

Telecontrol equipment and systems —

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

ICS 33.200

National foreword

This British Standard is the UK implementation of EN 60870-5-101:2003+A1:2016. It is identical to IEC 60870-5-101:2003, incorporating amendment 1:2015. It supersedes BS EN 60870-5-101:2003 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

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Telecontrol equipment and systems
Part 5-101: Transmission protocols –
Companion standard for basic telecontrol tasks
(IEC 60870-5-101:2003)

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Partie 5-101: Protocoles de transmission -
Norme d'accompagnement
pour les tâches élémentaires
de téléconduite
(CEI 60870-5-101:2003)

Fernwirkrichtungen und -systeme
Teil 5-101: Übertragungsprotokolle -
Anwendungsbezogene Norm
für grundlegende Fernwirkaufgaben
(IEC 60870-5-101:2003)

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Foreword

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

Endorsement notice

The text of the International Standard IEC 60870-5-101:2003 was approved by CENELEC as a European Standard without any modification.

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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.

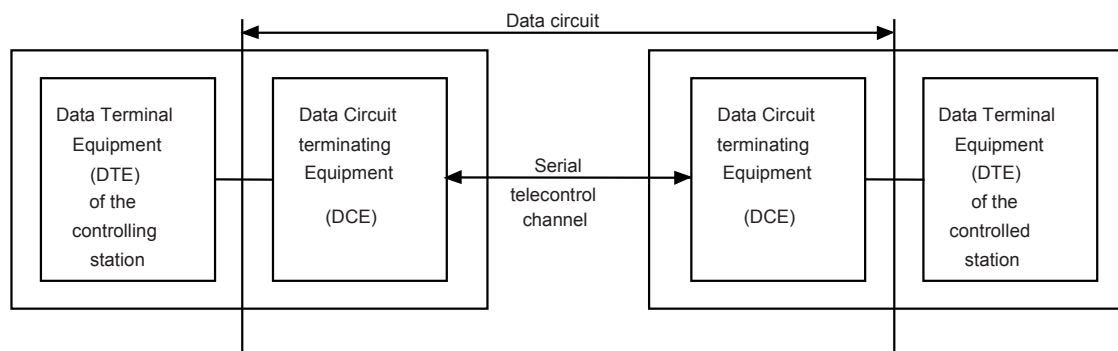
Selected application functions of IEC 60870-5-5	User process
Selected application information elements of IEC 60870-5-4	Application (layer 7)
Selected application service data units of IEC 60870-5-3	
Selected link transmission procedures of IEC 60870-5-2	Link (layer 2)
Selected transmission frame formats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

A1 IEC 60870-5-2 defines a set of link transmission procedures using a control field and the optional address field. **A1** 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. **A1** In addition a companion standard specifies the time-out interval (T_o) of the primary station (see A.1 of IEC 60870-5-2 for details of link timing). **A1**

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.

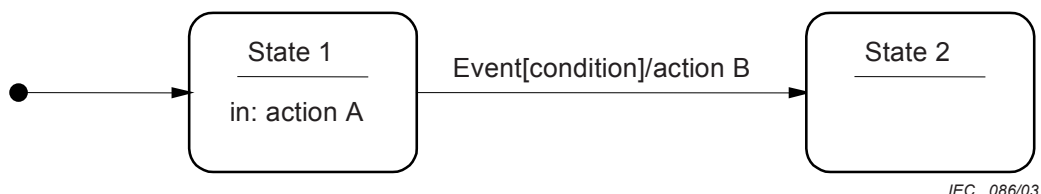


Figure 3 – State transition diagram by Grady Booch/Harel

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.

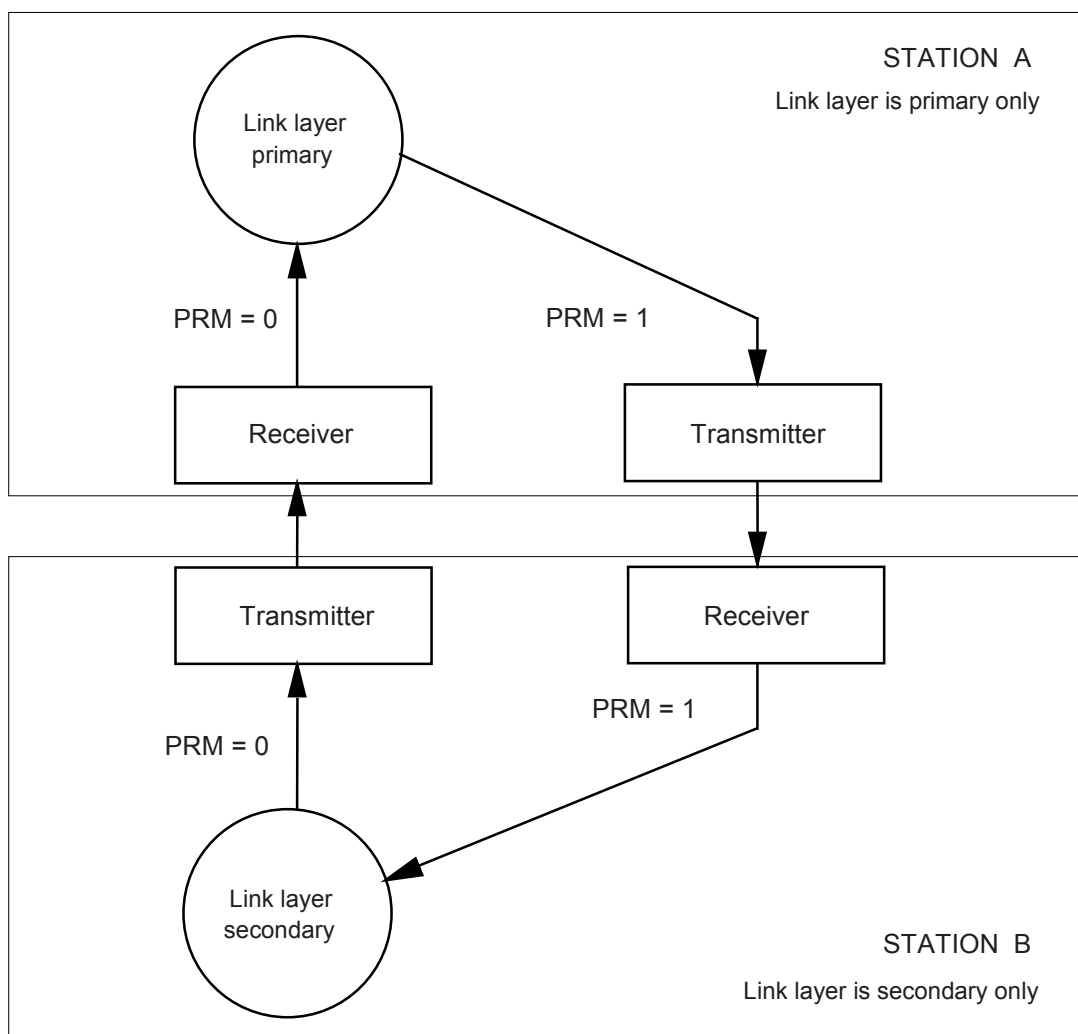
Table 3 shows the permissible combinations of the unbalanced link layer procedures.

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.

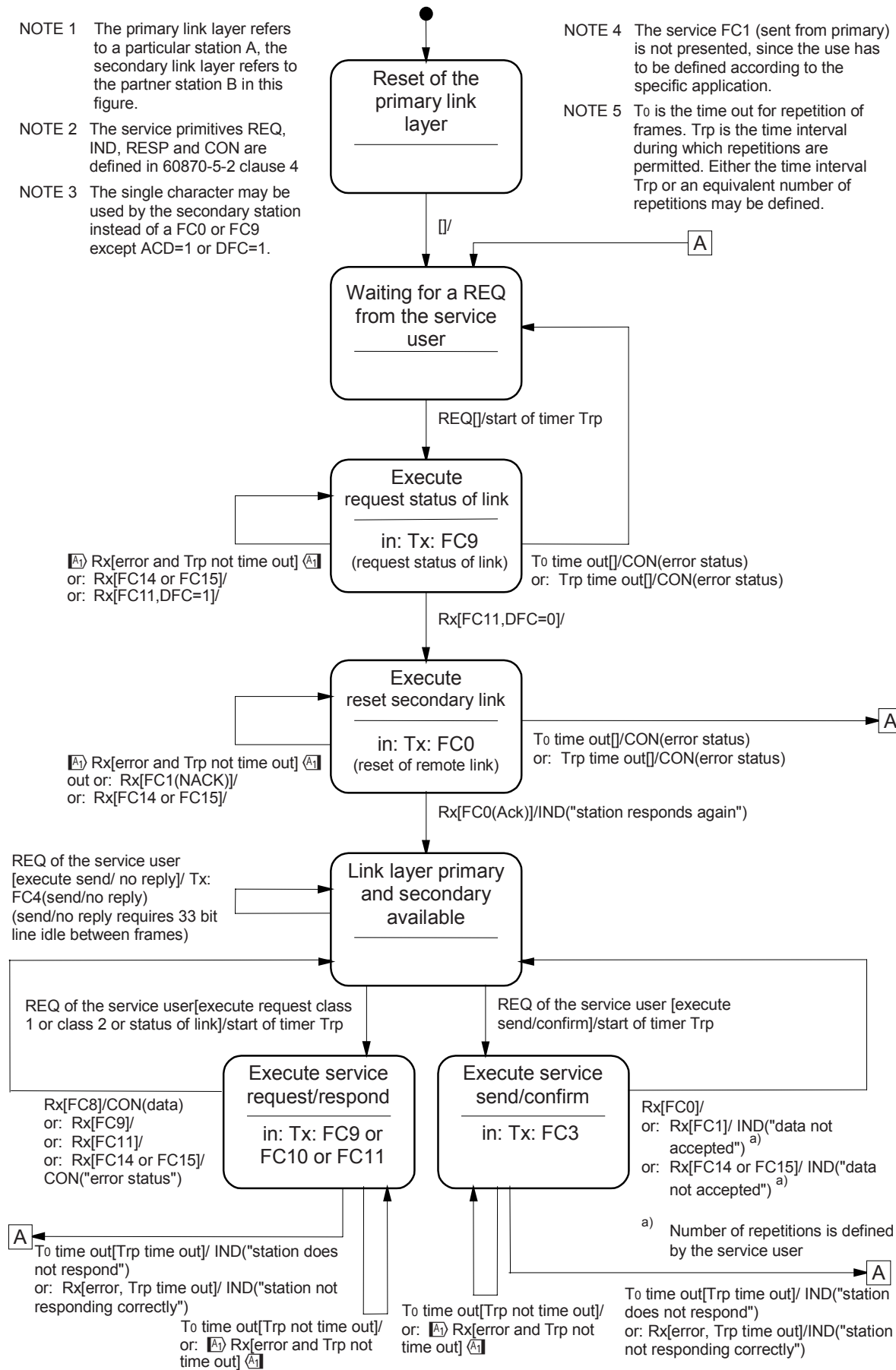
For unbalanced transmission procedures, The primary station contains only a primary link layer and the secondary station contains only a secondary link layer (see Figure 4). More than one secondary station may be connected to one primary station. Compatible communication between the primary station and 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.



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**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.



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

6.2.1.2 Balanced transmission procedures

[A₁] The request to the standardized function codes in primary direction (0 up to 3 and 9) have to receive positive or negative responses. **[A₁]** 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).

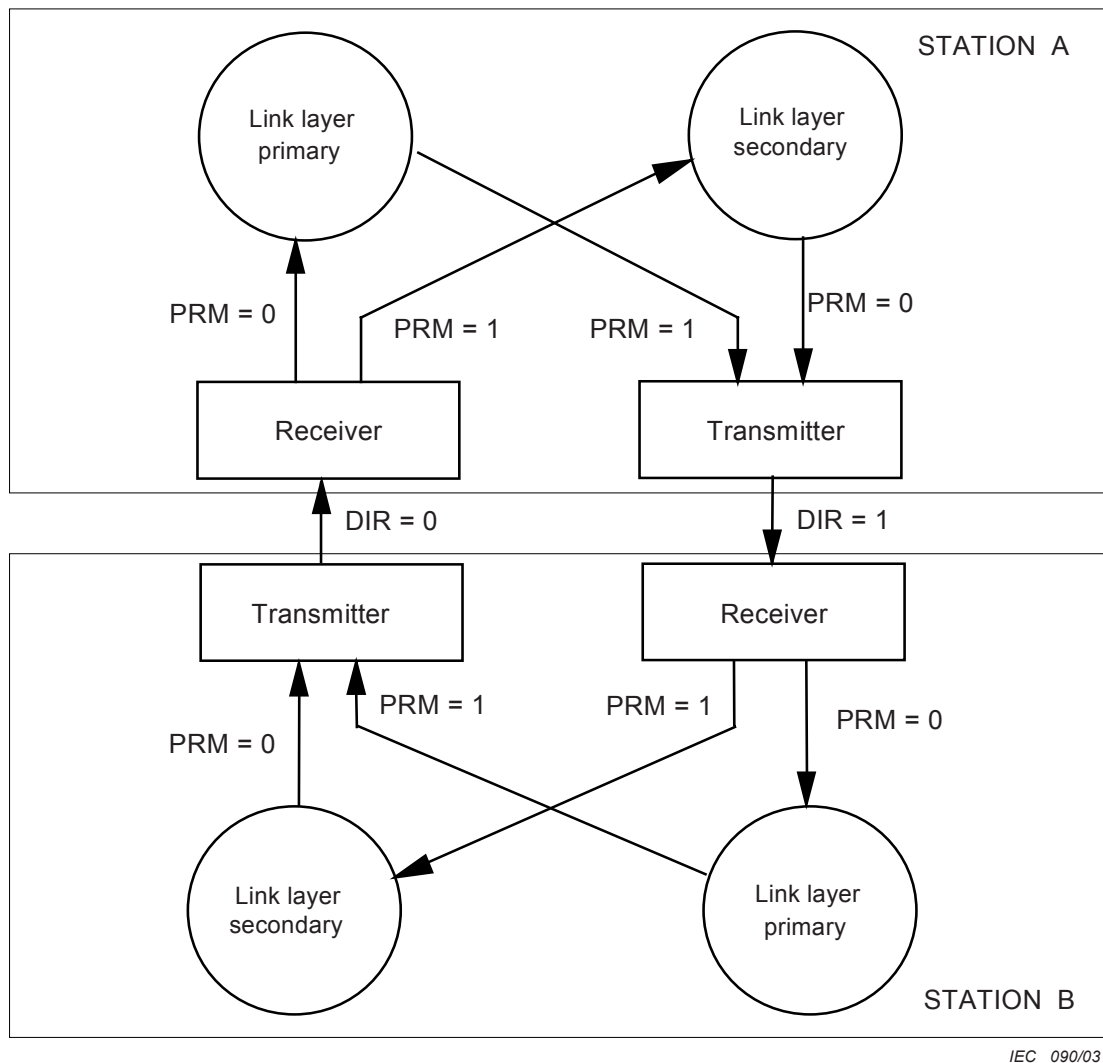


Figure 7 – Balanced transmission procedures, primary and secondary link layers

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.

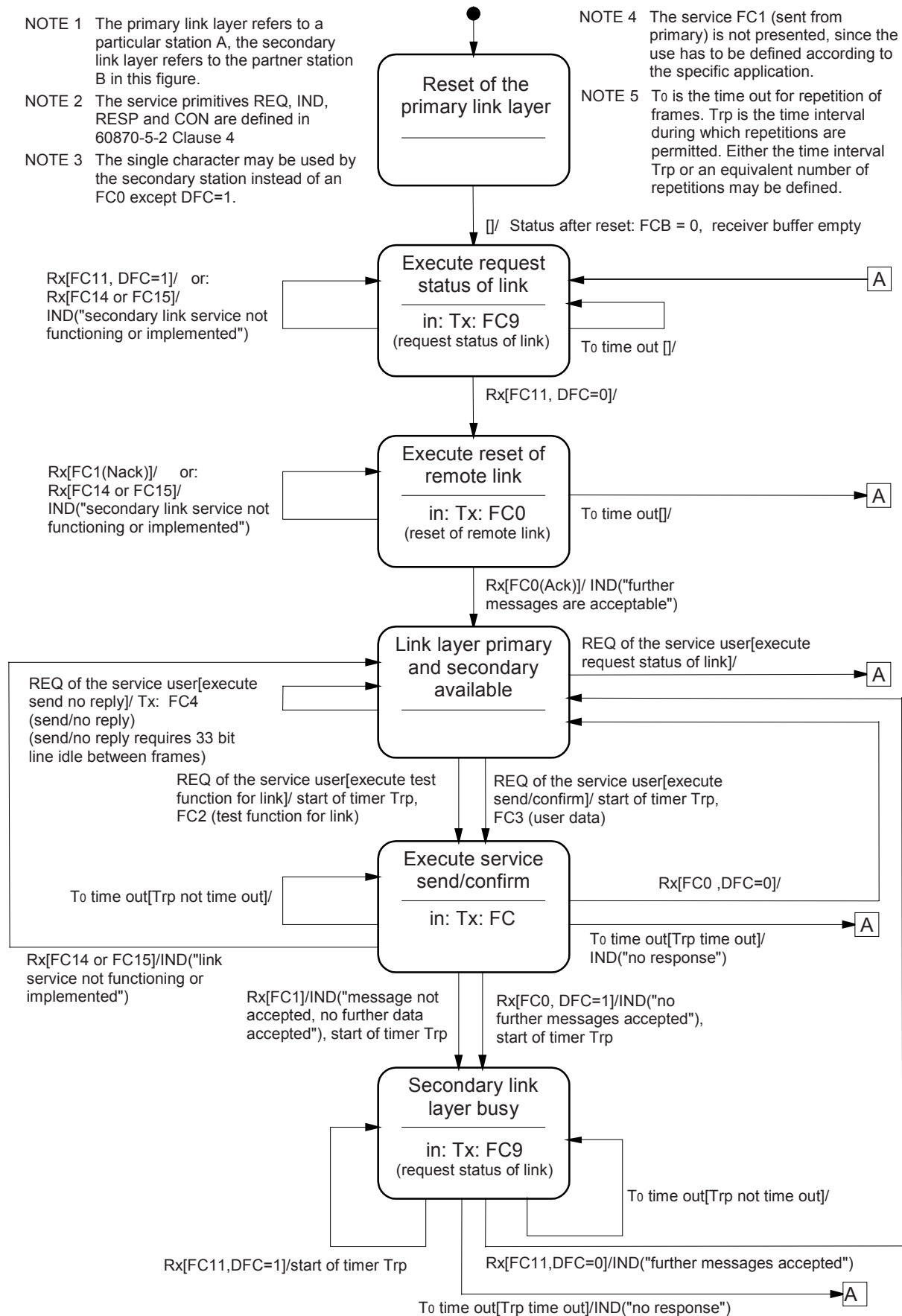


Figure 8 – State transition diagram for balanced transmission primary to secondary

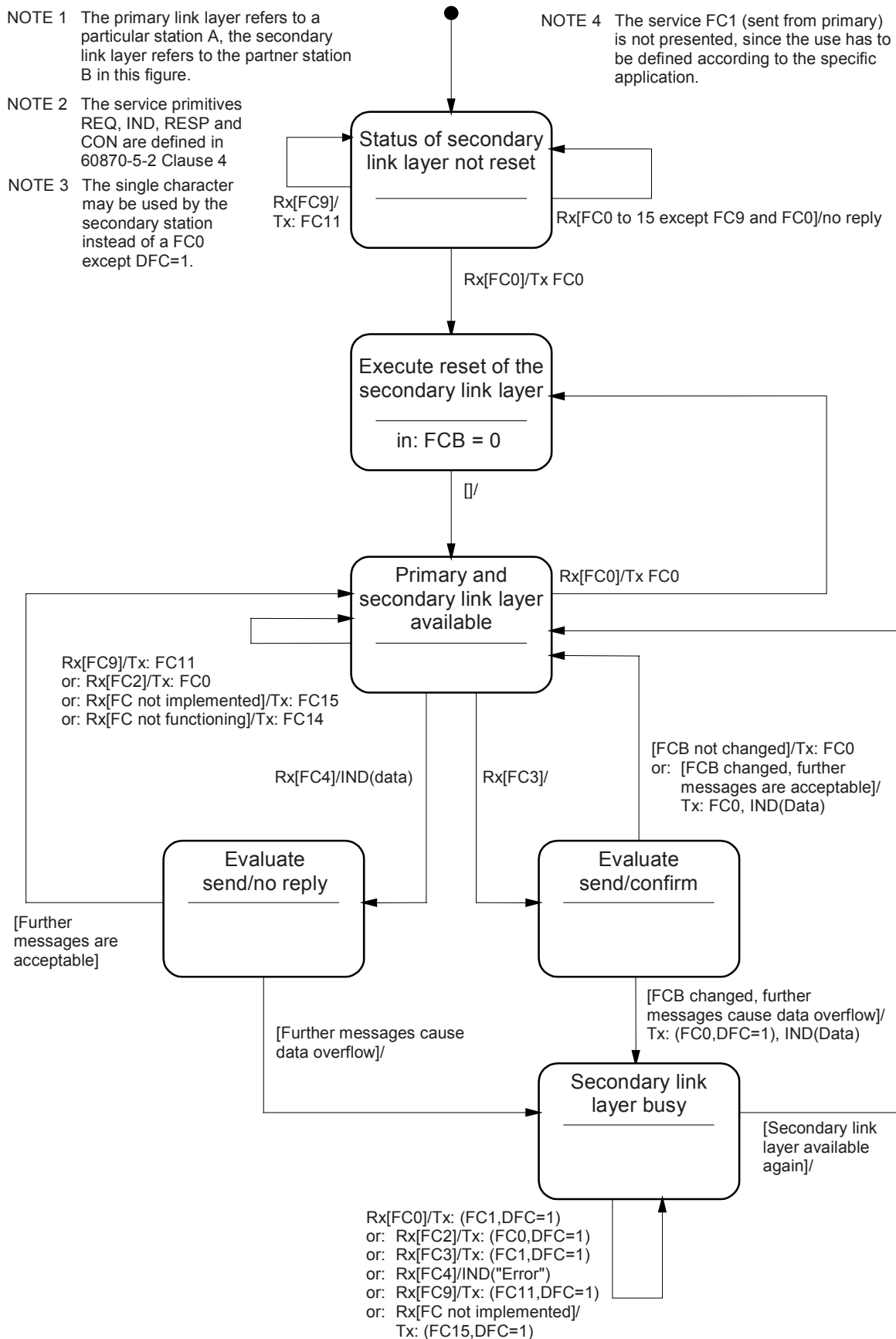


Figure 9 – State transition diagram for balanced transmission secondary to primary

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

LBAm_{ax} number of octets of the longest frame from B to A

LADDR length of the link address field

BAB, BBA, LBAm_{ax}, 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

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

$$t_R = \text{reaction time of station B (specific per equipment)}$$

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

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

$$T_{LBA} = 11 \times LBAm_{ax}/BBA$$

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 $t_R = 50 \text{ ms}$.

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)

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

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

$$t_{GB} = 33/BBA \text{ }^1)$$

$$T_{LPSBA} = 11 \times LBA_{max}/BBA$$

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

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)

LBAm _{max}	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. ^{A1} ASDU's containing no INFORMATION OBJECT are permitted too. Additionally: In some cases the ASDU consist of the DATA UNIT IDENTIFIER only. ^{A1}

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. ^{A1} The COMMON ADDRESS is the station address, which permits the addressing of the whole station or just a particular station sector. ^{A1}

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).

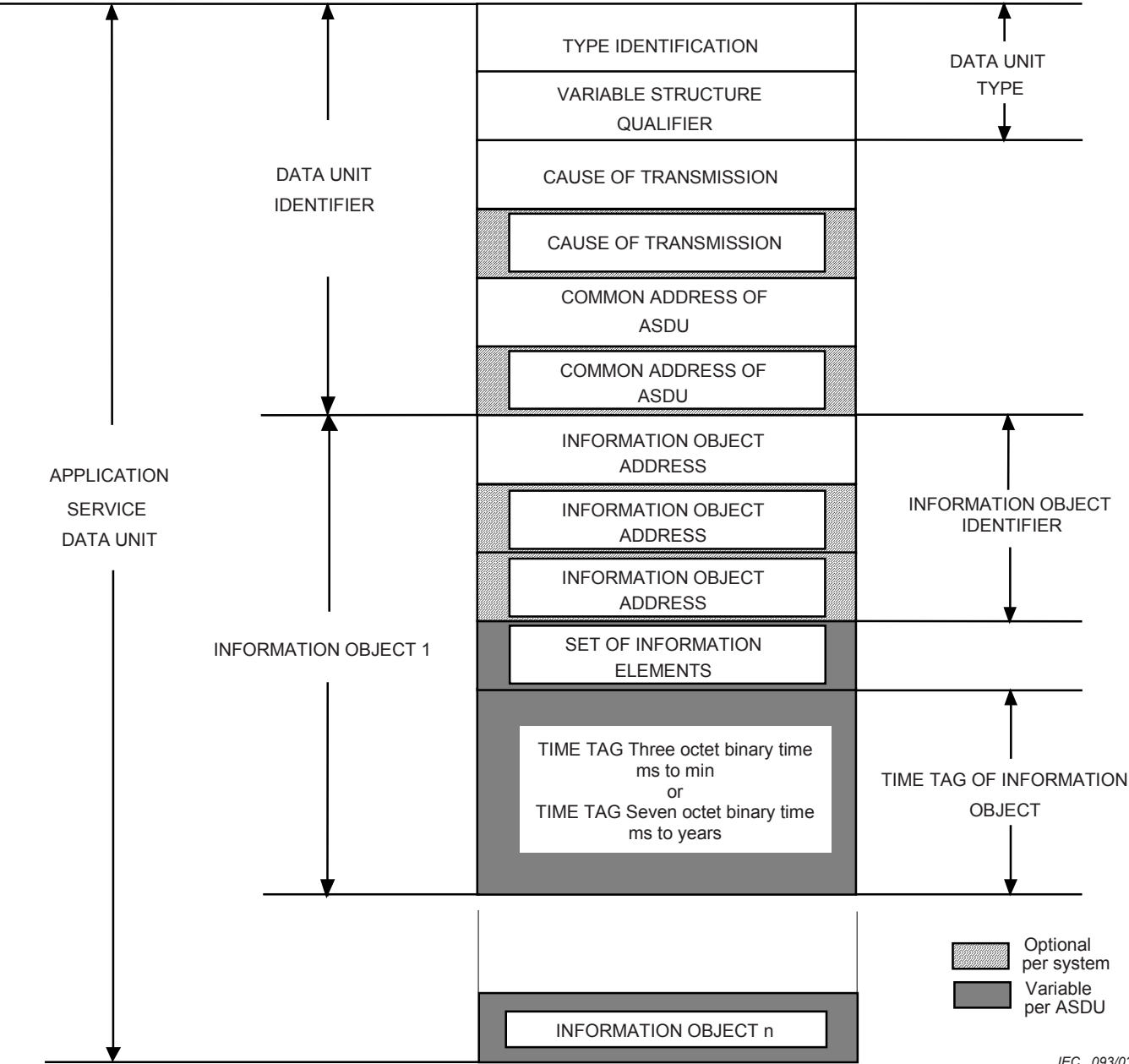
TIME TAGS (if present) always belong to an individual INFORMATION OBJECT.

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.



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- 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.

A1 Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard. **A1**

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>

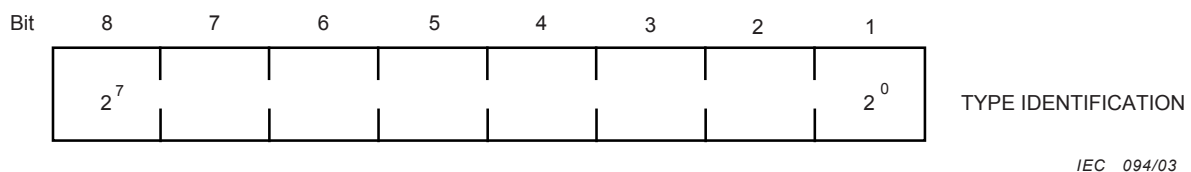


Figure 11 – Type identification

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 have to 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	

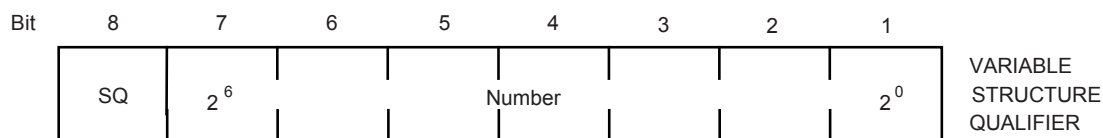
**Table 13 – Semantics of TYPE IDENTIFICATION –
File transfer**

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 ^{A1} ASDUs marked (**CON**) in control direction are confirmed application services and have to 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. ^{A1}

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.



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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.

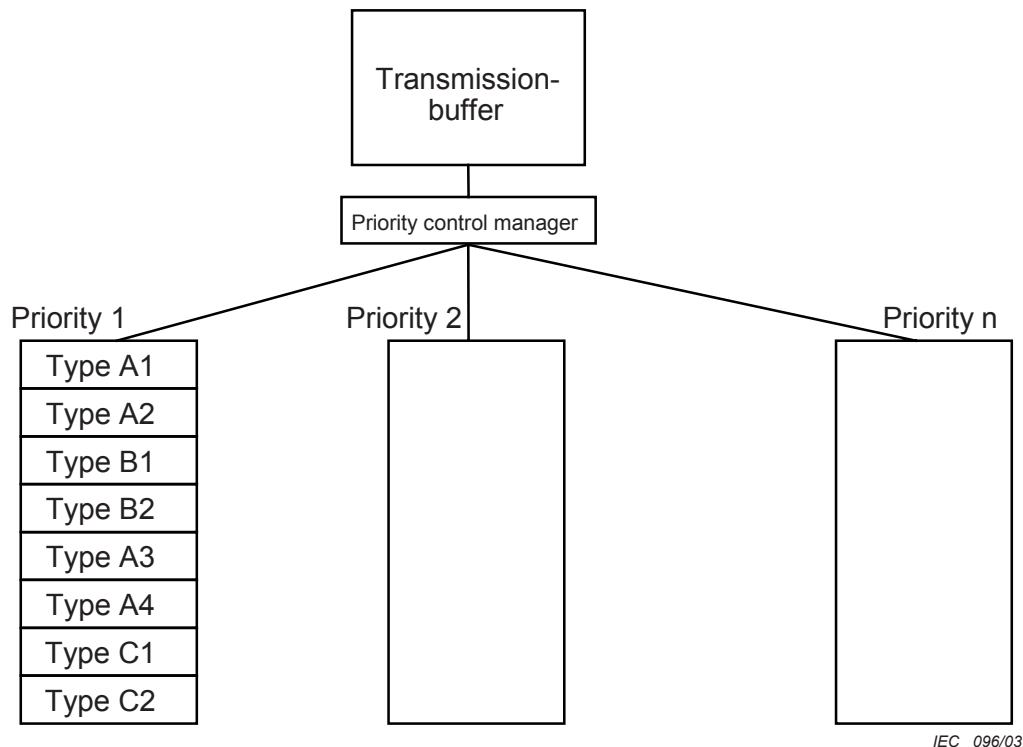


Figure 13 – Presentation of types of information objects in priority buffers

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

- 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;
- 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;
- 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.

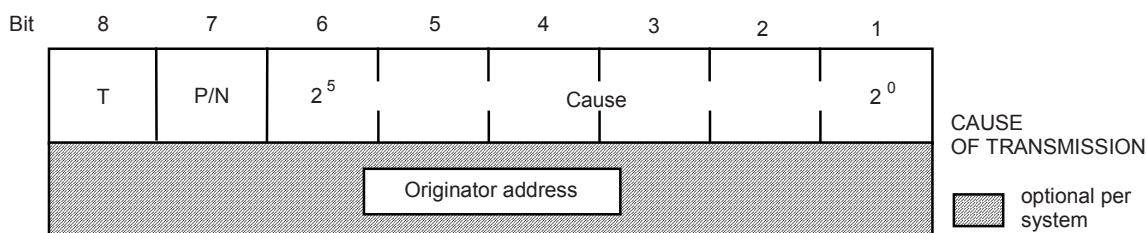
NOTE When using structured information object addresses, the ASDUs that are defined for sequences of information elements in a single information object might not be completed to optimal lengths due to possible gaps in the address numbering. Typically this reduces the packing efficiency for station interrogation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

A1 Octet 3 (and optionally Octet 4) of the DATA UNIT IDENTIFIER of the ASDU defines the CAUSE OF TRANSMISSION field which is specified in the following. **A1**



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Figure 14 – CAUSE OF TRANSMISSION field

A1 7.2.3.1 Definition of the semantics of values of the CAUSE OF TRANSMISSION field **A1**

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.

A1 ASDUs marked (**CON**) in control direction are confirmed application services and shall 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 (e.g. interrogated by station interrogation) to the source that activated the procedure. **A1**

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.

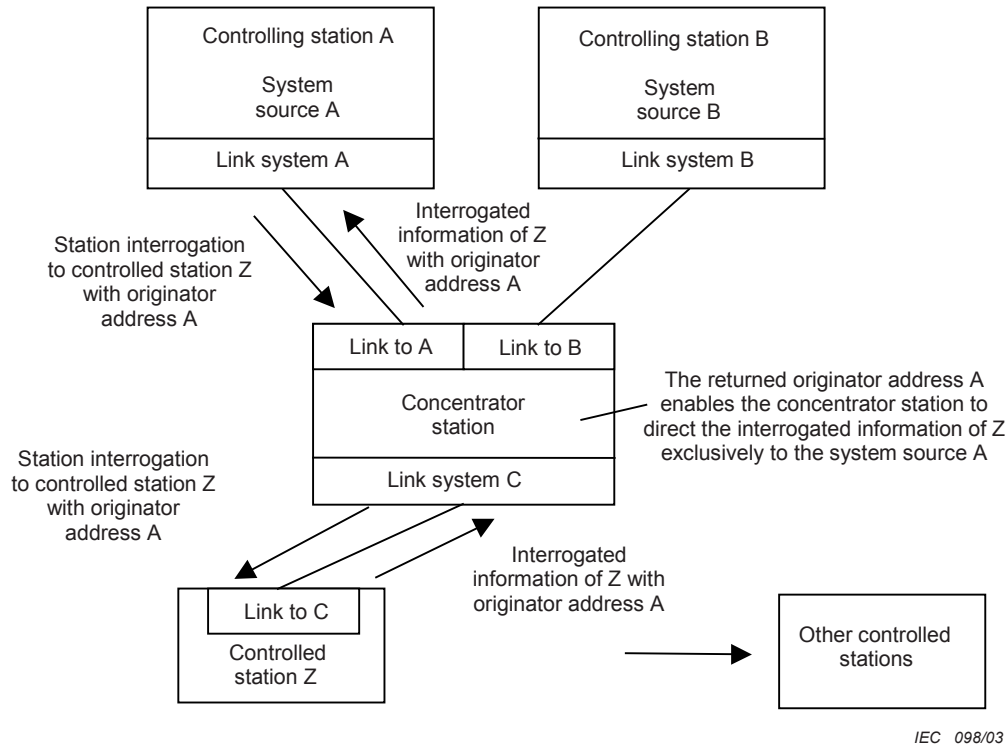


Figure 15 – Station interrogation via a concentrator station using the originator address

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.

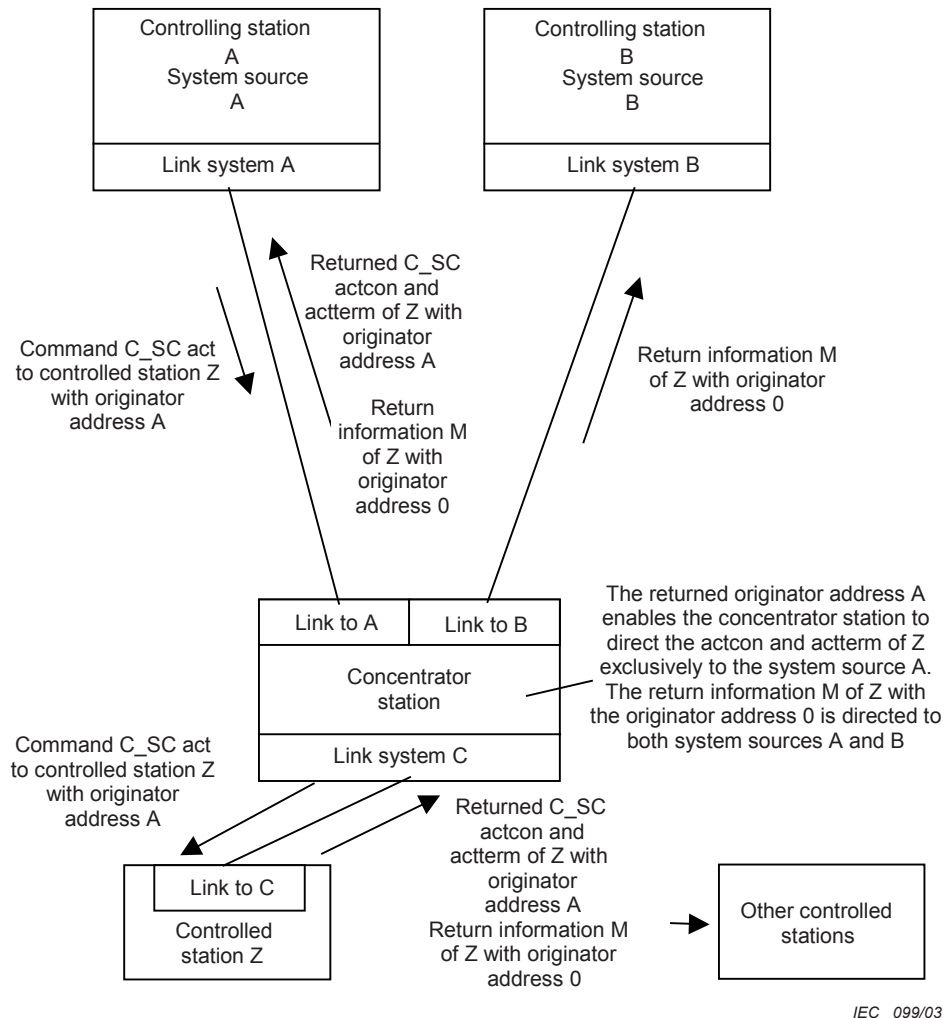


Figure 16 – Command transmission via a concentrator station using the originator address

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.

A1 ASDUs in the control direction and ASDUs defined for monitor direction used in reverse mode (see clause 8. Interoperability) with not supported 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: **A1**

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

A1 Octet 4 and optionally Octet 5 (or – if the originator address is used – Octet 5 and optionally Octet 6) of the DATA UNIT IDENTIFIER of the ASDU define the station address which is specified in the following. **A1**

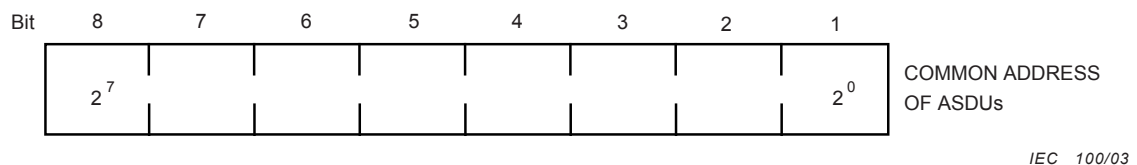


Figure 17 – COMMON ADDRESS of ASDUs (one octet)

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

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

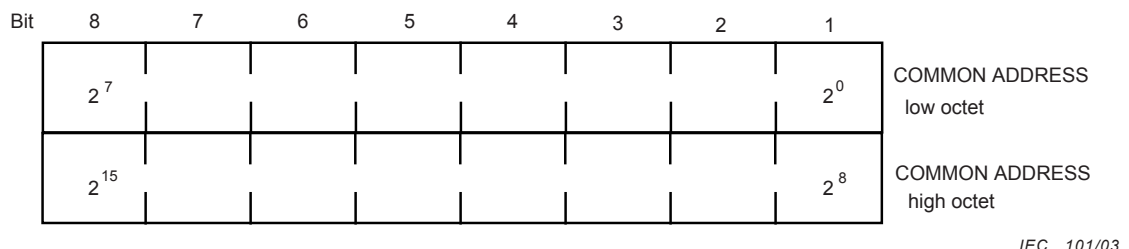


Figure 18 – COMMON ADDRESS of ASDUs (two octets)

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.

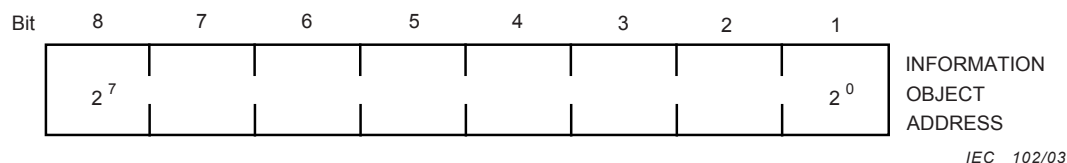


Figure 19 – INFORMATION OBJECT ADDRESS (one octet)

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

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

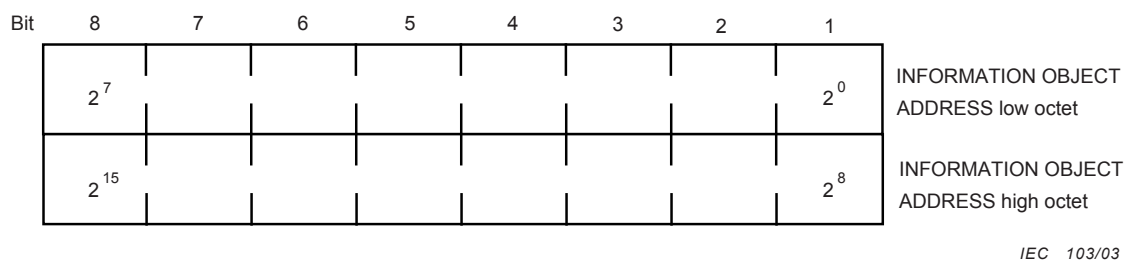
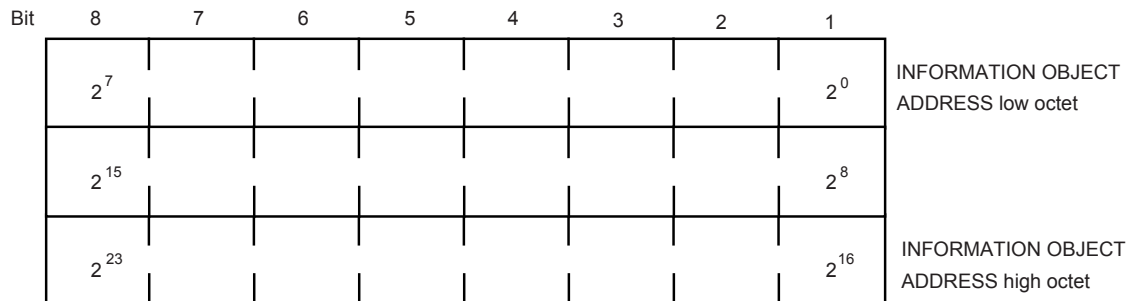


Figure 20 – INFORMATION OBJECT ADDRESS (two octets)

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

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



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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)
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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]<-2¹⁵..+2¹⁵-1> (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]<-2³¹..+2³¹-1> (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 +2³¹-1 to zero or from -2³¹ 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.