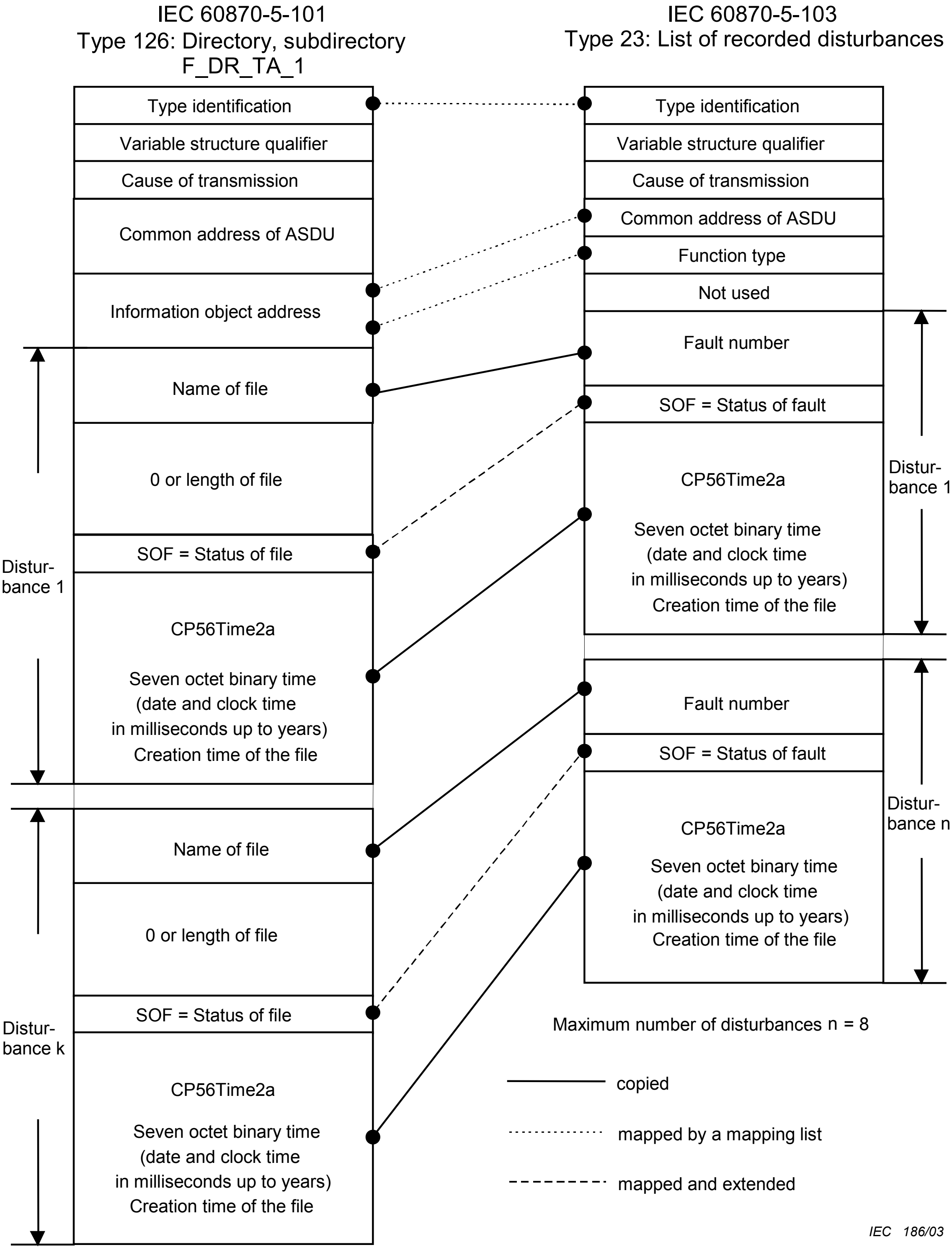

Figure 102 – Allocation of the data unit type 23 to the directory F_DR_TA_1

Table 18 – Allocation of type identification to type identification (IEC 60870-5-101 and IEC 60870-5-103)

IEC 60870-5-101	**IEC 60870-5-103**
Type identification	Type identification
<126>	<23>

Variable structure qualifier and cause of transmission are used independently from each other.

The common address of F_DR_TA_1 is used according to the definitions of this standard.

The information object address of F_DR_TA_1 of the interface of the controlling station to the controlled station is specified independently from the common address/function type of the interface to the protection equipment and allocated to the common address/function type of the type identification 23 via a Table of the substation automation system. The sequence of the fault numbers (names) may be interrupted by gaps due to the deletion of disturbances and restarts of the protection equipment. As a consequence a name may even occur several times. Thus, disturbance data files have to be unambiguously addressed with the information object address B and the name = fault number (see Table 19). Whereas, the information object addresses are defined in a fixed way, the names (fault numbers) may change, for example, when they are generated or deleted. In this case, the topical directories are transmitted spontaneously to the controlling station.

The directories or the recently transmitted files must not be updated in the substation automation system whilst a transfer of files to the controlling station is being performed. In the case of a coincidence of a change of the directory of the substation control system with a request (call) of the controlling station before the topical directory has been transmitted to the controlling station, the object address and the name of the file may be changed and be incorrect. In this case, the request (call) is rejected negatively and has to be repeated.

Table 19 – Example for the definition of information object addresses (directory or subdirectory)

Object address A	**Object address A+1**	**Object address A+2**	**Object address A+n**
1000	1001	1002	1000 + n
FOR = 0	FOR = 1	FOR = 0	FOR = 0
NAME = 1	NAME = 2	NAME = 1	NAME = 1

allocation of A + 1 = 1001 to B = 2000

Object address B	**Object address B+1**	**Object address B+2**	**Object address B+n**
2000	2001	2002	2000 + n
FOR = 0	FOR = 0	FOR = 0	FOR = 0
NAME = fault number = 10000	NAME = fault number = 10001	NAME = fault number = x	NAME = fault number = y

When the file is requested by the controlling station from the protection equipment, the length of the file is not known in the substation automation system at the time that the directory or subdirectory is transmitted. In this case, the field length of file is defined as <0>.

Allocation of the name of file to fault number in the case of FOR = 0:

The name of the file is the same as the fault number in the case of FOR = 0.

Table 20 – Allocation of SOF status of file to SOF status of fault (IEC 60870-5-101 and IEC 60870-5-103)

IEC 60870-5-101	IEC 60870-5-103
UI5[1..5]<0..31>	
<0> = not defined	
<1>	TP:=BS1[1]:=<0>; TEST:=BS1[3]:=<0>; OTEV:=BS1[4]:=<0>
<2>	TP:=BS1[1]:=<1>; TEST:=BS1[3]:=<0>; OTEV:=BS1[4]:=<0>
<3>	TP:=BS1[1]:=<0>; TEST:=BS1[3]:=<1>; OTEV:=BS1[4]:=<0>
<4>	TP:=BS1[1]:=<1>; TEST:=BS1[3]:=<1>; OTEV:=BS1[4]:=<0>
<5>	TP:=BS1[1]:=<0>; TEST:=BS1[3]:=<0>; OTEV:=BS1[4]:=<1>
<6>	TP:=BS1[1]:=<1>; TEST:=BS1[3]:=<0>; OTEV:=BS1[4]:=<1>
<7>	TP:=BS1[1]:=<0>; TEST:=BS1[3]:=<1>; OTEV:=BS1[4]:=<1>
<8>	TP:=BS1[1]:=<1>; TEST:=BS1[3]:=<1>; OTEV:=BS1[4]:=<1>
<9..15> = reserved for further compatible definitions	
<16..31> = for special use (private range)	
LFD := BS1[6]<0..1>	Not available
<0> := Additional file follows	
<1> := Last file of the directory	
FOR := BS1[7]<0..1>	Not available
<0> := Name defines file	
<1> := Name defines subdirectory	
FA := BS1[8]<0..1>	Not available (TM not relevant for 101)
<0> := file waits for transfer	
<1> := Transfer of this file is active	

The clock time CP56Time2a is added at the point of time when the disturbance data file is generated in the protection equipment. This time is copied in the ASDU F_DR_TA_1.

7.4.11.2.6 Procedures

For procedures regarding transmission of directory and transmission of disturbance data with the ASDUs defined in 7.4.11.2.4 and 7.4.11.2.5, see Figures 103 and 104. The definitions correspond to the procedures defined in 6.12 of IEC 60870-5-5. In order to transmit voluminous directories with more than a single ASDU, the LFD bit of the octet status of file of F_DR_TA_1 is defined as follows:

LFD = last file of directory =

<0> := additional file of the directory follows;

<1> := last file of the directory.

The directory may also be transmitted spontaneously following any change (see Figure 103). If the list of recorded disturbances of a protection equipment changes, for example due to a reset, the topical list of recorded disturbances is transmitted after re-initialization to the substation automation system, following any station interrogation. This leads to changes of the directories and to spontaneous transmissions of the topical directories from the substation automation system to the controlling station. If the link to the controlling station is disrupted, the directory has to be requested again after the restoration of the link.

Controlling station	Communication services	Controlled station	Action
A_CALL_DIRECTORY.req →	F_SC_NA_1 req →	A_CALL_DIRECTORY.ind →	Request of directory
A_DIRECTORY.ind ←	F_DR_TA_1 req ←	A_DIRECTORY.req ←	Requested directory 1, additional directory follows
A_DIRECTORY.ind ←	F_DR_TA_1 req ←	A_DIRECTORY.req ←	Requested directory 2, additional directory follows
. . .	. . .	. . .	
A_DIRECTORY.ind ←	F_DR_TA_1 req ←	A_DIRECTORY.req ←	Requested directory n, directory contains last file
. . .	. . .	. . .	
A_DIRECTORY.req ←	F_DR_TA_1 spont ←	A_DIRECTORY.req ←	Spontaneous transmission of a directory (possibly several ASDUs for each change)

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Figure 103 – Sequential procedure, transmission of the directory

Controlling station	Communication services	Controlled station	Action
A_SELECT_FILE.req	**F_SC_NA_1 file**	A_SELECT_FILE.ind	Selection of disturbance to be transmitted (automatically or by operator)
A_FILE_READY.ind	**F_FR_NA_1 file**	A_FILE_READY.req	Selected disturbance is ready to be transmitted (pos/neg)
A_CALL_FILE.req	**F_SC_NA_1 file**	A_CALL_FILE.ind	Request of disturbance to be transmitted (automatically or by operator)
A_SECTION1_READY.ind	**F_SR_NA_1 file**	A_SECTION1_READY.req	Section 1 (parameter of a disturbance) is ready to be transmitted (pos/neg)
A_CALL_SECTION1.req	**F_SC_NA_1 file**	A_CALL_SECTION1.ind	Request of section 1
A_SEGMENT1.ind	**F_SG_NA_1 file**	A_SEGMENT1.req	Section 1 (parameter of a disturbance) is being transmitted
A_LAST_SEGMENT1.ind	**F_LS_NA_1 file**	A_LAST_SEGMENT1.req	Last segment section 1 (parameter of a disturbance) is transmitted (pos/neg)
A_ACK_SECTION1.req	**F_AF_NA_1 file**	A_ACK_SECTION1.ind	Acknowledge of transmission of section 1 (pos/neg)
A_SECTION2_READY.ind	**F_SR_NA_1 file**	A_SECTION2_READY.req	Section 2 (tags of a disturbance) is ready to be transmitted (pos/neg)
A_CALL_SECTION2.req	**F_SC_NA_1 file**	A_CALL_SECTION2.ind	Request of section 2

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Figure 104 – Sequential procedure, transmission of disturbance data files

Controlling station	Communication services	Controlled station	Action
A_SEGMENT1.ind	**F_SG_NA_1 file**	A_SEGMENT1.req	Section 2 (tags of disturbance) is being transmitted
A_SEGMENT1.ind	**F_SG_NA_1 file**	A_SEGMENT1.req	Section 2 (tags of disturbance) is being transmitted
A_LAST_SEGMENT1.ind	**F_LS_NA_1 file**	A_LAST_SEGMENT1.req	Last segment section 2 (tags of a disturbance) is transmitted (pos/neg)
A_ACK_SECTION2.req	**F_AF_NA_1 file**	A_ACK_SECTION2.ind	Acknowledge of transmission of section 2 (pos/neg)
A_SECTION3_READY.ind	**F_SR_NA_1 file**	A_SECTION3_READY.req	Section 3 (parameter of channel 1) is ready to be transmitted (pos/neg)
A_CALL_SECTION3.req	**F_SC_NA_1 file**	A_CALL_SECTION3.ind	Request of section 3
A_SEGMENT1.ind	**F_SG_NA_1 file**	A_SEGMENT1.req	Section 3 (parameter of channel 1) is being transmitted
A_LAST_SEGMENT.ind	**F_LS_NA_1 file**	A_LAST_SEGMENT.req	Last segment section 3 (parameter of channel 1) is transmitted (pos/neg)
A_ACK_SECTION3.req	**F_AF_NA_1 file**	A_ACK_SECTION3.ind	Acknowledge of transmission of section 3 (pos/neg)
A_SECTION4_READY.ind	**F_SR_NA_1 file**	A_SECTION4_READY.req	Section 4 (disturbance data of channel 1) is ready to be transmitted (pos/neg)
A_CALL_SECTION4.req	**F_SC_NA_1 file**	A_CALL_SECTION4.ind	Request of section 4
A_SEGMENT1.ind	**F_SG_NA_1 file**	A_SEGMENT1.req	Section 4 (disturbance data of channel 1) is being transmitted
A_SEGMENT1.ind	**F_SG_NA_1 file**	A_SEGMENT1.req	Section 4 (disturbance data of channel 1) is being transmitted
A_LAST_SEGMENT.ind	**F_LS_NA_1 file**	A_LAST_SEGMENT.req	Last segment section 4 (disturbance data of channel 1) is transmitted (pos/neg)
A_ACK_SECTION4.req	**F_AF_NA_1 file**	A_ACK_SECTION4.ind	Acknowledge of transmission of section 4 (pos/neg)
A_SECTIONm_READY.ind	**F_SR_NA_1 file**	A_SECTIONm_READY.req	Section m (parameter of channel n) is ready to be transmitted (pos/neg)
A_CALL_SECTION m.req	**F_SC_NA_1 file**	A_CALL_SECTION m.ind	Request of section m

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Figure 104 *(continued)*

Controlling station	Communication services	Controlled station	Action
A_SEGMENT1.ind ←	← **F_SG_NA_1 file** ←	A_SEGMENT1.req ←	Section m (parameter of channel n) is being transmitted
A_LAST_SEGMENT.ind ←	← **F_LS_NA_1 file** ←	A_LAST_SEGMENT.req ←	Last segment section m (parameter of channel n) is transmitted (pos/neg)
A_ACK_SECTION m.req →	→ **F_AF_NA_1 file** →	A_ACK_SECTION m.ind →	Acknowledge of transmission of section m (pos/neg)
A_SECTION m+1_READY.ind ←	← **F_SR_NA_1 file** ←	A_SECTION m+1_READY.req ←	Section m+1 (disturbance data of channel n) is ready to be transmitted (pos/neg)
A_CALL_SECTION m+1.req →	→ **F_SC_NA_1 file** →	A_CALL_SECTION m+1.ind →	Request of section m+1
A_SEGMENT1.ind ←	← **F_SG_NA_1 file** ←	A_SEGMENT1.req ←	Section m+1 (disturbance data of channel n) is being transmitted
A_SEGMENT2.ind ←	← **F_SG_NA_1 file** ← ⋮	A_SEGMENT2.req ←	Section m+1 (disturbance data of channel n) is being transmitted
A_LAST_SEGMENT.ind ←	**F_LS_NA_1 file** ←	A_LAST_SEGMENT.req ←	Last segment section m+1 (disturbance data of channel n) is transmitted (pos/neg)
LAST_ACK_SECTION m+1.req →	→ **F_AF_NA_1 file** →	LAST_ACK_SECTION m+1.ind →	Acknowledge of transmission of section m+1 (pos/neg)
A_LAST_SECTION.ind ←	← **F_LS_NA_1 file** ←	A_LAST_SECTION.req ←	Last section is transmitted (pos/neg)
A_ACK_FILE.req →	→ **F_AF_NA_1 file** →	A_ACK_FILE.ind →	Acknowledge of transmission of disturbance (pos/neg)
A_DIRECTORY.ind ←	← **F_DR_TA_1 spont** ←	A_DIRECTORY.req ←	List of disturbances (topical) may be transmitted in order to update the directory

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Figure 104 *(concluded)*

7.4.11.2.7 Conditions in case of interruptions of the transmission of disturbance data

Subclauses 7.2.6 and 7.3.6 specify provisions for the correct transfer of files which include the test of the completeness and consistency of data files. In the case of recognition of irregular conditions by the controlling station, it may repeat the request for the transmission of a section or a complete file.

The effectiveness of these test routines supposes the correct data transmission of the ASDUs with the following type identifications

– 120 file ready
– 121 section ready
– 122 call directory, select file, call file, call section
– 123 last section, last segment
– 124 ACK file, ACK section

which are used to control the file transfer.

In case of incorrectness or loss of one of the above ASDUs, the file transfer is disrupted and cannot be continued without repetitions. The station which detects such incorrectness has to interrupt the transmission of the file transfer eventually after a defined time out. After the recognition of the defect by the controlling station, it transmits F_SC_NA_1 with SCQ = 3 (deactivate file). If the defect is detected by the controlled station it transmits F_LS_NA_1 with LSQ = 2 (file transfer with deactivation).

In case of the complete loss of the communication services of the link layer, the file transfer is deactivated without a specific error indication. The file transfer has to be re-initialized when the link layer functionality is available again.

7.4.11.3 Transmission of sequences of events (spontaneous digital information)

This Subclause defines the transmission of sequences of events (spontaneous digital information) which are acquired and recorded as information objects in the substation. The information objects are mapped onto the file transfer mechanism defined in this standard, when onward transmission to the controlling station is required.

7.4.11.3.1 Structure of the record of sequences of events in a section of a file

Figure 105 shows the structure of the record of sequences of events (spontaneous digital information). Each event is transmitted as an ASDU defined in 7.3. The file with the recorded spontaneous digital information consists of exactly one section, which corresponds to a section defined in IEC 60870-5-5.

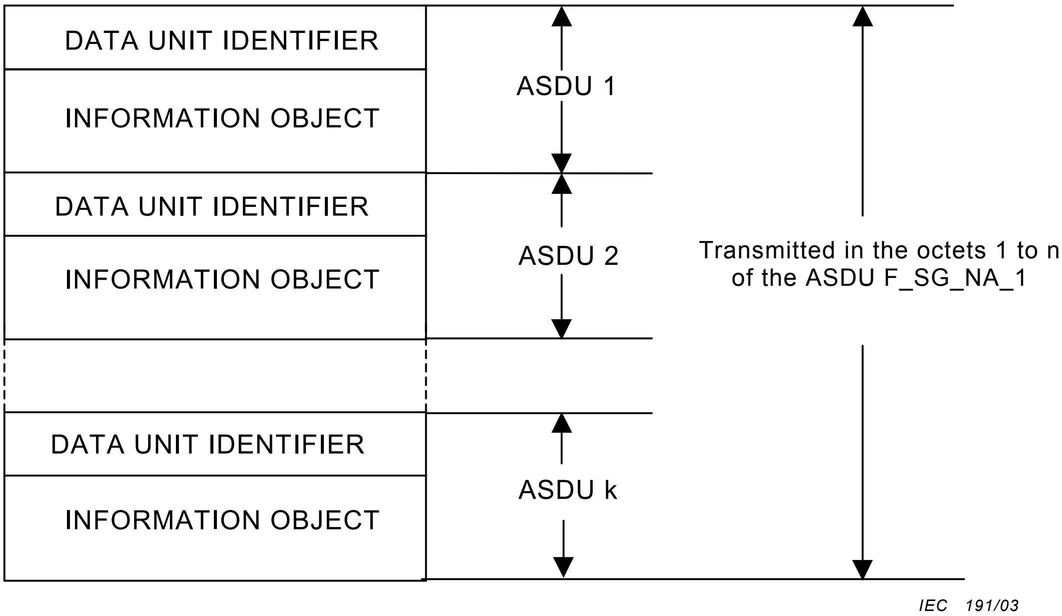

Figure 105 – Record of sequences of events in the section of a data file

ASDUs with the following type identifications may be transmitted as spontaneous digital information:

<30>	:=	Single-point information with time tag CP56Time2a	M_SP_TB_1
<31>	:=	Double-point information with time tag CP56Time2a	M_DP_TB_1
<32>	:=	Step position information with time tag CP56Time2a	M_ST_TB_1
<33>	:=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
<34>	:=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
<35>	:=	Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
<36>	:=	Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
<37>	:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
<38>	:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
<39>	:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
<40>	:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

The variable structure qualifier is set to 1, i.e. only one information object is transmitted per ASDU.

7.4.11.3.2 Procedures

The procedures for the transmission of the directory are defined in Figure 103. The procedures of transmission of sequences of events specified in 7.4.11.3.1 are defined in Figure 106. The definitions correspond to the procedures defined in 6.12 of IEC 60870-5-5.

ASDUs <30> to <40>, which are transmitted to the controlling station via file transfer, are buffered in the controlled station including the point of time at which they are acquired. If a predefined number (parameter) of buffered ASDUs is exceeded (complete file to be transmitted), the controlled station transmits spontaneously the directory F_DR_TA_1 to the controlling station. The transmission of a sequence of event file which is ready to be transmitted may be activated by sending an ASDU F_SC_NA_1 Name of file = 3 and FOR = 0:

– by an operator in the controlling station;
– automatically by the controlling station after receiving the spontaneously transmitted directory;
– automatically once per day when files are available to be transmitted indicated by the directory;

– after the restart of the controlling or controlled station when files are available to be transmitted indicated by the directory;

– when the link layer is available again after an interruption.

Controlling station	Communication services	Controlled station	Action
A_SELECT_FILE.req →	F_SC_NA_1 file →	A_SELECT_FILE.ind →	Selection of event data to be transmitted (automatically or by operator)
A_FILE_READY.ind ←	F_FR_NA_1 file ←	A_FILE_READY.req ←	Selected event data is ready to be transmitted (pos/neg)
A_CALL_FILE.req →	F_SC_NA_1 file →	A_CALL_FILE.ind →	Request of event data to be transmitted (automatically or by operator)
A_SECTION_READY.ind ←	F_SR_NA_1 file ←	A_SECTION_READY.req ←	Section (data) is ready to be transmitted (pos/neg)
A_CALL_SECTION.req →	F_SC_NA_1 file →	A_CALL_SECTION_.ind →	Request of section
A_SEGMENT.ind ←	F_SG_NA_1 file ←	A_SEGMENT.req ←	Section (data) is being transmitted
. . .	. . .	. . .	
A_SEGMENT.ind ←	F_SG_NA_1 file ←	A_SEGMENT.req ←	Section (data) is being transmitted
A_LAST_SEGMENT.ind ←	F_LS_NA_1 file ←	A_LAST_SEGMENT.req ←	Last segment of section (data) is transmitted
A_ACK_SECTION.req →	F_AF_NA_1 file →	A_ACK_SECTION.ind →	ACK (pos/neg) of transmission of section 1
A_LAST_SECTION.ind ←	F_LS_NA_1 file ←	A_LAST_SECTION.req ←	Last section is transmitted (pos/neg)
A_ACK_FILE.req →	F_AF_NA_1 file →	A_ACK_FILE.ind →	Acknowledge (pos/neg) of transmission of data

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Figure 106 – Sequential procedure, transmission of sequences of events

Maximum length of a segment: 240 octets

Maximum length of the section: 64 000 octets

7.4.11.3.3 Conditions in case of interruptions of the transmission of sequences of events

(See 7.4.11.2.7.)

7.4.11.4 Transmission of sequences of recorded analogue values

This Subclause defines the transmission of sequences of recorded analogue values (for example, measured values, integrated totals) acquired in a controlled station. The recorded analogue values are transmitted via the file transfer defined in IEC 60870-5-5 and this standard when onward transmission to the controlling station is required. Compressed records are not defined in this standard but may be transmitted as transparent data files.

7.4.11.4.1 Structure of data files containing sequences of recorded analogue values

Each file consists of one or more than one section, which corresponds to a section defined in IEC 60870-5-5. The structure of the sections is identical. Each section contains the information elements of a specific sequence of recorded analogue values (binary counter readings or measured values) which is defined by the record identifier.

Section 1 sequence of recorded analogue values of section 1

Section 2 sequence of recorded analogue values of section 2

Section 3 sequence of recorded analogue values of section 3

etc.

Figure 107 shows the structure of sequences of recorded analogue values which are transmitted in the octets 1 to n of the ASDU F_SG_NA_1.

CP56Time2a	Start time Ts of recording	Transmitted in the octets 1 to n of the ASDU F_SG_NA_1
Time interval	Definition of the time interval	
UI16	Record address	
UI16	Number of information elements	
INFORMATION ELEMENT	Value (Ts + 0 × time interval)	
INFORMATION ELEMENT	Value (Ts + 1 × time interval)	
INFORMATION ELEMENT	Value (Ts + m × time interval)	

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Figure 107 – Section of a data file containing sequences of recorded analogue values

The following information elements may be transmitted as sequences of recorded analogue values:

– binary counter reading according to 7.2.6.9;

– normalized value according to 7.2.6.6;

– normalized value according to 7.2.6.6 with quality descriptor QDS according to 7.2.6.3.

The time interval (interval between information elements) is the product of the time base and the factor.

Definition of the time interval:

Time interval		:=	CP16{ Factor, Time base}
Factor		:=	UI8[1..8]<0..255>
	<0>	:=	Not used
	<1..255>	:=	Factor
Time base		:=	UI8[9..15]<0..255>
	<0>	:=	Not used
	<1>	:=	1 ms
	<2>	:=	10 ms
	<3>	:=	100 ms
	<4>	:=	1000 ms
	<5>	:=	1 min
	<6>	:=	1 h
	<7..15>	:=	Reserved for standard definitions of this companion standard (compatible range)
	<16..255>	:=	Reserved for special use (private range)

Definition of the record identifier:

Record identifier := CP16{Record address, Record qualifier}

Record address := UI14[1..14]<0..16383>

Record qualifier := UI2[15..16]<0..3>

<0> := Not used

<1> := Sequences of recorded normalized values according to 7.2.6.6

<2> := Sequences of recorded binary counter readings according to 7.2.6.9

<3> := Reserved for special use (private range)

The record identifier defines the set of information elements (normalized values or counter readings) and the address of the complete sequence of recorded analogue values. The record address does not relate to a specific address of an information element.

7.4.11.4.2 Procedures

The procedures for the transmission of the directory are defined in Figure 103. The procedures of transmission of recorded analogue values specified in 7.4.11.4.1 are defined in Figure 108. The definitions correspond to the procedures defined in 6.12 of IEC 60870-5-5. The transmission of a file sequence of recorded analogue values which is ready to be transmitted may be activated by sending an ASDU F_SC_NA_1 Name of file = 4 and FOR = 0:

- by an operator in the controlling station;
- automatically by the controlling station after receiving the spontaneously transmitted directory;
- automatically once per day when files are available to be transmitted indicated by the directory;
- after the restart of the controlling or controlled station when files are available to be transmitted, indicated by the directory;
- when the link layer is available again after an interruption.

Controlling station	Communication services	Controlled station	Action
A_SELECT_FILE.req →	F_SC_NA_1 file →	A_SELECT_FILE.ind →	Selection of file containing analogue values to be transmitted (automatically or by operator)
A_FILE_READY.ind ←	F_FR_NA_1 file ←	A_FILE_READY.req ←	Selected file containing analogue values is ready to be transmitted (pos/neg)
A_CALL_FILE.req →	F_SC_NA_1 file →	A_CALL_FILE.ind →	Request of file containing analogue values to be transmitted (automatically or by operator)
A_SECTION1_READY.ind ←	F_SR_NA_1 file ←	A_SECTION_READY1.req ←	Section 1 (data) is ready to be transmitted (pos/neg)
A_CALL_SECTION1.req →	F_SC_NA_1 file →	A_CALL_SECTION1.ind →	Request of section 1
A_SEGMENT.ind ←	F_SG_NA_1 file ←	A_SEGMENT.req ←	Section 1 (data) is being transmitted
. .	. .	. .	. .
A_SEGMENT.ind ←	F_SG_NA_1 file ←	A_SEGMENT.req ←	Section 1 (data) is being transmitted
A_LAST_SEGMENT.ind ←	F_LS_NA_1 file ←	A_LAST_SEGMENT.req ←	Last segment of section 1 (data) is transmitted
A_ACK_SECTION1.req →	F_AF_NA_1 file →	A_ACK_SECTION1.ind →	Acknowledge of transmission of section 1 (pos/neg)
A_SECTION2_READY.ind ←	F_SR_NA_1 file ←	A_SECTION_READY2.req ←	Section 2 (data) is ready to be transmitted (pos/neg)
A_CALL_SECTION2.req →	F_SC_NA_1 file →	A_CALL_SECTION2.ind →	Request of section 2
A_SEGMENT.ind ←	F_SG_NA_1 file ←	A_SEGMENT.req ←	Section 2 (data) is being transmitted
. .	. .	. .	. .
A_SEGMENT.ind ←	F_SG_NA_1 file ←	A_SEGMENT.req ←	Section 2 (data) is being transmitted
A_LAST_SEGMENT.ind ←	F_LS_NA_1 file ←	A_LAST_SEGMENT.req ←	Last segment of section 2 (data) is transmitted
A_ACK_SECTION2.req →	F_AF_NA_1 file →	A_ACK_SECTION2.ind →	Acknowledge of transmission of section 2 (pos/neg)
. .	. .	. .	. .
A_SECTIONn_READY.ind ←	F_SR_NA_1 file ←	A_SECTIONn_READY.req ←	Section n (data) is ready to be transmitted (pos/neg)
A_CALL_SECTIONn.req →	F_SC_NA_1 file →	A_CALL_SECTIONn.ind →	Request of section n
A_SEGMENT.ind ←	F_SG_NA_1 file ←	A_SEGMENT.req ←	Section n (data) is being transmitted
. .	. .	. .	. .
A_SEGMENT.ind ←	F_SG_NA_1 file ←	A_SEGMENT.req ←	Section n (data) is being transmitted
A_LAST_SEGMENT.ind ←	F_LS_NA_1 file ←	A_LAST_SEGMENT.req ←	Last segment of section n (data) is transmitted
A_ACK_SECTIONn.req →	F_AF_NA_1 file →	A_ACK_SECTIONn.ind →	Acknowledge of transmission of section n (pos/neg)
A_LAST_SECTION.ind ←	F_LS_NA_1 file ←	A_LAST_SECTION.req ←	Last section is transmitted (pos/neg)
A_ACK_FILE.req →	F_AF_NA_1 file →	A_ACK_FILE.ind →	Acknowledge of transmission of data

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Figure 108 – Sequential procedure, transmission of sequences of recorded analogue values

7.4.11.4.3 Conditions in case of interruptions of the transmission of sequences of recorded analogue values

(See 7.4.11.2.7.)

7.4.12 Selections from acquisition of transmission delay

Options of IEC 60870-5-5, 6.13:
C_CD_NA_1 SPONTANEOUS (load delay) in the control direction is used.

When a clock synchronization command is received, the time information must be corrected by the controlled station with the value received in the load delay command.

NOTE A_SDT.ind freezes the time at the instant when the first bit of a C_CD frame is received by the controlled station and A_SDT + tR.ind freezes the time at the instant when the first bit of a C_CD ACTCON frame is received by the controlling station (see Figure 23 of IEC 60870-5-5).

7.4.13 Background scan

The background scan is used to update process information from the controlled station to the controlling station as an additional safeguard to the station interrogation and spontaneous transmission procedures. ASDUs with the same type identification numbers as defined for the station interrogation procedure may be transmitted with cause of transmission <2> background scan on a low-priority continuous basis. The background scan is initiated by the controlled station and therefore independent from station interrogation commands. The transmission cycle is configured by fixed parameters in the controlled station. Measured values reported by periodic or cyclic transmission (COT = 1) are not usually reported as background scan (COT = 2), spontaneous (COT = 3) or station interrogation (COT = 20 to 36).

Table 21 – Type identifications for background scan

Direction (C=command M=monitor)	**Type identification**	**Cause of transmission**	
M	<1> M_SP_NA_1		
	<3> M_DP_NA_1	<2> background scan	
	<5> M_ST_NA_1		
	<7> M_BO_NA_1		
	<9> M_ME_NA_1		
	<11> M_ME_NB_1		
	<13> M_ME_NC_1		
	<20> M_PS_NA_1		
	<21> M_ME_ND_1		

7.4.14 Read procedure

Controlling station	**Communication services**	**Controlled station**	**Action**
A_RD_DATA.req	C_RD_NA_1 <5> REQ	A_RD_DATA.ind	Read information object which is specified by the information object address
A_M_DATA.ind	M_ <5> REQ	A_M_DATA.req	Respond information object which has been read

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Figure 109 – Sequential procedure, read procedure

The application process in the controlling station sends the read command as an A_RD_DATA.req to the communication services, the communication services transmit a C_RD_NA_1 REQ PDU containing the information object address which specifies the requested information object.

The application process in the controlled station returns the requested information object as an A_M_DATA.req to the communication services. The communication services in the controlled station attach the requested information object to the assigned ASDU in the monitor direction and transmit it as an M_PDU with the cause of transmission <5> REQ.

The following ASDUs M_REQ may be returned in the monitor direction:

<1>	M_SP_NA_1 REQ			
<2>	M_SP_TA_1 REQ	or	<30>	M_SP_TB_1 REQ
<3>	M_DP_NA_1 REQ			
<4>	M_DP_TA_1 REQ	or	<31>	M_DP_TB_1 REQ
<5>	M_ST_NA_1 REQ			
<6>	M_ST_TA_1 REQ	or	<32>	M_ST_TB_1 REQ
<7>	M_BO_NA_1 REQ			
<8>	M_BO_TA_1 REQ	or	<33>	M_BO_TB_1 REQ
<9>	M_ME_NA_1 REQ			
<10>	M_ME_TA_1 REQ	or	<34>	M_ME_TD_1 REQ
<11>	M_ME_NB_1 REQ			
<12>	M_ME_TB_1 REQ	or	<35>	M_ME_TE_1 REQ
<13>	M_ME_NC_1 REQ			
<14>	M_ME_TC_1 REQ	or	<36>	M_ME_TF_1 REQ
<20>	M_PS_NA_1 REQ			
<21>	M_ME_ND_1 REQ			
<126>	F_DR_TA_1 REQ			

If the values in the data unit identifier (except the variable structure qualifier) and the information object address of the read command are unknown (not defined) in the controlled station, the mirrored C_RD_NA_1 with the cause of transmission <44 – 47> is returned (see 7.2.3.1).

8 Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications.This Clause summarizes the parameters of the previous Clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers, it is necessary that all partners agree on the selected parameters.

The selected parameters should be marked in the white boxes as follows:

☐	Function or ASDU is not used
X	Function or ASDU is used as standardized (default)
R	Function or ASDU is used in reverse mode
B	Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific Clause or parameter.

NOTE In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

8.1 System or device

(system-specific parameter, indicate the definition of a system or a device by marking one of the following with an "**X**")

☐ System definition

☐ Controlling station definition (master)

☐ Controlled station definition (slave)

8.2 Network configuration

(network-specific parameter, all configurations that are used are to be marked with an "**X**")

☐ Point-to-point	☐ Multipoint-partyline
☐ Multiple point-to-point	☐ Multipoint-star

8.3 Physical layer

(network-specific parameter, all interfaces and data rates that are used are to be marked with an "**X**")

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
☐ 100 bit/s	☐ 2 400 bit/s	☐ 2 400 bit/s	☐ 56 000 bit/s
☐ 200 bit/s	☐ 4 800 bit/s	☐ 4 800 bit/s	☐ 64 000 bit/s
☐ 300 bit/s	☐ 9 600 bit/s	☐ 9 600 bit/s	
☐ 600 bit/s		☐ 19 200 bit/s	
☐ 1 200 bit/s		☐ 38 400 bit/s	

Transmission speed (monitor direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
☐ 100 bit/s	☐ 2 400 bit/s	☐ 2 400 bit/s	☐ 56 000 bit/s
☐ 200 bit/s	☐ 4 800 bit/s	☐ 4 800 bit/s	☐ 64 000 bit/s
☐ 300 bit/s	☐ 9 600 bit/s	☐ 9 600 bit/s	
☐ 600 bit/s		☐ 19 200 bit/s	
☐ 1 200 bit/s		☐ 38 400 bit/s	

8.4 Link layer

(network-specific parameter, all options that are used are to be marked with an "**X**". Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure

☐ Balanced transmission

☐ Unbalanced transmission

Frame length

☐ Maximum length L (control direction)

☐ Maximum length L (monitor direction)

Address field of the link

☐ Not present (balanced transmission only)

☐ One octet

☐ Two octets

☐ Structured

☐ Unstructured

☐ Time during which repetitions are permitted (Trp) or number of repetitions

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

☐ The standard assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission
9, 11, 13, 21	<1>

☐ A special assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission

NOTE In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.

8.5 Application layer

Transmission mode for application data

Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU
(system-specific parameter, all configurations that are used are to be marked with an "**X**")

☐ One octet ☐ Two octets

Information object address
(system-specific parameter, all configurations that are used are to be marked with an "**X**")

☐ One octet ☐ Structured
☐ Two octets ☐ Unstructured
☐ Three octets

Cause of transmission
(system-specific parameter, all configurations that are used are to be marked with an "**X**")

☐ One octet ☐ Two octets (with originator address)
Originator address is set to zero if not used

Selection of standard ASDUs

Process information in monitor direction
(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

	Type ID	Description	Identifier
☐	<1> :=	Single-point information	M_SP_NA_1
☐	<2> :=	Single-point information with time tag	M_SP_TA_1
☐	<3> :=	Double-point information	M_DP_NA_1
☐	<4> :=	Double-point information with time tag	M_DP_TA_1
☐	<5> :=	Step position information	M_ST_NA_1
☐	<6> :=	Step position information with time tag	M_ST_TA_1
☐	<7> :=	Bitstring of 32 bit	M_BO_NA_1
☐	<8> :=	Bitstring of 32 bit with time tag	M_BO_TA_1
☐	<9> :=	Measured value, normalized value	M_ME_NA_1
☐	<10> :=	Measured value, normalized value with time tag	M_ME_TA_1
☐	<11> :=	Measured value, scaled value	M_ME_NB_1
☐	<12> :=	Measured value, scaled value with time tag	M_ME_TB_1
☐	<13> :=	Measured value, short floating point value	M_ME_NC_1
☐	<14> :=	Measured value, short floating point value with time tag	M_ME_TC_1
☐	<15> :=	Integrated totals	M_IT_NA_1
☐	<16> :=	Integrated totals with time tag	M_IT_TA_1
☐	<17> :=	Event of protection equipment with time tag	M_EP_TA_1
☐	<18> :=	Packed start events of protection equipment with time tag	M_EP_TB_1
☐	<19> :=	Packed output circuit information of protection equipment with time tag	M_EP_TC_1
☐	<20> :=	Packed single-point information with status change detection	M_PS_NA_1
☐	<21> :=	Measured value, normalized value without quality descriptor	M_ME_ND_1
☐	<30> :=	Single-point information with time tag CP56Time2a	M_SP_TB_1
☐	<31> :=	Double-point information with time tag CP56Time2a	M_DP_TB_1
☐	<32> :=	Step position information with time tag CP56Time2a	M_ST_TB_1
☐	<33> :=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
☐	<34> :=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☐	<35> :=	Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
☐	<36> :=	Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
☐	<37> :=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38> :=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39> :=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40> :=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Either ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, <19> or of the set <30 –40> are used.

Process information in control direction

(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐	<45> :=	Single command	C_SC_NA_1
☐	<46> :=	Double command	C_DC_NA_1
☐	<47> :=	Regulating step command	C_RC_NA_1
☐	<48> :=	Set point command, normalized value	C_SE_NA_1
☐	<49> :=	Set point command, scaled value	C_SE_NB_1
☐	<50> :=	Set point command, short floating point value	C_SE_NC_1
☐	<51> :=	Bitstring of 32 bit	C_BO_NA_1

System information in monitor direction

(station-specific parameter, mark with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐	<70> :=	End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐	<100>:=	Interrogation command	C_IC_NA_1
☐	<101>:=	Counter interrogation command	C_CI_NA_1
☐	<102>:=	Read command	C_RD_NA_1
☐	<103>:=	Clock synchronization command	C_CS_NA_1
☐	<104>:=	Test command	C_TS_NA_1
☐	<105>:=	Reset process command	C_RP_NA_1
☐	<106>:=	Delay acquisition command	C_CD_NA_1

Parameter in control direction
(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐ <110>:= Parameter of measured value, normalized value P_ME_NA_1

☐ <111>:= Parameter of measured value, scaled value P_ME_NB_1

☐ <112>:= Parameter of measured value, short floating point value P_ME_NC_1

☐ <113>:= Parameter activation P_AC_NA_1

File transfer
(station-specific parameter, mark each type ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

☐ <120>:= File ready F_FR_NA_1

☐ <121>:= Section ready F_SR_NA_1

☐ <122>:= Call directory, select file, call file, call section F_SC_NA_1

☐ <123>:= Last section, last segment F_LS_NA_1

☐ <124>:= Ack file, ack section F_AF_NA_1

☐ <125>:= Segment F_SG_NA_1

☐ <126>:= Directory {blank or X, only available in monitor (standard) direction} F_DR_TA_1

Type identification and cause of transmission assignments
(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used.

Mark type identification/cause of transmission combinations:

"**X**" if used only in the standard direction;

"**R**" if used only in the reverse direction;

"**B**" if used in both directions.

Type identification		**Cause of transmission**																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1																			
<2>	M_SP_TA_1																			
<3>	M_DP_NA_1																			
<4>	M_DP_TA_1																			
<5>	M_ST_NA_1																			
<6>	M_ST_TA_1																			
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1																			
<10>	M_ME_TA_1																			
<11>	M_ME_NB_1																			
<12>	M_ME_TB_1																			
<13>	M_ME_NC_1																			
<14>	M_ME_TC_1																			
<15>	M_IT_NA_1																			
<16>	M_IT_TA_1																			
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1																			
<31>	M_DP_TB_1																			
<32>	M_ST_TB_1																			
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1																			
<35>	M_ME_TE_1																			
<36>	M_ME_TF_1																			
<37>	M_IT_TB_1																			
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1																			
<46>	C_DC_NA_1																			
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1																			

Type identification		Cause of transmission																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<70>	M_EI_NA_1																			
<100>	C_IC_NA_1																			
<101>	C_CI_NA_1																			
<102>	C_RD_NA_1																			
<103>	C_CS_NA_1																			
<104>	C_TS_NA_1																			
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1[a)]																			

[a)] Blank or X only.

8.6 Basic application functions

Station initialization
(station-specific parameter, mark with an "**X**" if function is used)

☐ Remote initialization

Cyclic data transmission
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Cyclic data transmission

Read procedure
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Read procedure

Spontaneous transmission
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous
(station-specific parameter, mark each information type with an "**X**" where both a type ID without time and corresponding type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1

☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1
(if defined for a specific project, see 7.2.1.1)

☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1

☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1

☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

Station interrogation
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ global

☐ group 1	☐ group 7	☐ group 13
☐ group 2	☐ group 8	☐ group 14
☐ group 3	☐ group 9	☐ group 15
☐ group 4	☐ group 10	☐ group 16
☐ group 5	☐ group 11	Information object addresses assigned to each group must be shown in a separate table
☐ group 6	☐ group 12	

Clock synchronization
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Clock synchronization

☐ Day of week used

☐ RES1, GEN (time tag substituted/ not substituted) used

☐ SU-bit (summertime) used

Command transmission
(object-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Direct command transmission
☐ Direct set point command transmission
☐ Select and execute command
☐ Select and execute set point command
☐ C_SE ACTTERM used

☐ No additional definition
☐ Short-pulse duration (duration determined by a system parameter in the controlled station)
☐ Long-pulse duration (duration determined by a system parameter in the controlled station)
☐ Persistent output

Transmission of integrated totals
(station- or object-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Mode A: local freeze with spontaneous transmission
☐ Mode B: local freeze with counter interrogation
☐ Mode C: freeze and transmit by counter interrogation commands
☐ Mode D: freeze by counter-interrogation command, frozen values reported spontaneously

☐ Counter read
☐ Counter freeze without reset
☐ Counter freeze with reset
☐ Counter reset

☐ General request counter
☐ Request counter group 1
☐ Request counter group 2
☐ Request counter group 3
☐ Request counter group 4

Parameter loading
(object-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Threshold value
☐ Smoothing factor
☐ Low limit for transmission of measured value
☐ High limit for transmission of measured

Parameter activation
(object-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Test procedure

File transfer
(station-specific parameter, mark with an "**X**" if function is used)

File transfer in monitor direction

☐ Transparent file
☐ Transmission of disturbance data of protection equipment
☐ Transmission of sequences of events
☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Background scan

Acquisition of transmission delay
(station-specific parameter, mark with an "**X**" if function is used only in the standard direction, "**R**" if used only in the reverse direction, and "**B**" if used in both directions)

☐ Acquisition of transmission delay

Annex A
(informative)

Proof of the synchronization stability of frame format class FT 1.2

A.1 Introduction

This abstract proves that the frame format FT 1.2 defined in IEC 60870-5-1 fulfils the required data integrity requirements of data integrity class 2 which requires that less than 4 bit errors must not cause undetectable message errors.

The abstract includes the proof of the detection of three bit inversions at any position of the transmitted frames including the line idles. Synchronization slips caused by bit inversions are demonstrably detected. Bit inversions which may occur within shifted frames are detected by the rules defined in IEC 60870-5-2 (parity and arithmetical check sum).

The proof is provided by the following steps:

a) proof of the shift insusceptibility of the defined characters;

b) proof that the characters are mutually not susceptible to shift, i.e. a character for a fixed block length must not be converted into a character for variable block length by less than 4 bit errors and vice versa;

c) proof of the shift insusceptibility of frames with variable block length.

All rules for format class FT 1.2 specified in IEC 60870-5-1 have also to be taken into consideration.

A.1.1 UART definition

	START	LSB							MSB	EVEN PARITY	STOP
	0	D1	D2	D3	D4	D5	D6	D7	D8	P	1
Bit sequence on the line	1	2	3	4	5	6	7	8	9	10	11

IEC 196/03

A.1.2 Frame format definitions FT 1.2

The following START, END and CONTROL characters are defined and can be used even in a mixed configuration.

Frame format with variable block length:

	1	2–9	10	11
	0	START 68H	P	1
	0	L	P	1
	0	L	P	1
	0	START 68H	P	1
1 ↓ *n*	USER DATA			
	0	CHECKSUM	P	1
	0	END 16H	P	1

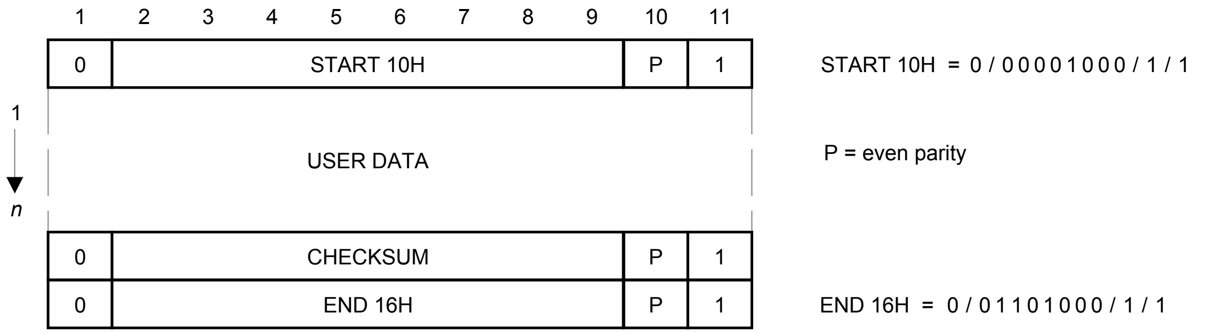
START 68H = 0 / 0 0 0 1 0 1 1 0 / 1 / 1

P = even parity

END 16H = 0 / 0 1 1 0 1 0 0 0 / 1 / 1

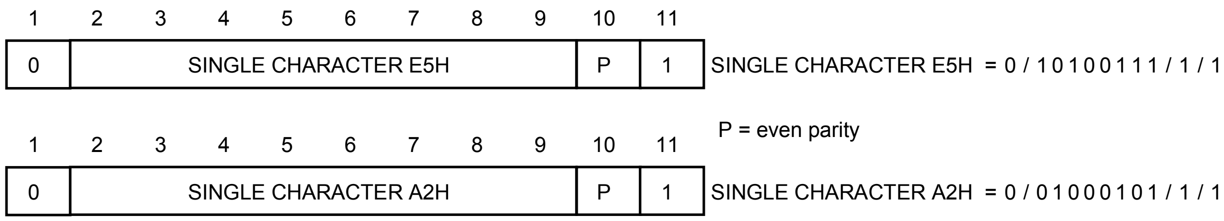
IEC 197/03

Frame format with fixed block length:



IEC 198/03

Single characters:



IEC 199/03

NOTE The single character A2 is not used in the IEC 60870-5 series (see IEC 60870-5-2).

The defined numbers specified in hexadecimal code are directly delivered from the processor to the UART, i.e. the reversed sequence of bits of the octets per line is considered.

All four specified octets have at least 4 zero bits (including START bit), so that extinction can only occur by 4 bit errors (0 in 1).

The defined characters shall also comply with the following conditions:

a) shifts as the result of incorrect synchronization in idle condition or in the information field, caused by ≤ 4 bit errors, must not produce undetectable frame errors;

b) in case of a shift produced by incorrect synchronization, caused by ≤ 4 bit errors, START 68H must not be transformed into START 10H or vice versa;

c) in case of a shift produced by incorrect synchronization, caused by ≤ 4 bit errors, START 68H must not be transformed into single characters E5H or A2H or vice versa;

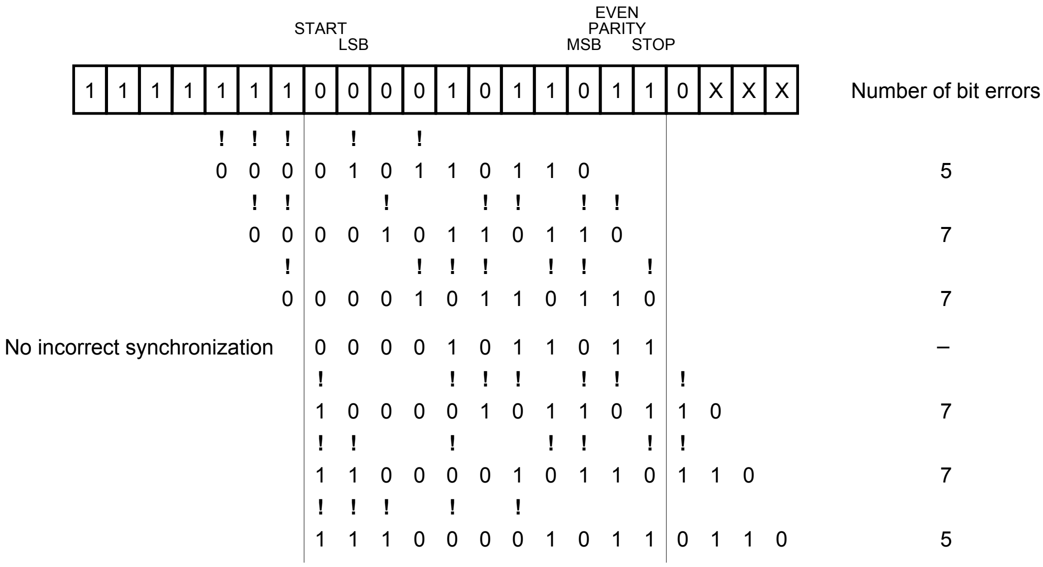
d) in case of a shift produced by incorrect synchronization, caused by ≤ 4 bit errors, START 10H must not be transformed into single characters E5H or A2H or vice versa.

A.1.3 Explanatory information on the proofs according to A.2 and A.3

The upper line comprises the original bit configuration embedded in the idle state. X defines a position at which 1 or 0 bits may occur arbitrarily. An "!" identifies a bit error. The following lines specify the incorrectly synchronized bit configurations and the number of necessary bit errors required to fulfil them.

A.2 Proof of the shift insusceptibility of the specified characters

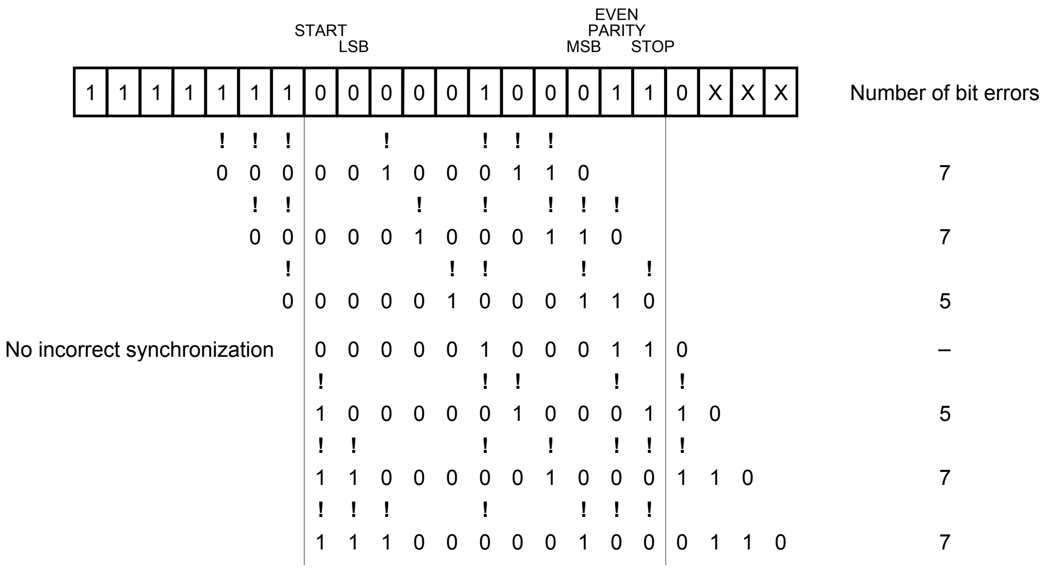
A.2.1 Shift insusceptibility of START 68H



IEC 200/03

All further shifts are produced by at least 4 bit errors.

A.2.2 Shift insusceptibility of START 10H



IEC 201/03

All further shifts are produced by at least 4 bit errors.

A.2.3 Shift insusceptibility of SINGLE CHARACTER E5H

								START	LSB							MSB	EVEN PARITY	STOP								
	1	1	1	1	1	1	1	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	Number of bit errors
		!		!		!	!	!		!		!														
		0	1	0	1	0	0	1	1	1	1	1														7
			!		!		!			!		!	!													
			0	1	0	1	0	0	1	1	1	1	1													6
				!		!			!	!		!	!													
				0	1	0	1	0	0	1	1	1	1	1												6
					!		!	!	!			!	!													
					0	1	0	1	0	0	1	1	1	1	1											6
						!					!	!	!													
						0	1	0	1	0	0	1	1	1	1	1										4
							!	!	!	!	!		!													
							0	1	0	1	0	0	1	1	1	1	1									6
No incorrect synchronization								0	1	0	1	0	0	1	1	1	1	1								–
								!	!	!	!	!		!												
								1	0	1	0	1	0	0	1	1	1	1	1							6
								!					!	!	!											
								1	1	0	1	0	1	0	0	1	1	1	1	1						4
								!		!	!	!			!	!										
								1	1	1	0	1	0	1	0	0	1	1	1	1	1					6
								!		!			!	!		!	!									
								1	1	1	1	0	1	0	1	0	0	1	1	1	1	1				6
								!		!		!			!		!	!								
								1	1	1	1	1	0	1	0	1	0	0	1	1	1	1	1			6
								!		!		!	!	!		!		!	!							
								1	1	1	1	1	1	0	1	0	1	0	0	1	1	1	1	1		8

IEC 202/03

All further shifts are produced by at least 4 bit errors.

A.2.4 Shift insusceptibility of SINGLE CHARACTER A2H

								START	LSB							MSB	EVEN PARITY	STOP								
	1	1	1	1	1	1	1	0	0	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	Number of bit errors
		!	!		!	!	!	!			!	!														
		0	0	1	0	0	0	1	0	1	1	1														8
			!	!		!	!		!	!	!	!	!													
			0	0	1	0	0	0	1	0	1	1	1													9
				!	!		!					!	!													
				0	0	1	0	0	0	1	0	1	1	1												5
					!	!				!	!		!		!											
					0	0	1	0	0	0	1	0	1	1	1											6
						!	!	!		!		!			!											
						0	0	1	0	0	0	1	0	1	1	1										6
							!		!	!			!	!	!											
							0	0	1	0	0	0	1	0	1	1	1									6
No incorrect synchronization								0	0	1	0	0	0	1	0	1	1	1								–
								!		!	!			!	!	!										
								1	0	0	1	0	0	0	1	0	1	1	1							6
								!	!	!		!		!			!									
								1	1	0	0	1	0	0	0	1	0	1	1	1						6
								!	!				!	!		!		!								
								1	1	1	0	0	1	0	0	0	1	0	1	1	1					6
								!	!		!					!	!		!							
								1	1	1	1	0	0	1	0	0	0	1	0	1	1	1				6
								!	!		!	!		!		!	!	!		!						
								1	1	1	1	1	0	0	1	0	0	0	1	0	1	1	1			9
								!	!		!	!	!	!		!	!	!	!		!					
								1	1	1	1	1	1	0	0	1	0	0	0	1	0	1	1	1		11

IEC 203/03

All further shifts are produced by at least 4 bit errors.

A.2.5 Shift insusceptibility of END 16H

```
                                                               EVEN
                                            START             PARITY
                                               LSB           MSB STOP
                              X X X X X X 1 | 0 0 1 1 0 1 0 0 0 1 1 | 1 1 1 1 1 1 1       Number of bit errors
                                            | !     !   ! ! ! !     |
                                    1 0 0 1 | 1 0 1 0 0 0 1 1 1 1 1 | 1 1 1                6
                                          ! | ! ! !     !   ! !     |
                                      1 0 0 | 1 1 0 1 0 0 0 1 1 1 1 | 1 1 1 1   1          7
                                          ! |   !   ! ! !     !     |
                                        1 0 | 0 1 1 0 1 0 0 0 1 1 1 | 1 1 1 1 1 1 1        6

No incorrect synchronization              1 | 0 0 1 1 0 1 0 0 0 1 1 | 1 1 1 1 1 1          –
                                            | !   !   ! ! !     !   |
                                            | 1 0 0 1 1 0 1 0 0 0 1 | 1 1 1 1 1 1 1        6
                                            |   ! ! ! !     !   ! ! |
                                            |   1 0 0 1 1 0 1 0 0 0 | 1 1 1 1 1 1 1        7
                                            |       !     !   ! ! ! | !
                                            |     1 0 0 1 1 0 1 0 0 | 0 1 1 1 1 1 1        6
                                            |           ! ! !     ! | ! !
                                            |       1 0 0 1 1 0 1 0 | 0 0 1 1 1 1 1 1      6
                                            |         ! !   ! ! !   | ! ! !
                                            |         1 0 0 1 1 0 1 | 0 0 0 1 1 1 1 1 1    8
```

IEC 204/03

All further shifts are produced by at least 4 bit errors.

A.3 Proof of the mutual shift insusceptibility of the characters

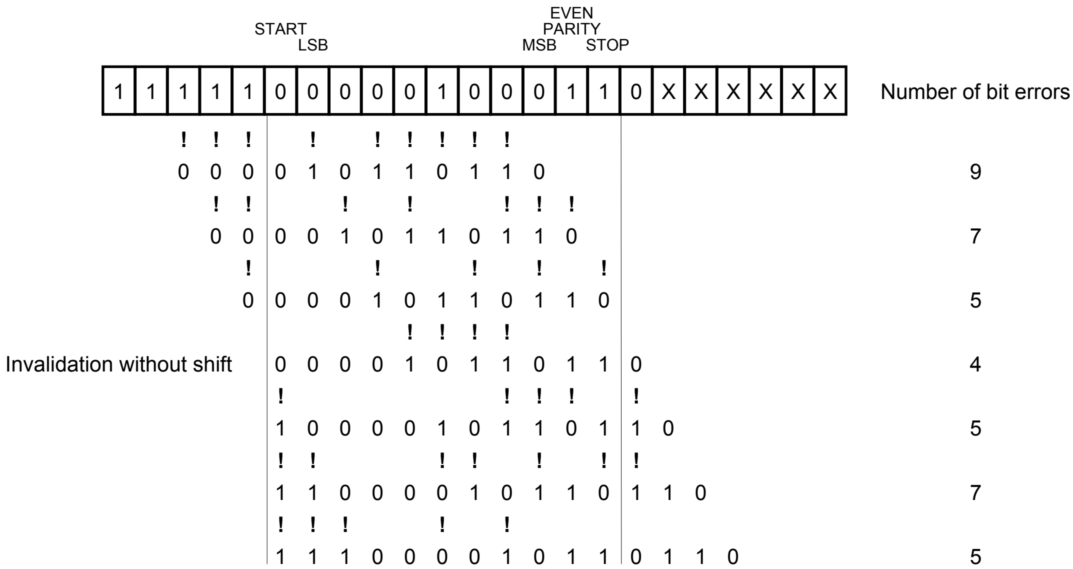
A.3.1 Shift insusceptibility of START 68H against START 10H

```
                                                           EVEN
                                        START             PARITY
                                           LSB           MSB STOP
                              1 1 1 1 1 | 0 0 0 0 1 0 1 1 0 1 1 | 0 X X X X X X   Number of bit errors
                                  ! ! ! |     !   !             |
                                  0 0 0 | 0 0 1 0 0 0 1 1 0     |                  5
                                    ! ! |       ! !   !   ! !   |
                                    0 0 | 0 0 0 1 0 0 0 1 1 0   |                  7
                                      ! |             ! ! !   ! |
                                      0 | 0 0 0 0 1 0 0 0 1 1 0 |                  5
                                        |         ! ! ! !       |
Invalidation without shift              | 0 0 0 0 0 1 0 0 0 1 1 | 0                4
                                        | !       !     !   !   | !
                                        | 1 0 0 0 0 0 1 0 0 0 1 | 1 0              5
                                        | ! !     !   !     ! ! | !
                                        | 1 1 0 0 0 0 0 1 0 0 0 | 1 1 0            7
                                        | ! ! !   !   ! ! ! ! ! |
                                        | 1 1 1 0 0 0 0 0 1 0 0 | 0 1 1 0          9
```

IEC 205/03

All further shifts are produced by at least 4 bit errors.

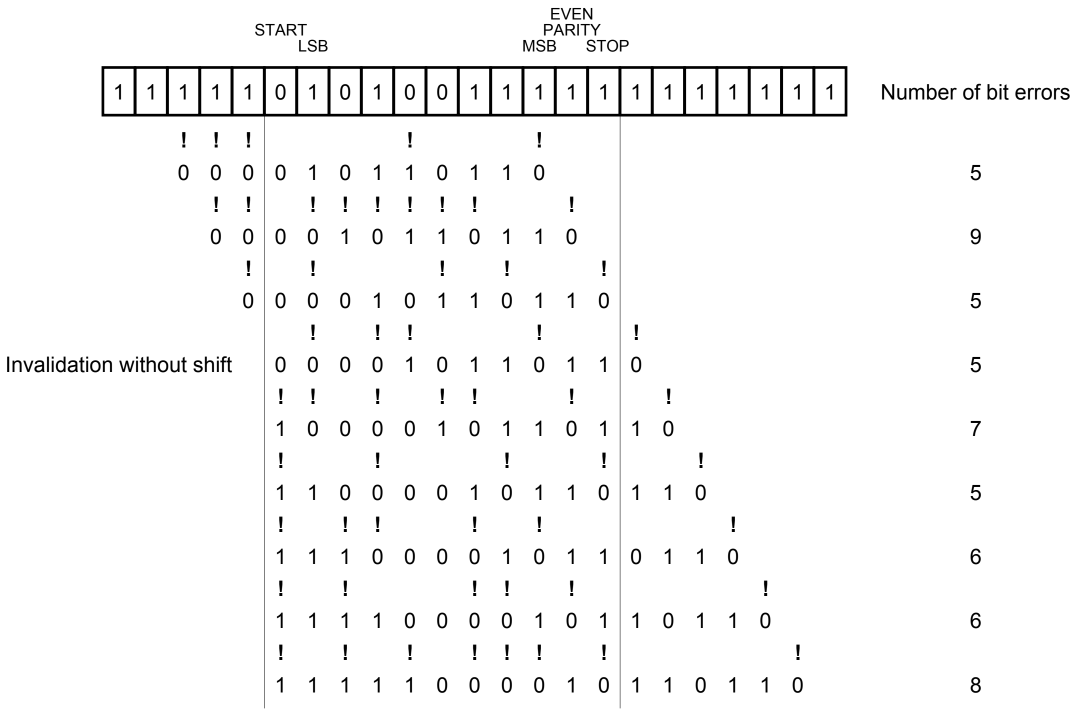
A.3.2 Shift insusceptibility of START 10H against START 68H



IEC 206/03

All further shifts are produced by at least 4 bit errors.

A.3.3 Shift insusceptibility of SINGLE CHARACTER E5H against START 68H



IEC 207/03

All further shifts are produced by at least 4 bit errors.

A.3.4 Shift insusceptibility of START 68H against SINGLE CHARACTER E5H

							START LSB								MSB	EVEN PARITY	STOP								
	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	1	1	0	X	X	X	X	X	X	Number of bit errors
	!		!		!	!	!	!	!	!															
	0	1	0	1	0	0	1	1	1	1	1														8
		!		!		!		!	!	!		!													
		0	1	0	1	0	0	1	1	1	1	1													7
			!		!				!	!		!													
			0	1	0	1	0	0	1	1	1	1	1												5
				!		!	!			!		!													
				0	1	0	1	0	0	1	1	1	1	1											5
					!			!				!			!										
					0	1	0	1	0	0	1	1	1	1	1										4
						!	!		!		!	!			!										
						0	1	0	1	0	0	1	1	1	1	1									6
								!		!	!				!										
Invalidation without shift							0	1	0	1	0	0	1	1	1	1	1								4
							!	!					!		!			!							
							1	0	1	0	1	0	0	1	1	1	1	1							5
							!	!		!	!	!	!	!	!			!							
							1	1	0	1	0	1	0	0	1	1	1	1	1						9
							!	!	!					!				!							
							1	1	1	0	1	0	1	0	0	1	1	1	1	1					5

IEC 208/03

All further shifts are produced by at least 4 bit errors.

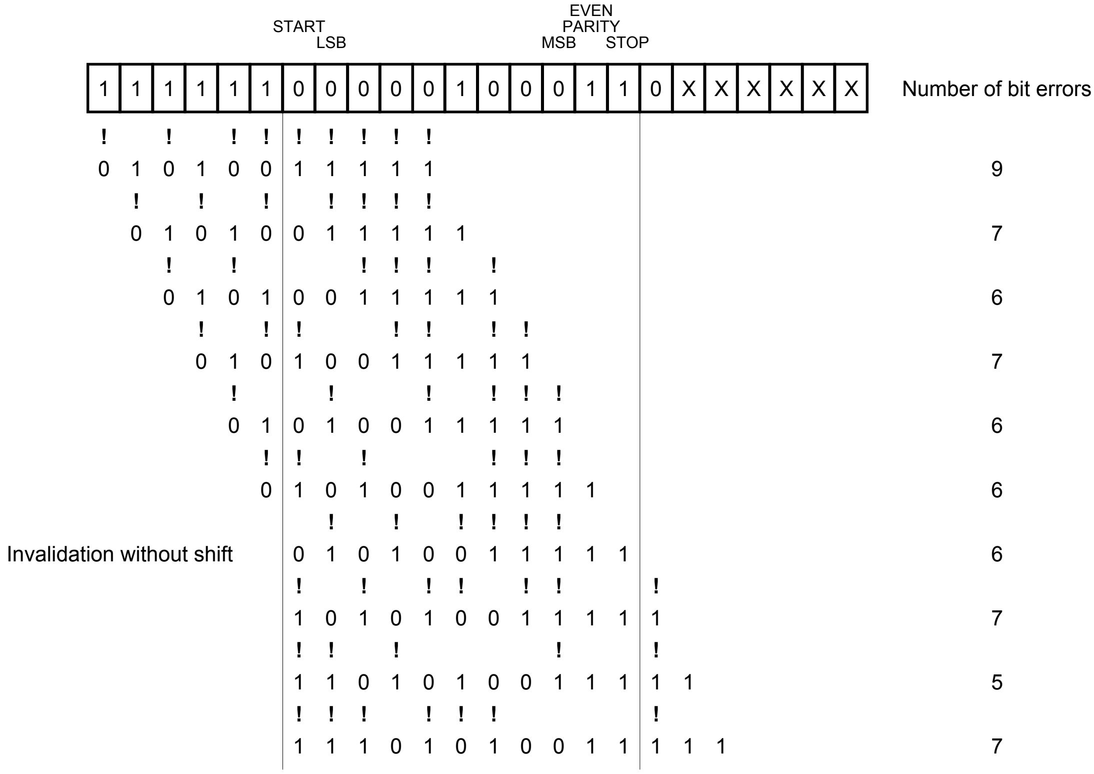
A.3.5 Shift insusceptibility of SINGLE CHARACTER E5H against START 10H

							START LSB								MSB	EVEN PARITY	STOP								
	1	1	1	1	1	1	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	Number of bit errors
				!	!	!		!	!	!					!										
				0	0	0	0	0	1	0	0	0	1	1	0										7
					!	!		!					!			!									
					0	0	0	0	0	1	0	0	0	1	1	0									5
						!		!		!	!		!	!			!								
						0	0	0	0	0	1	0	0	0	1	1	0								7
								!		!		!	!	!	!			!							
Invalidation without shift							0	0	0	0	0	1	0	0	0	1	1	0							7
							!	!		!				!	!	!			!						
							1	0	0	0	0	0	1	0	0	0	1	1	0						7
							!			!			!		!	!	!			!					
							1	1	0	0	0	0	0	1	0	0	0	1	1	0					7
							!		!	!			!	!		!	!	!			!				
							1	1	1	0	0	0	0	0	1	0	0	0	1	1	0				9
							!		!				!	!	!		!	!	!			!			
							1	1	1	1	0	0	0	0	0	1	0	0	0	1	1	0			9
							!		!		!		!	!	!	!		!	!	!			!		
							1	1	1	1	1	0	0	0	0	0	1	0	0	0	1	1	0		11

IEC 209/03

All further shifts are produced by at least 4 bit errors.

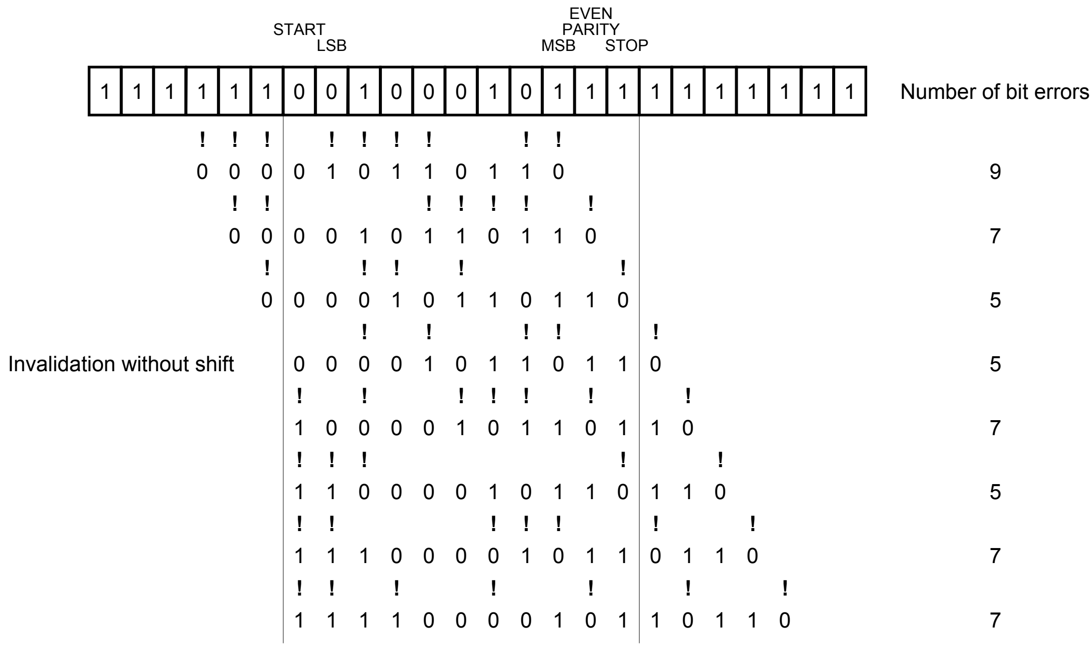
A.3.6 Shift insusceptibility of START 10H against SINGLE CHARACTER E5H



IEC 210/03

All further shifts are produced by at least 4 bit errors.

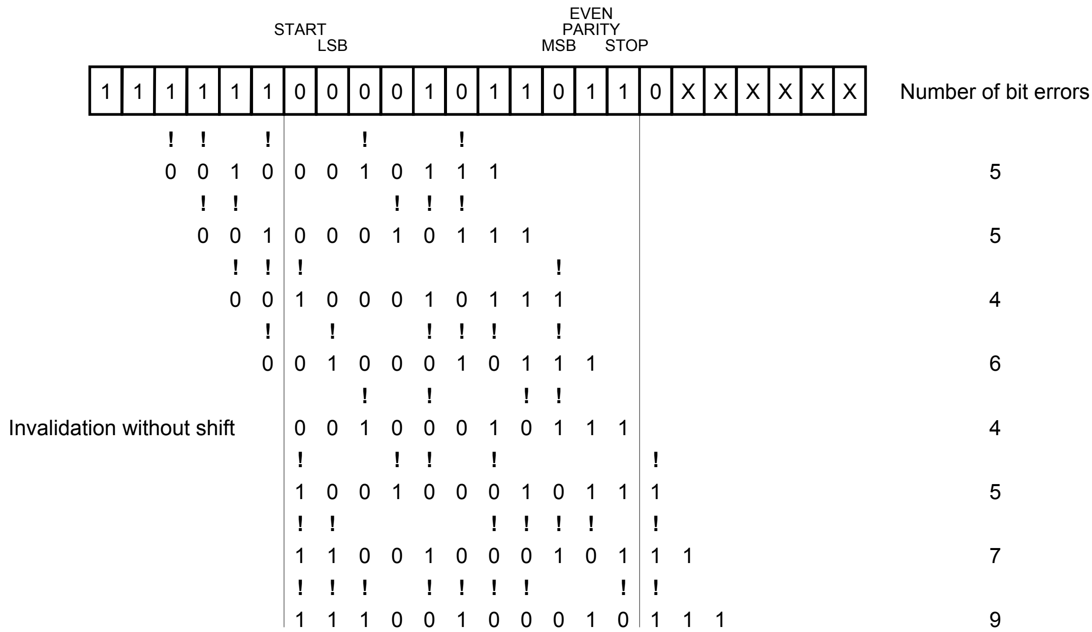
A.3.7 Shift insusceptibility of SINGLE CHARACTER A2H against START 68H



IEC 211/03

All further shifts are produced by at least 4 bit errors.

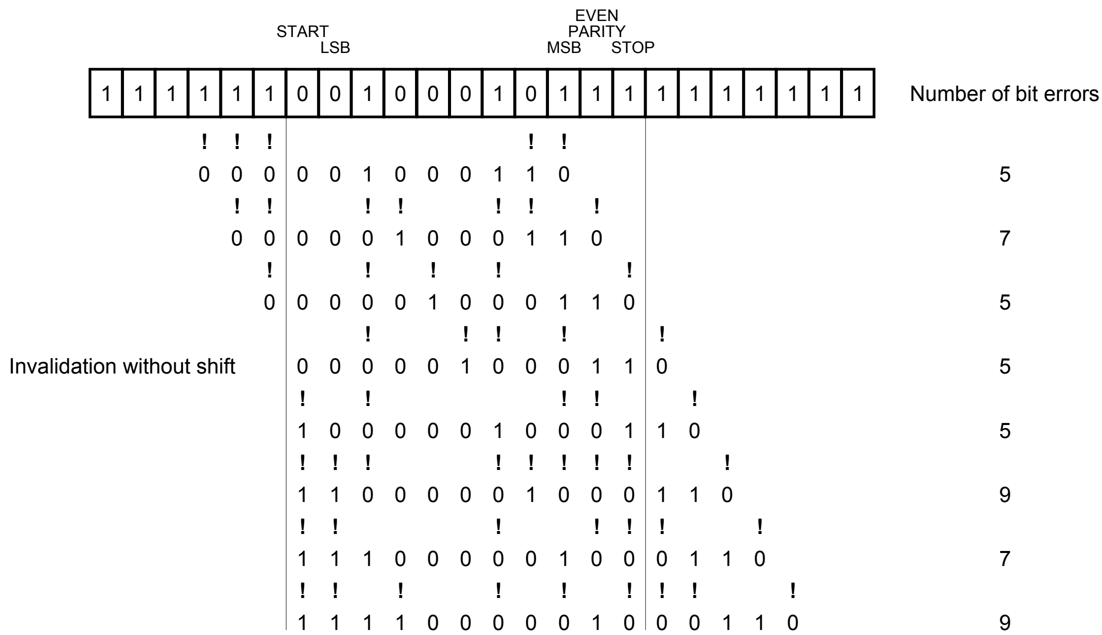
A.3.8 Shift insusceptibility of START 68H against SINGLE CHARACTER A2H



IEC 212/03

All further shifts are produced by at least 4 bit errors.

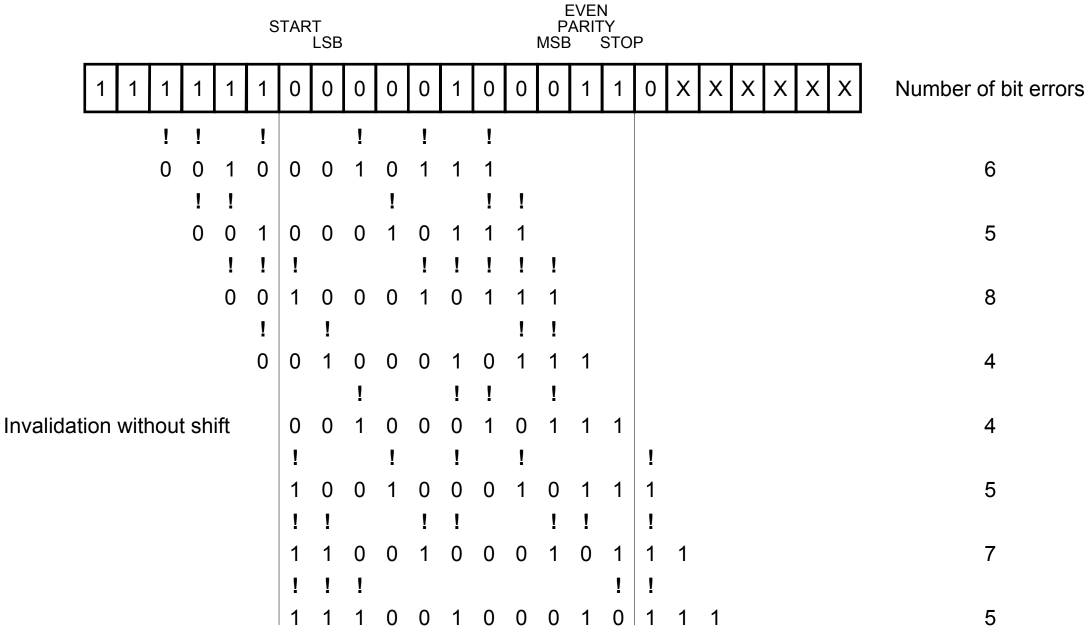
A.3.9 Shift insusceptibility of SINGLE CHARACTER A2H against START 10H



IEC 213/03

All further shifts are produced by at least 4 bit errors.

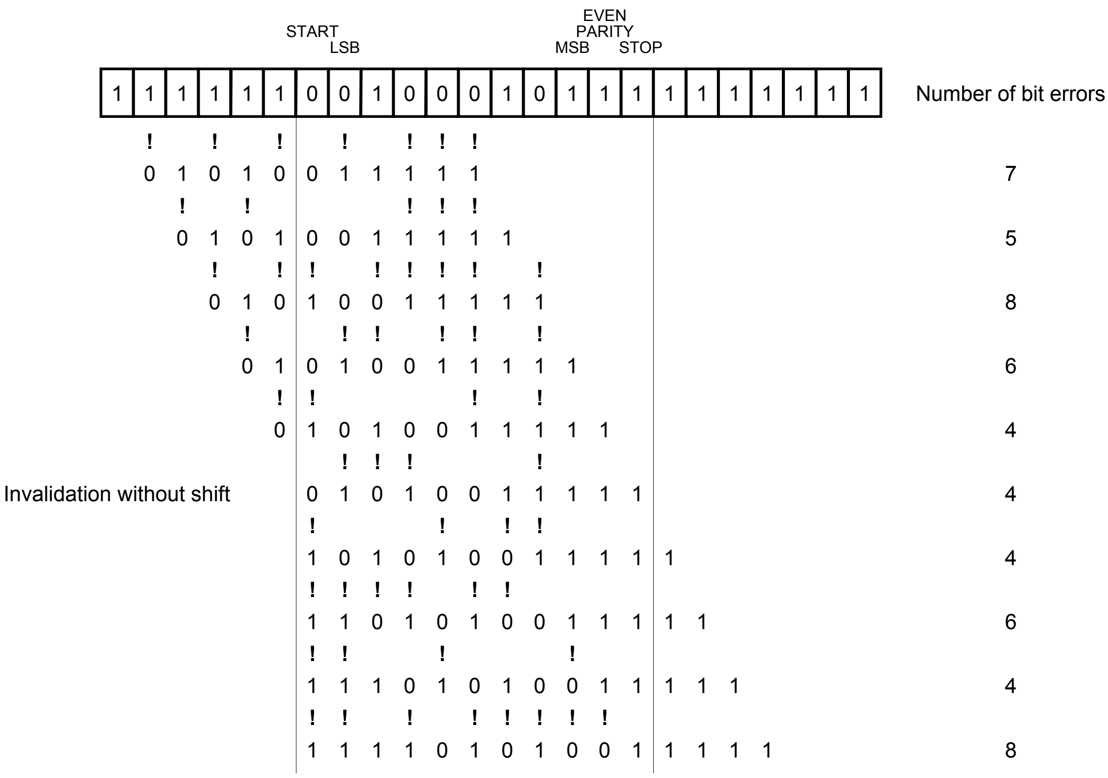
A.3.10 Shift insusceptibility of START 10H against SINGLE CHARACTER A2H



IEC 214/03

All further shifts are produced by at least 4 bit errors.

A.3.11 Shift insusceptibility of SINGLE CHARACTER A2H against SINGLE CHARACTER E5H



IEC 215/03

All further shifts are produced by at least 4 bit errors.

A.3.12 Shift insusceptibility of SINGLE CHARACTER E5H against SINGLE CHARACTER A2H

							START	LSB							MSB	EVEN PARITY	STOP								
	1	1	1	1	1	1	0	1	0	1	0	0	1	1	1	1	1	X	X	X	X	X	X	X	Number of bit errors
			!	!		!		!	!	!	!	!													
			0	0	1	0	0	0	1	0	1	1	1												8
				!	!			!				!													
				0	0	1	0	0	0	1	0	1	1	1											4
					!	!	!	!		!	!														
					0	0	1	0	0	0	1	0	1	1	1										6
						!				!		!	!												
						0	0	1	0	0	0	1	0	1	1	1									4
								!	!	!				!											
Invalidation without shift							0	0	1	0	0	0	1	0	1	1	1								4
							!	!					!		!										
							1	0	0	1	0	0	0	1	0	1	1	1							4
							!			!	!		!	!		!									
							1	1	0	0	1	0	0	0	1	0	1	1	1						6
							!		!	!		!	!	!	!		!								
							1	1	1	0	0	1	0	0	0	1	0	1	1	1					8
							!		!					!	!	!									
							1	1	1	1	0	0	1	0	0	0	1	0	1	1	1				5
							!		!		!		!		!	!	!								
							1	1	1	1	1	0	0	1	0	0	0	1	0	1	1	1			7

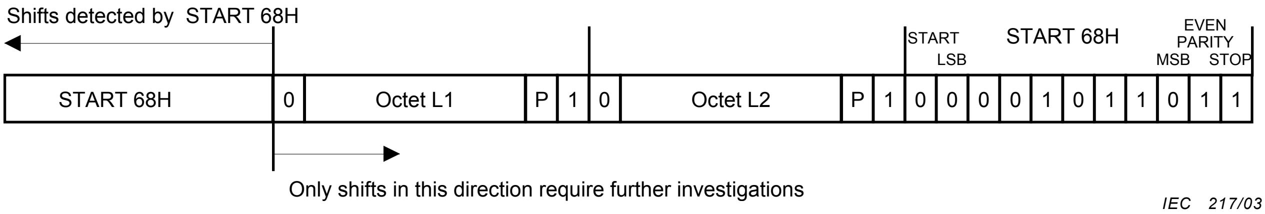
IEC 216/03

All further shifts are produced by at least 4 bit errors.

A.4 Shift insusceptibility for frames with variable block length

For the structure of the frame see A.1.2.

Only the character START 68H is used for frames with variable length. The proof of the shift insusceptibility of this character guarantees that all synchronization slips caused by less than 4 bit errors are detected (see A.2). Thus shifts can only occur caused by invalidation of startbits from 0 to 1 beginning with the first length octet L1.

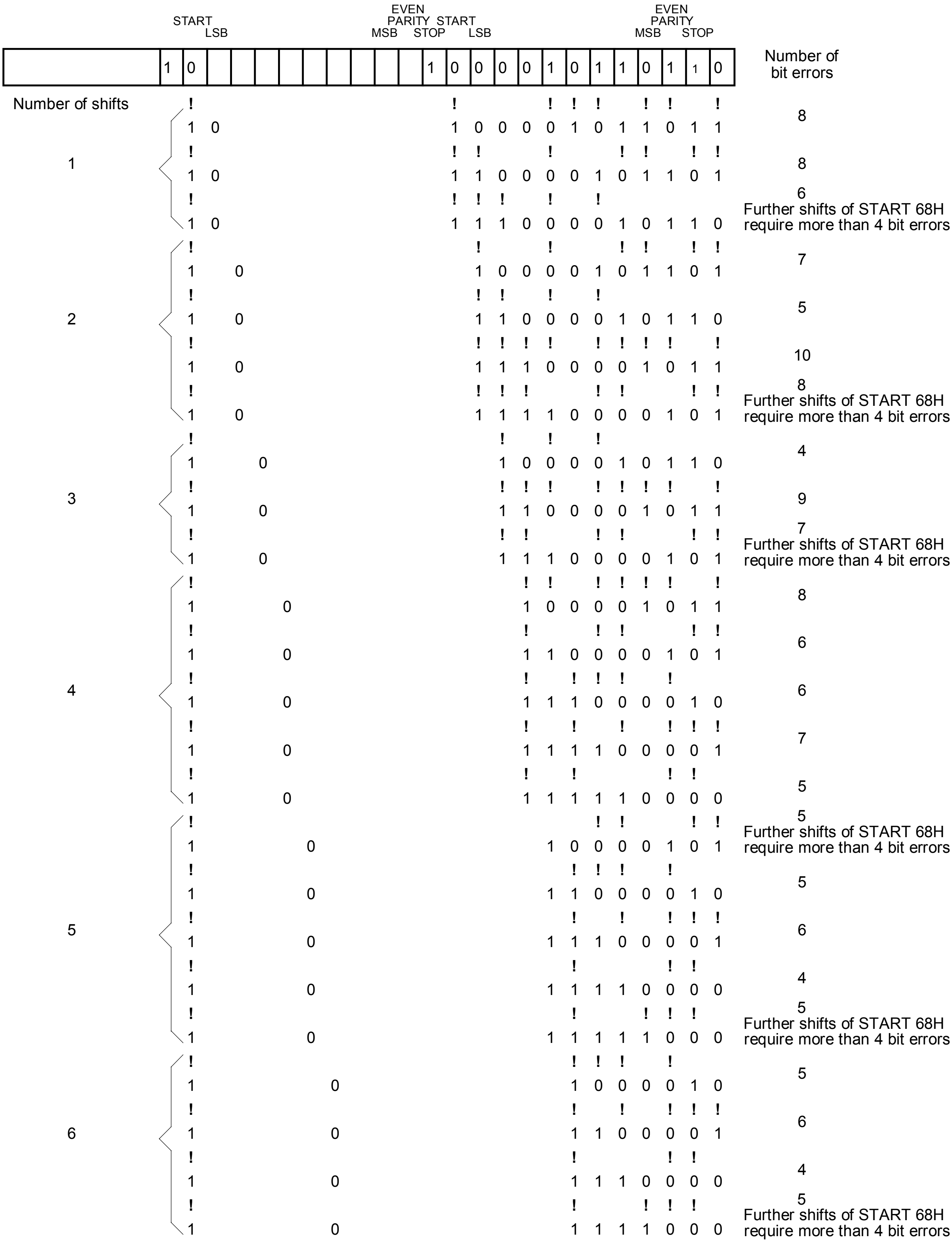


IEC 217/03

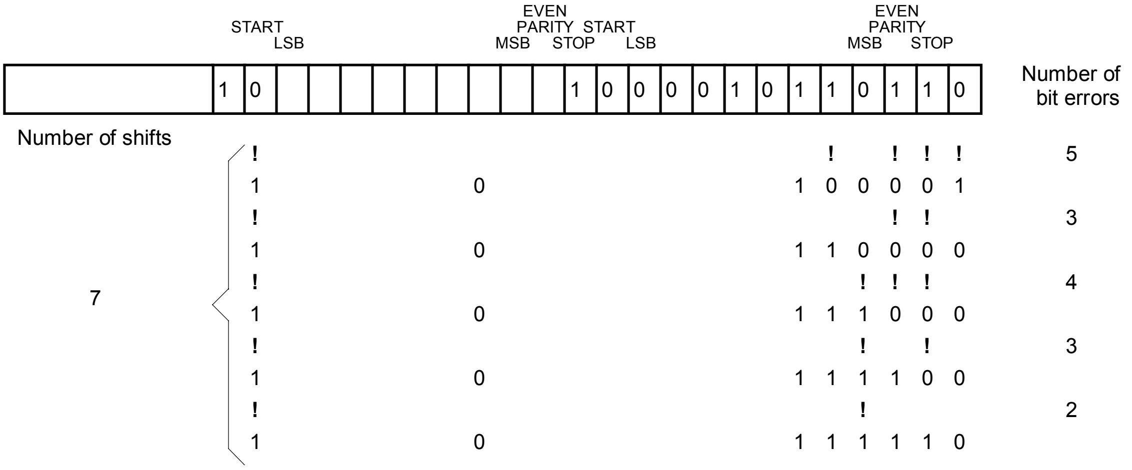
The rules in IEC 60870-5-1 state that octet L1 must always have the same information content as octet L2 when it is sent. The proof that this frame length specification cannot be invalidated undetected by less than 4 bit errors must be provided.

The second START 68H character could be detected as the first length character as the result of extinction of the characters L1 and L2. However, the extinction of these two characters requires at least 4 bit errors, because every character contains at least 2 zero bits: 1 zero bit is the start bit of the character and at least 1 zero bit occurs in the data field due to the even parity bit prescription.

If only one length character (L1 or L2) is extinguished completely, the second START 68H character is evaluated as the length character L2. The number of zero bits in the START 68H character (6 bits), however, is so great that this condition cannot be achieved with less than 4 bit errors since the information content L1 must always be equal to L2. Consequently, what happens if the length characters are shifted partially into the second START 68H character as the result of synchronization errors is investigated. This corresponds to a shift of the second START 68H character relative to its original position. Below, how many synchronization slip positions the length character need to be shifted into the second START 68H character and how many bit errors are needed to cause this in each case is indicated.


START
LSB
EVEN
PARITY
MSB
STOP
START
LSB
EVEN
PARITY
MSB
STOP
Number of bit errors
Number of shifts
Further shifts of START 68H require more than 4 bit errors

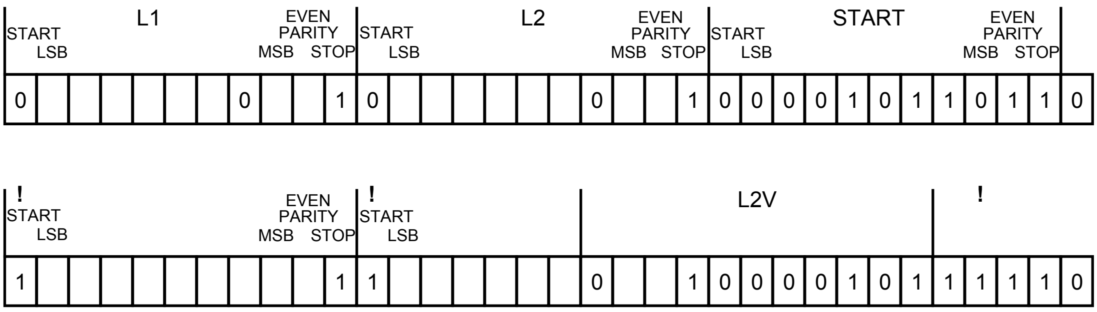
IEC 218/03



IEC 219/03

This demonstrates that shifts of at least seven positions are necessary for a shifted second START 68H character to be found as a result of less than 4 bit errors.

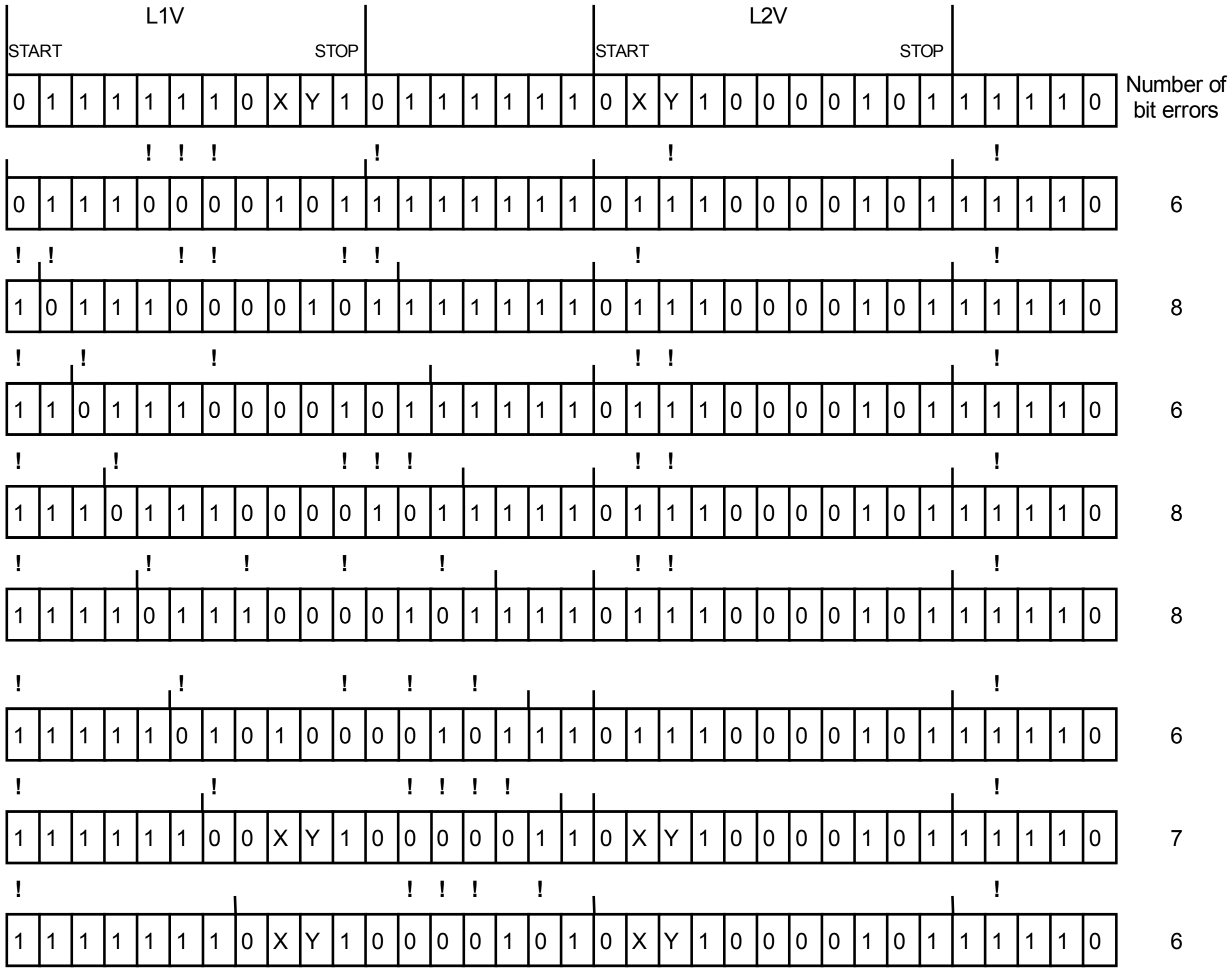
Two bit errors can thus produce the following configuration L2V:



IEC 220/03

However, this condition can only be achieved if bits 2 to 7 in the characters L1 and L2 (both must have been originally identical) are one bit.

Under these conditions, the erroneous character L2V must be equal to the erroneous L1V which has to be generated by less than 4 bit errors. The combinations which occur in this case are shown in the diagram below with the number of necessary bit errors. The bits X and Y in character L1 must be equal to those in character L2. If they differ in the shifted characters, additional bit errors must have occurred.



IEC 221/03

Thus, in the case of shifts to the START 68H character, far more bit errors are necessary to produce undetected, incorrect length specifications than in the case shown above, produced by extinction of complete length characters.

These results were checked by a computer programme. During the test the following criteria, a) to d), were checked for frame lengths 0 to 255 in each case with all possible shifts of L1, L2 and START 68H:

a) identity check for L1 and L2;
b) parity check;
c) start bit of character = 0;
d) bit configuration of the character START 68H.

The cases shown above were confirmed.

Annex B
(informative)

Admittance of line idle intervals between characters of frame format class FT 1.2

Rule 3 of the format class FT 1.2 (see 6.2.4.2.1 of IEC 60870-5-1) requires that no line idle interval between characters of a coherent frame are admitted. The reason for this rule is to avoid undetectable sync slip errors within the frame that may occur, when the line idle bits (line idle is binary 1) are inverted into zero bits which would be interpreted as start bits. Figure B.1 shows a single line idle bit which is wrongly inserted by the transmitter after the first character.

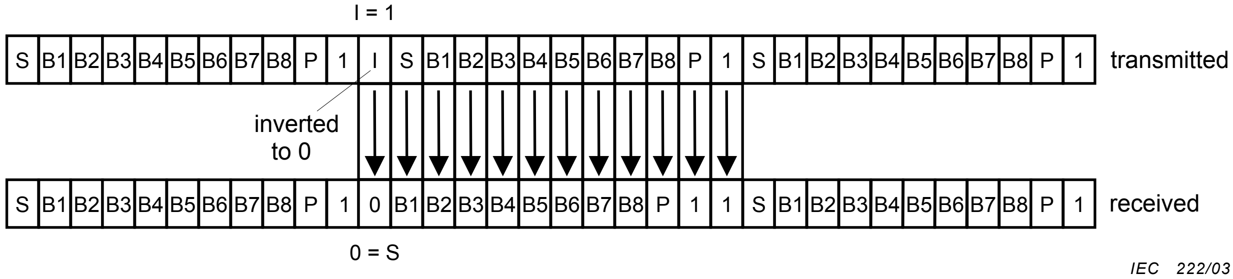


Figure B.1 – Shift of a character caused by an inverted additional line idle bit

The additional line idle bit is normally interpreted by the receiver as an additional stop bit. In this case, the receiver synchronizes correctly on the next following start bit. If that line idle bit were to be inverted into a zero bit, then the receiver would start one bit earlier which would cause a shift of one bit of the following character as shown in line two of Figure B.1. In this case, the transmitted start bit shifts to bit one (B1) of the following character, which is then always zero. Bit 8 (B8) is shifted to the parity position and the parity to the stop position. The next following stop bit would be interpreted as a line idle and the next (third) character would be started correctly without any shifting.

In the following, it is required to prove whether the above-described scenario, that means a line idle extension of a single bit, does not reduce the data integrity and the hamming distance d = 4. If this is true, line idles of only one bit length could be admitted.

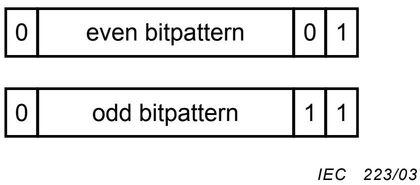


Figure B.2 – Relation of even and odd bit pattern to the parity bit

The number of ones of a character may be even or odd and the parity bit, that completes to an even number of ones, is either zero (even bit pattern) or one (odd bit pattern, see Figure B.2).

If the parity bit is zero and the character is shifted, caused by an inverted line idle bit as shown in Figure B.1, then the zero parity would be shifted into the stop bit position which causes a stop bit error in any case.

If the parity bit is one, then the stop bit would remain as a one bit without any error detection. In this case, bit 8 of the transmitted frame is shifted to the parity bit position. If bit 8 is zero, the parity changes from one to zero (odd or even!), but the character remains odd.

NOTE Bit position one of the shifted character is always zero (see Figure B.1).

If bit 8 is one, the parity does not change (it remains one) but the character changes from odd to even. In both cases, the error is detected.

Conclusion

In any case, a second bit inversion besides the first one (change of line idle into a start bit) is necessary to receive an undetectable wrong character. This fulfils hamming distance d = 2.

Further conclusion

If an additional line idle inversion occurs between two other characters of the same frame, then at least 4 bit errors would be necessary to receive an undetectable wrong frame. This fulfils hamming distance d = 4.

The following is proof of the hamming distance in the case of transmitting only one instance of an additional single line idle bit between characters of a frame and of the influence of the checksum-test (arithmetical sum at the end of the frame).

S	B1	B2	B3	B4	B5	B6	B7	B8	P	1	
0	0	1	1	1	1	1	1	1	1	1	transmitted
0	0	0	1	1	1	1	1	1	1	1	received

IEC 224/03

Figure B.3 – Shifted bit pattern

Figure B.3 shows the worst case of a shifted bit pattern, where the difference of the transmitted and the received shifted character is one bit only. An additional bit inversion of bit position B2 would change the character into even and therefore the parity would be correct. But in this case, the original transmitted character would be restored and there is no reason to reject it.

In all other cases, at least two additional bit inversions (making a total of four or more) are needed to receive an undetectable wrong frame, because the checksum (arithmetical sum) would fail.

EXAMPLE (based on Figure B.3):

If bit 3 of the second character changes, then the parity bit fulfils the even condition. The difference of the shifted character to the original one is at least two bits which is detected by the checksum in any case.

Summarized conclusion

Even when line idle intervals of a length of one transmitted bit occur between characters of a FT 1.2-frame, the hamming distance d = 4 is fulfilled. More than one bit line idle is strictly prohibited.

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