

Norwegian IEC 870-5-101

User Conventions

Approved version

Revision no. 2.0

Revision no.:	Date:	Chapter:	Comments:
1.0	97-09-24	All	Initial version
1.1	97-10-24	All	Changes in fonts and figure ref., and insert of chapter 7.4 - 7.6
1.2	98-02-19	7	Foreword added. Redundant communication clarified. Sequences added for redundant communication.
1.3	98-03-19	5.2.1.11 - 5.2.1.16 5.2.4.5 5.2.5.1 7.2.2	Terminology changed for full time ASDUs to correspond to IEC standard ASDU for Line Activation Cmd. added ASDU figure corrected Chapter for redundant lines balanced mode rewritten
1.4	98-12-01	Fig. 6.3, 6.10, 6.13, 6.15, 6.20, 6.21 Fig. 6.7 and 6.8 5.1.1 5.1.4 5.1.5 5.2.2.4 5.2.4.4 5.2.4.5 6.1.7 7.2.2 7.5	Text in figures "FIXED FRAME FC=0,ACD=1" changed to "ACK" Text in figures "FIXED FRAME FC=9,ACD=0" changed to "NACK" Multiple point to point made eligible in interoperability list. <14> made eligible in interoperability list. Interoperability list (command transmission) made more detailed. "No additional definition" made eligible. Activation termination added as possible cause of transmission. Typo corrected Removed More detailed description added Chapter for redundant lines balanced mode rewritten Clarified

2.0	00-03-24	Foreword	Text regarding the maintenance of the document added.
		1	Texts added regarding existence of supplementary definitions to IEC 870-5-101 and the priority of documents if conflict between documents occurs
		2.3	Definition of controlling and controlled station added
		4.2	Added: Day of week is not used and set to 0.
		4.2.9	Text removed: Two octet Common addresses can be used within NUC
		5.1	Interoperability - Text modified due to new notation. Additional functions/ASDUs can be used on project bases.
		5.1.1 - 5.1.5	Notation for selected functions/ASDUs in the interoperability list modified.
		5.1.4	ASDUs with time tag: 2, 4, 10 and 14 not selectable. (ASDUs with time tag CP56Time2a shall be used instead)
		5.1.5	C_SE ACTTERM used changed to NOT set in Interoperability list
		5.2.1.2 5.2.1.4 5.2.1.8	ASDUs with time tag: 2, 4, 10 and 14 not selectable. (ASDUs with time tag CP56Time2a shall be used instead)
		5.2.1.12 5.2.1.13 5.2.1.14 5.2.1.15 5.2.1.16	Type identification presented in Data unit identifiers in Fig. 16,17,18,19 and 20 corrected Text "(Not used = 0) added for "Days of week 1..7"
		5.2.1.9	Sequence of information elements (SQ=1) now supported for ASDU 13 (included in supplementary definitions to IEC 870-5-101)
		5.2.4.2	Information object address should be =0
		6.1.7	Detailed description regarding select and execute command added.
		6.1.9	Text added: IOA's of parameters should be equal to the IOA's to the related measured values
		6.2.1.3	Detailed description regarding the use of the DCF bit added.
		6.2.2.4	Paragraph outlined in "bold"
		7.1	"Measurands" changed to "Measured values"
		7.1.2	Type of indication and recommended IOA for the buffer overflow event added
		7.1.4	Text added: SQ=1 should be used for Measured values as response to general interrogation
		7.3.4	Typo corrected.
		7.8	New chapter describing scaling of normalised measured values, measured value parameters and set point commands added.

FOREWORD	7
1 INTRODUCTION.....	8
2 PROTOCOL STRUCTURE.....	9
2.1 Communication Protocol	9
2.2 Anatomy of a communication Protocol	9
2.3 Definitions.....	10
2.4 Protocol structure	11
3 TRANSMISSION SPECIFICATIONS	13
3.1 Network configurations.....	13
3.2 Protocol character format.....	14
3.3 Transmission rules	15
4 TRANSMISSION FRAME FORMATS	16
4.1 Standard frame formats.....	16
4.2 General structure of application data	18
4.2.1 Start character/length	20
4.2.2 Control field	20
4.2.3 Control field unbalanced mode:.....	21
4.2.4 Control field balanced mode:.....	24
4.2.5 Link address:	27
4.2.6 Type identification:	27
4.2.7 Variable structure qualifier:	28
4.2.8 Cause of transmission	29
4.2.9 Common address of ASDUs	31
4.2.10 Information object address.....	31
4.2.11 Information of elements	32
4.3 Presentation of frame with fixed length, unbalanced mode.....	33
4.4 Presentation of frame with fixed length, balanced mode.....	35
5 APPLICATION LAYER TELEGRAM FORMATS	41
5.1 Interoperability	41
5.1.1 Network configuration	41
5.1.2 Physical layer	41
5.1.3 Link layer	42
5.1.4 Application layer.....	42
5.1.5 Basic application functions	45
5.2 Definition and presentation of the specific ASDUs.....	47
5.2.1 ASDUs for process information in monitor direction.....	47
5.2.1.1 Single-point information without time tag	47
5.2.1.2 Single-point information with time tag (not used)	51
5.2.1.3 Double-point information without time tag.....	53
5.2.1.4 Double-point information with time tag (not used).....	57
5.2.1.5 Step position information	59
5.2.1.6 Bitstring of 32 bit	61
5.2.1.7 Measured value, normalised value	63
5.2.1.8 Measured value, normalised value with time tag (not used)	67

5.2.1.9	Measured value, short floating point number.....	69
5.2.1.10	Integrated totals with time tag (not used).....	73
5.2.1.11	Single-point information with time tag CP56Time2a	75
5.2.1.12	Double-point information with time tag CP56Time2a.....	77
5.2.1.13	Step position information with time tag CP56Time2a.....	80
5.2.1.14	Measured value, normalised value with time tag CP56Time2a..	82
5.2.1.15	Measured value, short floating point number with time tag CP56Time2a.....	84
5.2.1.16	Integrated totals with time tag CP56Time2a	87
5.2.2	ASDUs for process information in control direction	89
5.2.2.1	Single command	89
5.2.2.2	Double command	90
5.2.2.3	Regulating step command	91
5.2.2.4	Set-point command, normalised value	92
5.2.2.5	Bitstring of 32 bit	93
5.2.3	ASDUs for system information in monitor direction.....	94
5.2.3.1	End of initialisation	94
5.2.4	ASDUs for system information in control direction	95
5.2.4.1	Interrogation command	95
5.2.4.2	Clock synchronisation command	96
5.2.4.3	Test command	97
5.2.4.4	Reset process command	98
5.2.5	ASDUs for parameter in control direction.....	99
5.2.5.1	Parameter of measured values, normalised value.....	99
5.2.5.2	Parameter of measured values, short floating point number	100
6	COMMUNICATION PROCEDURES	101
6.1	Basic procedures	102
6.1.1	Station initialisation	102
6.1.1.1	Local initialisation of the controlling station in unbalanced transmission systems	102
6.1.1.2	Local initialisation of the controlled station in unbalanced transmission systems	104
6.1.1.3	Remote initialisation of the controlled station in unbalanced transmission systems	106
6.1.1.4	Local initialisation of the controlling station in balanced transmission systems	108
6.1.1.5	Local initialisation of the controlled station in balanced transmission systems	110
6.1.1.6	Remote initialisation of the controlled station in balanced transmission systems	112
6.1.2	Data acquisition by polling	114
6.1.3	Cyclic data transmission	114
6.1.4	Acquisition of events	114
6.1.4.1	Acquisition of events in unbalanced transmission systems.....	114
6.1.4.2	Acquisition of events in balanced transmission systems.....	117
6.1.5	General interrogation	118
6.1.6	Clock synchronisation.....	122
6.1.7	Command transmission.....	125

6.1.8	Transmission of integrated totals	129
6.1.9	Parameter loading	131
6.1.10	Test procedure	133
6.1.11	File transfer	135
6.1.12	Acquisition of transmission delay	135
6.2	Exception procedures	136
6.2.1	Unbalanced transmission systems	136
6.2.1.1	Disturbed send/confirm procedure	136
6.2.1.2	Disturbed request/respond procedure	136
6.2.1.3	Data flow control	137
6.2.1.4	Communication recovery.	141
6.2.2	Balanced transmission systems	143
6.2.2.1	Disturbed SEND frame	143
6.2.2.2	Disturbed CONFIRM frame	143
6.2.2.3	Disturbed channel in one direction	143
6.2.2.4	Data flow control	144
6.2.2.5	Communication recovery	149
7	FUNCTIONS	152
7.1	Event handling	152
7.1.1	Transfer of data from Controlled Station to Controlling Station	152
7.1.2	Event Buffers	152
7.1.3	Indications	152
7.1.4	Measured values	152
7.1.5	Pulse Counters	152
7.1.6	Priorities	152
7.2	Redundant lines	153
7.2.1	Unbalanced mode	153
7.2.1.1	General requirements	153
7.2.1.2	Initialisation	154
7.2.1.3	Automatic line switch	155
7.2.1.4	Application initiated line switch	157
7.2.2	Balanced mode	158
7.2.2.1	General requirements	158
7.2.2.2	Initialisation of controlling station	158
7.2.2.3	Initialisation of controlled station	160
7.2.2.4	User data from controlling station (commands)	162
7.2.2.5	User data from controlled station	164
7.3	Addressing	166
7.3.1	Link Address	166
7.3.2	Common Address of ASDU	166
7.3.3	Information Object Address	166
7.3.4	Addressing rules	166
7.3.5	Possible addressing conventions	166
7.4	Internal events	167
7.5	Parameter loading	167
7.6	Frame length	167
7.7	Database handling	167
7.8	Scaling	167

7.8.1 Scaling of normalised measured values 167

7.8.2 Parameters for normalised measured values 168

7.8.3 Scaling of normalised set point commands..... 168

Foreword

The Norwegian User Conventions for IEC 870-5-101 has been developed in a project involving many of the major companies in the area of power generation and power distribution. Also the major control equipment suppliers has contributed both financially and with actual work in the project. The project has been managed by RF-Rogaland Research and the steering committee has been headed by Statnet SF. About 40% of the financial support for the project has been supplied by The Research Council of Norway, the rest has been financed by support from the following companies:

ABB Kraft AS
Aker Elektro AS
Bailey Norge AS
I/S Øvre Otra
Lyse Kraft AS
Malthe Winje Automasjon AS
Nord-Trøndelag Elektrisitetsverk
Norsk Hydro ASA
Siemens AS
Statkraft SF
Statnett SF
Trondheim Energiverk AS
Vestfold Kraft DA
Viken Energinett AS

Statnett SF is responsible for the maintenance of the Norwegian User Conventions document for IEC 870-5-101. The need for making new revisions of the document will be reviewed on annually bases. This document and new revisions of this document will be available in PDF-format on Internet from Statnett SF: (www.statnett.no).

This document is free to be used by any project. We will kindly ask users to report errors or suggest improvements to the document. Please send this to:

Statnett SF
P.B. 5192, Majorstua
N-0302 Oslo
Norway

Att: Ketil Rian

or by E-mail to:

ketil.rian@statnett.no

1 INTRODUCTION

This paper will provide an overview of use of IEC 870-5-101 protocol in Norway.

The IEC Technical Committee 57 (Working Group 03) have developed a protocol standard for telecontrol, teleprotection, and associated telecommunications for electric power systems. The result of this work is IEC 870-5. Five documents specify the base IEC 870-5. The documents are:

IEC 870-5-1	Transmission Frame Formats
IEC 870-5-2	Data Link Transmission Services
IEC 870-5-3	General Structure of Application Data
IEC 870-5-4	Definition and coding of Information Elements
IEC 870-5-5	Basic Application Functions

The IEC Technical Committee 57 have also generated a companion standard IEC 870-5-101 especially for remote controlled units RTU. The IEC 870-5-101 is based of the five documents IEC 870-5-1 - 5.

The Norwegian User Conventions is based on IEC 870-5-101 standard. The Norwegian User Conventions is generated for to give an overview over functions and use of IEC standard in Norway

The document is generated to fill all needs for implementing the protocol. It should not be necessary to look into all the standard documents.

IEC has approved supplementary definitions to IEC 870-5-101. If conflicts are detected between descriptions in Norwegian User Conventions documents and the IEC 870-5-101 Companion standard document or Supplementary definitions, the Norwegian User Conventions document shall be given the highest priority.

2 PROTOCOL STRUCTURE

2.1 Communication Protocol

Communication Protocols are the grammars through which computer-based devices communicate with one another - the way they organise, and transmit the bits and bytes of electronic on-off (binary) signals whose patterns encode data. Simply, a protocol is a set of rules that governs how message containing data and control information are assembled at a source for their transmission across the network and then dissembled when they reach their destination.

2.2 Anatomy of a communication Protocol

Most standards organisations use a layered model or stack to develop protocol specifications, with each layer performing some very specific functions and services.

The open Systems Interconnect Reference Model

The Open Systems Interconnect (OSI) reference model is a layered set of protocols to facilitate open communications between computer networks. It was developed by the International Organisation for Standardisation (ISO) in conjunction with the Consultative Committee on International Telegraphy and Telephony (CCITT).

The purpose of the OSI communication model is to make multivendor networking easy to implement, thereby reducing the overall costs and enhancing the level of system integration that normally could be realised with constantly changing and expanding protocol solutions.

The 7 - Layer Stack

The 7-Layer stack is based on established international ISO protocol standards. The architecture intended to provide full communications functionality based on the OSI Reference Model and is capable of supporting the majority and the industry data communication requirements.

The 3 - Layer Stack

The 3 - layer stack is also based on stable international standards. The 3 - layer stack provides a simpler mechanism for data communication.

7 - layer

7. Application
6. Presentation
5. Session
4. Transport
3. Network
2. Data Link
1. Physical

3 - layer

7. Application
2. Data Link
1. Physical

2.3 Definitions

For the purpose of this user conventions, the following definitions apply:

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.

Group (of information objects)

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

Control direction

The direction of transmission from the controlling station, typical a SCADA system, to a controlled station, typical a station control system or a RTU..

Monitor direction

The direction of transmission from a controlled station to the controlling station.

Unbalanced transmission

Unbalanced transmission procedures are used in supervisory control and data acquisition (SCADA) systems in which a master station controls the data traffic by polling outstations sequentially. In this case the master station (master) is the primary station that initiates all message transfers while outstations are secondary stations (slaves) that may transmit only when they are polled.

The unbalanced mode procedure can be used generally, but must be used in party line configuration.

Balanced transmission

If balanced transmission procedures are used, each station may initiate message transfers.

The balanced mode procedure is restrict to "point to point or multiple point to point".

In due to unbalanced mode is balanced mode the most effective way of communication on «point to point or multiple point». Balanced transmission can be used in full duplex mode.

Controlled Station (Outstation, Remote station, Remote terminal unit (RTU), Slave station)

A station that is monitored or commanded by a master station.

Controlling Station (Master station)

A station at which telecontrol of outstations is performed.

2.4 Protocol structure

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. Figure1 shows the ENHANCED PERFORMANCE ARCHITECTURE model (EPA) and the selected standard definitions of the companion standard.

Selected application functions of IEC/DIS 870-5-5	User process
Selected application information elements of IEC 870-5-4	Application (layer 7)
Selected application service data units of IEC 870-5-3	
Selected link transmission procedures of IEC 870-5-2	Link (layer 2)
Selected transmission frame formats of IEC 870-5-1	
Selected ITU-T recommendations	Physical (layer 1)

Figure1 - Selected standard provisions of the defined telecontrol companion standard

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).

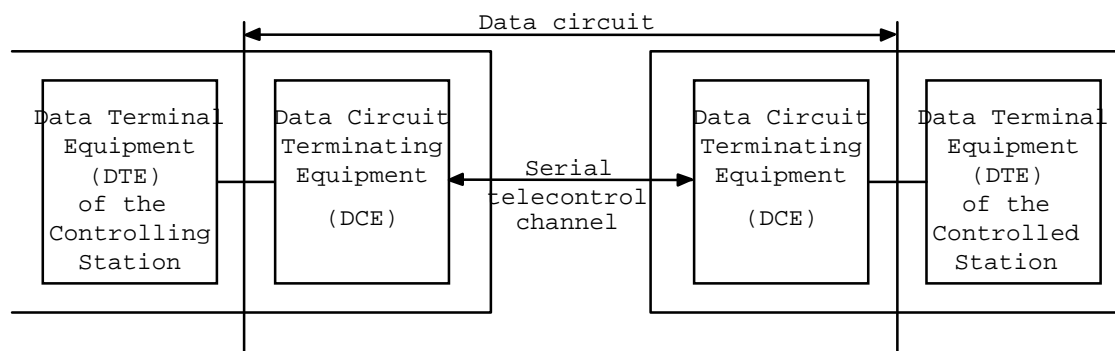


Figure 2 - *Interfaces and connections of controlling and controlled stations*

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.

Link layer

IEC 870-5-2 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.

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.

Application layer

Application layer define ASDUs (telegram types).

3 TRANSMISSION SPECIFICATIONS

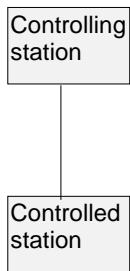
3.1 Network configurations

The following fixed network configurations are supported:

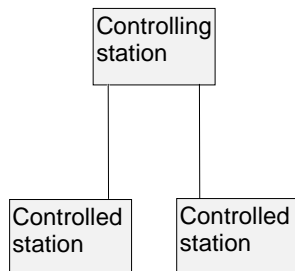
- Point - to - point
- Multiple point - to - point
- Party line
- Redundant line

Figure shows network configurations

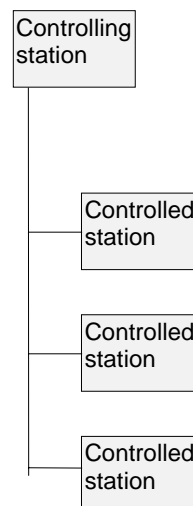
Point - to - point



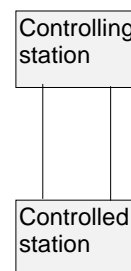
Multiple point - to - point



Party line



Redundant line




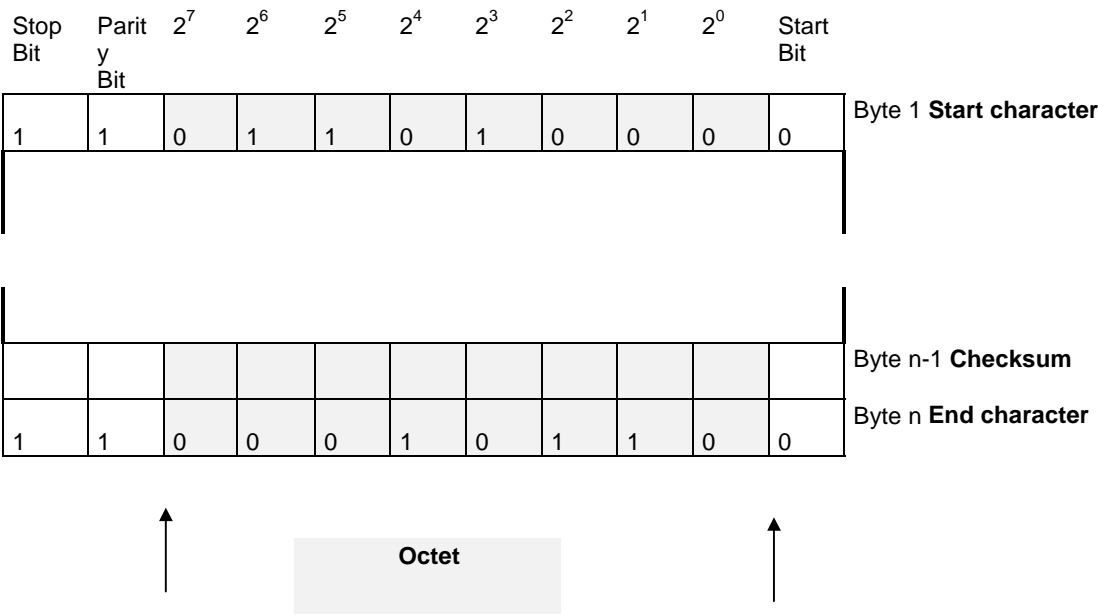
3.2 Protocol character format

IEC 870-5-101 specifies frame format **FT 1.2** .
IEC 870-5-101 is an asynchronous protocol with hamming distance = 4

Character format

- 1 Start bit
- 1 Stop bit
- 1 Parity bit (even)
- 8 Databits

Bit sequence on line 



3.3 Transmission rules

1	Line idle is binary 1.
2	Each character has one start bit (binary = 0) 8 information bits, one even parity bit and one stop bit (binary = 1).
3	No line idle intervals are admitted between characters of a frame.
4	Upon detecting an error according to rule 6, a minimum interval of 33 bits (3 characters) is required between frames.
5	The sequence of user data characters is terminated by a 8 bits checksum (CS). The checksum is the arithmetic sum over all user data octets.
6	The receiver checks:

per character	the start bit, the stop bit and the even parity bit
per frame	the start character, the length (2 bytes in frames with variable lengths), the frame check sum and the end character and, upon detecting an error, the line idle interval specified by rule 4

The frame is rejected if one of these checks fails, otherwise it is released to the user.

4 TRANSMISSION FRAME FORMATS

4.1 Standard frame formats

It is defined three frame format classes in IEC 870-5-1 norm.

The format class FT 1.1 defines a block code with Hamming distance 2, which is generated by adding a start bit, a parity bit and a stop bit to 8 information bits.

Sequences of FT 1.1 blocks supplemented by a check sum character form FT 1.2 product codes with Hamming distance 4..

The format class FT 2 is defined by a block code with Hamming distance 4 that contains up to 15 user data octets supplemented by one check octet.

The format class FT 3 is defined by a block code with Hamming distance 6 that contains up to 16 user data octets supplemented by two check octets.

The IEC870-5-101 protocol standard admits exclusive frame format FT 1.2.

Formats with fixed and with variable block length are admitted. Also the single control character is admitted.

Figure shows the three frame formats in IEC 870-5-101 format class FT 1.2

Frame with variable length

Start 68 H
L
L
Start 68 H
C
A
A
Link/ userdata
"
"
"
"
Checksum
End 16H

Frame with fixed length

Start 10H
C
A
Checksum
End 16H

Single character

E 5 H

- L Length field range 0 - 255
- L Specifies the number of subsequent user data octets including the control and the address fields
- C Control field
- A Address field (link)

Frame with variable length:

Frame is used for data transmission of user data between controlling and controlled station.

Frames are more specified in chapter 5 in this document.

Frame with fixed length:

Frame with fixed length is normally used for link layer services.

In special cases can frame with fixed length be used as a confirm frame instead of single character.

Single character:

Single character is normally used to confirm data on link services and to confirm user data.

Used of frame with fixed length and single character is more described in chapter 6 in this document.

4.2 General structure of application data

IEC 870-5-3 describes the Basic Application Data Units in transmission frames of telecontrol systems. This subclass selects specific field elements out of that standard and defines APPLICATION SERVICE DATA UNITS (ASDU) used in standard IEC 870-5-101 protocol.

ASDUs is specified as frames with variable length. Frame with variable length in format-class FT 1.2 start with:

- one octet START CHARACTER
- two octets FRAME LENGTH
- one octet START CHARACTER
- one octet LINK ADDRESS

and stop with:

- one octet CHECKSUM
- one octet STOP CHARACTER

Start and stop has always the same structure for all frames with variable length (ASDUs)

The APPLICATION SERVICE DATA UNIT (ASDU) 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.

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 ASDU

The size of the COMMON ADDRESS OF ASDU is determined by a fixed system 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 (two octets).

TIME TAGS (if present) belong always to a single INFORMATION OBJECT.

Day of week is not used in this companion standard and set to 0.

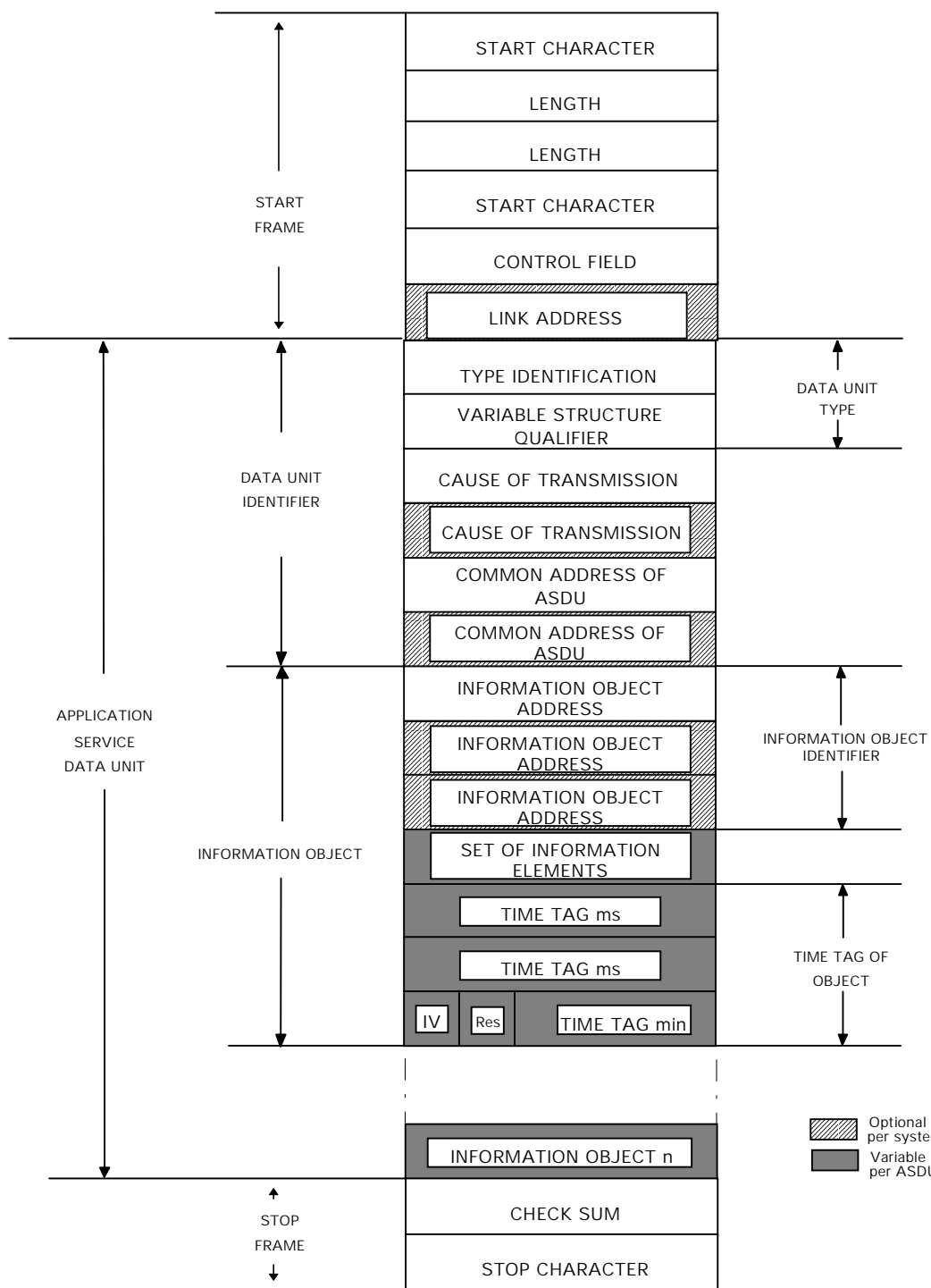
The INFORMATION OBJECT consists of an INFORMATION OBJECT IDENTIFIER, a SET OF INFORMATION ELEMENTS and, if present, a TIME TAG OF INFORMATION OBJECT.

The INFORMATION OBJECT IDENTIFIER consists only of the INFORMATION OBJECT ADDRESS. In most cases the COMMON ADDRESS OF ASDU 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.

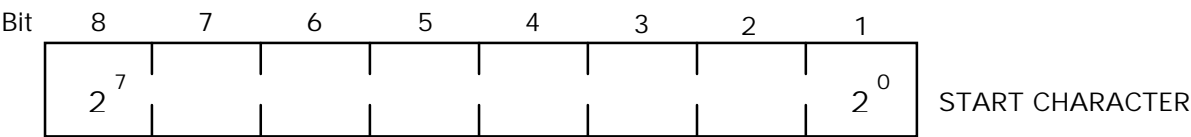
The SET OF INFORMATION ELEMENTS consists of a SINGLE INFORMATION ELEMENT/COMBINATION OF ELEMENTS or a SEQUENCE OF INFORMATION ELEMENTS.

NOTE

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



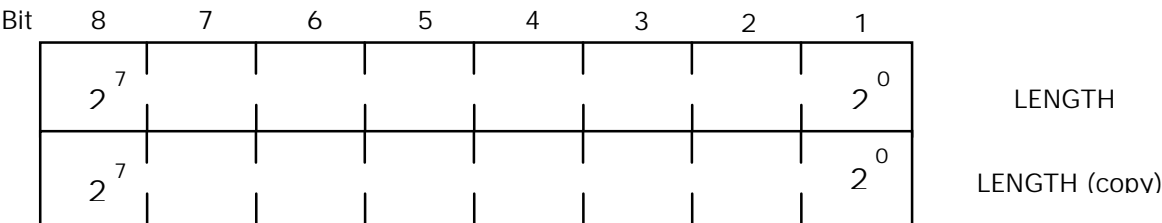
4.2.1 Start character/length



Start character mark limits between two frames.

Frames with variable length : 68 HEX

Frames with fast length: 10 HEX



Length field range : 0 - 255.

Length specifies the number and subsequent user data octets including the control and address fields

Range up to 255 octets have to be a parameter in controlled station.

4.2.2 Control field

The control field contains information that characterises the direction of the message, the type of the service provided and supports control functions for suppressing losses or duplications of messages.

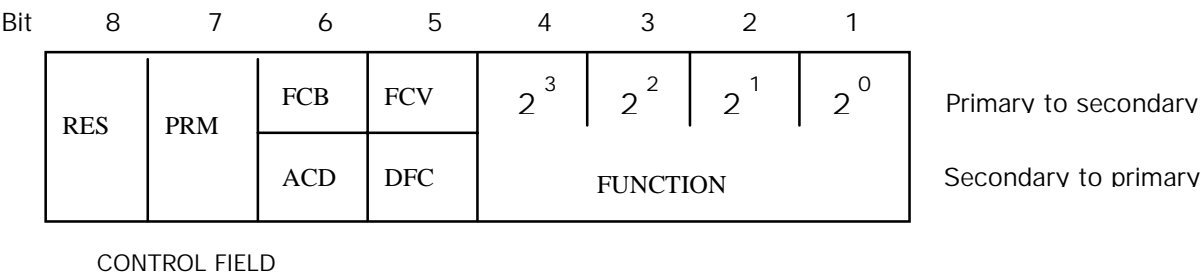
The control field is different for balanced and unbalanced mode.

4.2.3 Control field unbalanced mode:

Unbalanced transmission procedures are used in supervisory control and data acquisition systems in which a master station controls the data traffic by polling outstations sequentially. In this case the master station is the primary station that initiates all message transfers while the outstations are secondary stations that may transmit only when they are polled.

The following transmission services, initiated by the primary station, are supported by the link:

- Send/reply mainly used for global messages and for cyclic setpoints in control loops.
- Send/confirm mainly used for control commands and setpoint commands
- Request/respond used for polling sequences of this service may be used for cyclic updating functions.



RES	Reserved
PRM	Primary message 0 = message from secondary(responding) station. 1 = message from primary (initiating) station.
FCB	Frame count bit: 0 - 1 = alternating bit for successive SEND/CONFIRM or REQUEST/RESPOND services per station. The frame count bit is used to delete losses and duplications of information transfers. The primary station alternate the FCB bit for each new SEND/CONFIRM or REQUEST/RESPOND transmission service directed to the same secondary station. Thus the primary station keeps a copy of the frame count bit per secondary station. If an expected reply is timed out (missing) or grabbed, then the same SEND/CONFIRM and REQUEST/RESPOND service is repeated with the same frame count bit. In case of reset commands the FCB bit is always zero, and upon receipt of these commands the secondary station will always be set to expect the next frame primary to secondary with FCV = valid (FCV = 1) to have the opposite setting of FCB, i.e. FCB equal to one
FCV	Frame count bit valid. 0 = alternating function and FCB bit is invalid 1 = alternating function of FCB bit is valid SEND/NO REPLY services, broadcast messages and other transmission services that ignore the deletion of duplication or loss of information output do not alternate the FCB bit and indicates this by a cleared FCV bit
DFC	Data flow control 0 = further messages are acceptable 1 = further messages may cause data overflow Secondary (responding) stations indicate to the message initiating (primary) station that an immediate secession of further message may cause a buffer overflow.

ACD	Access demand. There are two classes of message data provided, namely class 1 and 2. 0 = no access demand for class 1 data transmission 1 = access demand for class 1 data transmission Class 1 data transmission is typically used for events or for messages with high priority. Class 2 data transmission is typically used for cyclic transmission or for low priority messages.
-----	---

Function codes of control-field in messages sent from primary (PRM = 1)

Unbalanced mode

Function code no	Frame type	Service function	FCV
0	SEND/CONFIRM expected	Reset remote link	0
1	SEND/CONFIRM expected	Reset of user process	0
2	SEND/CONFIRM expected	Reserved for balanced mode	-
3	SEND/CONFIRM expected	User data	1
4	SEND/NO REPLY expected	User data	0
5		Reserved	-
6 - 7		Reserved for special use agreement	-
8	REQUEST for access demand	Expected response specifies access demand	0
9	REQUEST/RESPOND expected	Request status of link	0
10	REQUEST/RESPOND expected	Request user data class 1	1
11	REQUEST/RESPOND expected	Request user data class 2	1
12 - 13		Reserved	-
14 - 15		Reserved for special use by agreement	-

Function codes of control-field in messages sent from secondary (PRM = 0)

Unbalanced mode

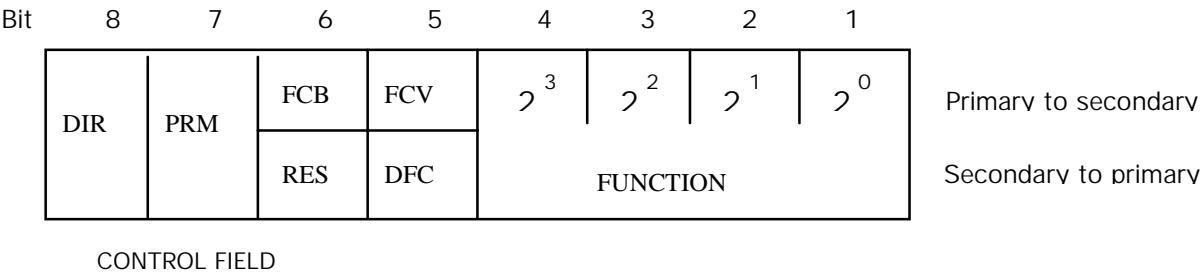
Function code no	Frame type	Service function
0	CONFIRM	ACK: Positive acknowledgement
1	CONFIRM	NACK: message not accepted, link busy
2 - 5		Reserved
6 - 7		Reserved for special use by agreement
8	RESPOND	User data
9	RESPOND	NACK: requested data not available
10		Reserved
11	RESPOND	Status of link or access demand
12		Reserved
13		Reserved for special use by agreement
14		Link service not functioning
15		Link service not implemented

4.2.4 Control field balanced mode:

Balanced transmission:

If blanced transmission procedures are used, each station may initiate message transfers. Because such stations may act simultaneously as primary and secondary stations, they are called combined stations. In the following, the combined stations is called either primary or secondary station according to its described functions.

The balanced transmission procedure is restricted to point to point and multiple point to point.



DIR	<p>Physical transmission direction</p> <p>DIR=1 Data from controlling to controlled station</p> <p>DIR=0 Data from controlled to controlling station</p>
PRM	<p>Primary message</p> <p>0 =message from secondary (responding) station</p> <p>1 = message from primary (initiating) station</p>
FCB	<p>Frame count bit: 0 - 1 = alternating bit for successive SEND/CONFIRM or REQUEST/RESPOND services per station.</p> <p>The frame count bit is used to delete losses and duplications of information transfers. The primary station alternate the FCB bit for each new SEND/CONFIRM or REQUEST/RESPOND transmission service directed to the same secondary station.</p> <p>Thus the primary station keeps a copy of the frame count bit per secondary station.</p> <p>If an expected reply is timed out (missing) or grabbed, then the same SEND/CONFIRM and REQUEST/RESPOND service is repeated with the same frame count bit.</p> <p>In case of reset commands the FCB bit is always zero, and upon receipt of these commands the secondary station will always be set to expect the next frame primary to secondary with FCV = valid (FCV = 1) to have the opposite setting of FCB, i.e. FCB equal to one</p>
FCV	<p>Frame count bit valid.</p> <p>0 = alternating function and FCB bit is invalid</p> <p>1 = alternating function of FCB bit is valid</p> <p>SEND/NO REPLY services, broadcast messages and other transmission services that ignore the deletion of duplication or loss of information output do not alternate the FCB bit and indicates this by a cleared FCV bit</p>
DFC	<p>Data flow control</p> <p>0 = further messages are acceptable</p> <p>1 = further messages may cause data overflow</p> <p>Secondary (responding) stations indicate to the message initiating (primary) station that an immediate secession of further message may cause a buffer overflow.</p>
RES	Reserved

Function codes of control-field in messages sent from primary (PRM = 1)

Balanced mode

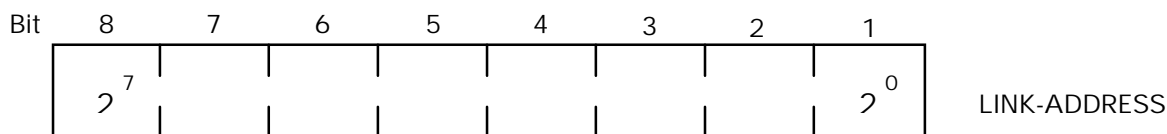
Function code no	Frame type	Service function	FCV
0	SEND/CONFIRM expected	Reset remote link	0
1	SEND/CONFIRM expected	Reset of user process	0
2	SEND/CONFIRM expected	Test function for link	1
3	SEND/CONFIRM expected	User data	1
4	SEND/NO REPLY expected	User data	0
5		Reserved	-
6 - 7		Reserved for special use agreement	-
8		Reserved for unbalanced transmission procedure	-
9	REQUEST/RESPOND expected	Request status of link	0
10		Reserved for unbalanced transmission procedure	-
11		Reserved for unbalanced transmission procedure	-
12 - 13		Reserved	-
14 - 15		Reserved for special use by agreement	-

Function codes of control-field in messages sent from secondary (PRM = 0)

Balanced mode

Function code no	Frame type	Service function
0	CONFIRM	ACK: Positive acknowledgement
1	CONFIRM	NACK: message not accepted, link busy
2 - 5		Reserved
6 - 7		Reserved for special use by agreement
8		Reserved for unbalanced transmission procedure
9		Reserved for unbalanced transmission procedure
10		Reserved
11	RESPOND	Status of link
12		Reserved
13		Reserved for special use by agreement
14		Link service not functioning
15		Link service not implemented

4.2.5 Link address:



Link transmission procedures using a control field and the optional address field.
Link - address field could be either one or two octets, or none, but not in Norwegian conventions.

4.2.6 Type identification:

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

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>



INFORMATION OBJECTS with or without TIME TAGS are distinguished with different numbers of the TYPE IDENTIFICATION.
ASDUs with undefined values of TYPE IDENTIFICATION are acknowledged negatively and discarded by both controlling and controlled stations.

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 user convention. The range of numbers 128 to 255 is not defined. Full interoperability would be obtained only when using ASDUs having TYPE IDENTIFICATION numbers in the range 1 to 127.

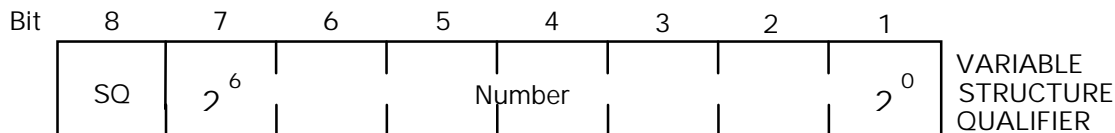
The following tables show the definition of TYPE IDENTIFICATION numbers for process and system information in monitor and control direction.

TYPE IDENTIFICATION	:=	UI8[1..8]<1..255>
<1..127>	:=	for standard definitions from IEC 870-5-101 standard
<128..135>	:=	reserved for routing of messages (private range) *
<136..255>	:=	for special use (private range) *

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

4.2.7 Variable structure qualifier:

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



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
SQ=Single/sequence	:=	BS1[8] <0..1>
<0>	:=	addressing of an individual element or combination of elements in a number of INFORMATION OBJECTS of the same type
<1>	:=	addressing of a SEQUENCE OF INFORMATION ELEMENTS in one object
SQ<0>and N<0..127>	:=	number of INFORMATION OBJECTS
SQ<1>and N<0..127>	:=	number of INFORMATION ELEMENTS of a single object per ASDU

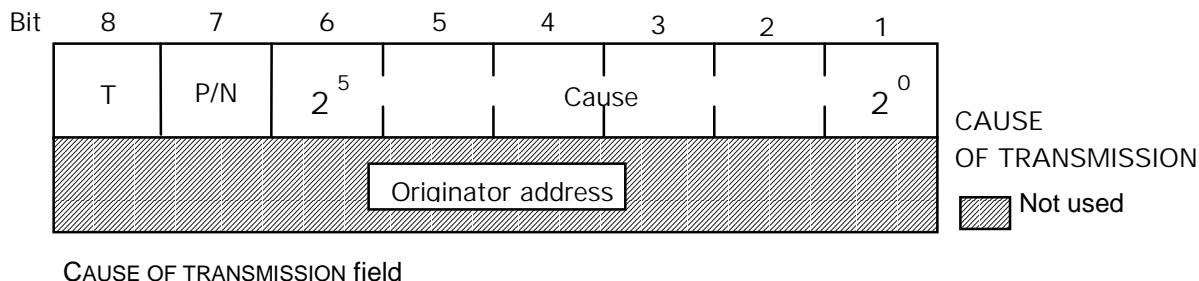
The SQ bit specifies the method of addressing the following INFORMATION OBJECTS or ELEMENTS.

SQ = 0: Each single element or a combination of 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 equal INFORMATION ELEMENTS (e.g. measured values of identical format) is addressed (see 5.1.5 of IEC 870-5-3) by the INFORMATION OBJECT ADDRESS. The INFORMATION OBJECT ADDRESS specifies the associated address of the first INFORMATION ELEMENT of the sequence. The following 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 INFORMATION ELEMENTS. In case of a SEQUENCE OF INFORMATION ELEMENTS only one INFORMATION OBJECT per ASDU is allocated.

4.2.8 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.



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 below
<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>	:=	default
<1..255>	:=	number of originator address

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 e.g. 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. The originator address is not used in Norwegian conventions.

If the originator address is not used and there is more than a single source in a system defined, the ASDUs in 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. The originator address is not used in Norwegian user conventions.

Semantics of CAUSE OF TRANSMISSION

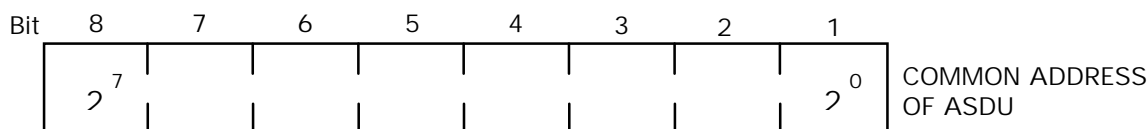
Cause of transmission possibilities for each ASDU used i Norway is described in clause 5.

Cause	:= UI6[1..6] <0..63>	
<0>	:= not used	
<1>	:= periodic, cyclic	per/cyc
<2>	:= background scan*	back
<3>	:= spontaneous	spont
<4>	:= initialised	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 general 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..47>	:= reserved for further compatible definitions	

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

4.2.9 Common address of ASDUs

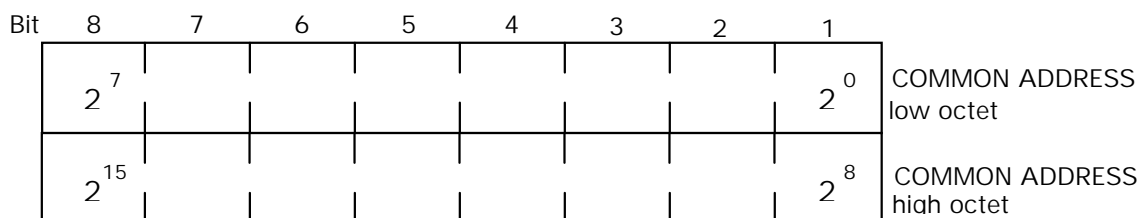
Octet 4 and optionally 5 of the DATA UNIT IDENTIFIER of the ASDU define the station address which is specified in the following. The length of the COMMON ADDRESS (one or two octets) is a parameter which is fixed per system.



COMMON ADDRESS of ASDU (one octet)

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

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



COMMON ADDRESS of ASDU (two octets)

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

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

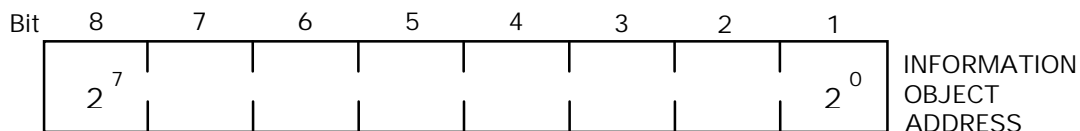
The COMMON ADDRESS is associated with all objects in an ASDU. The global address is a broadcast address directed to all stations of a specific system. ASDUs with a broadcast address in control direction have to be answered in monitor direction by ASDUs that contain the specific defined COMMON ADDRESS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

4.2.10 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.

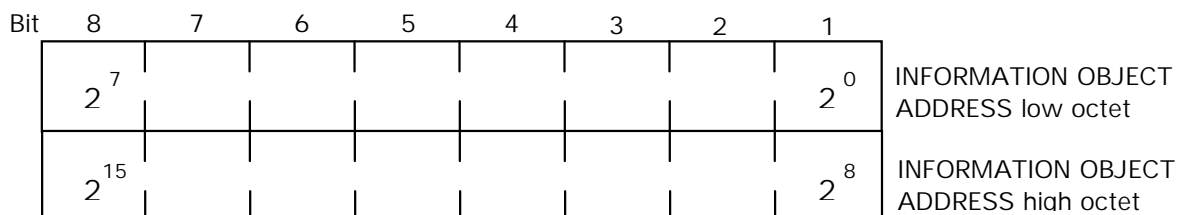
The INFORMATION OBJECT ADDRESS is used as a destination address in control direction and a source address in monitor direction.

In Norwegian user conventions are two octets for information object address used.



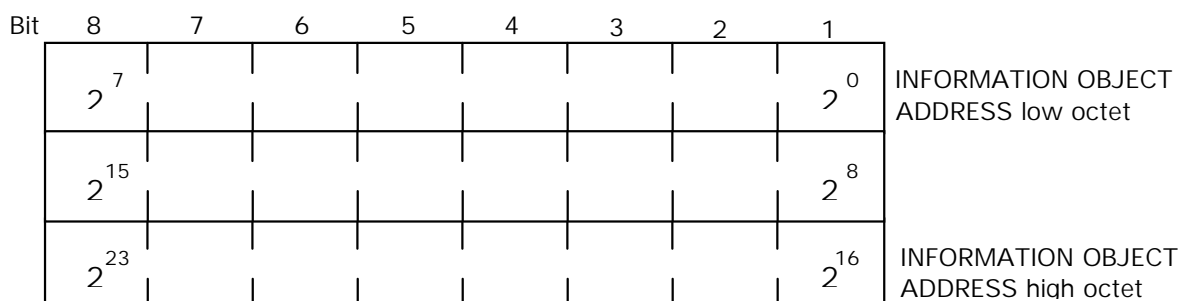
INFORMATION OBJECT ADDRESS (one octet)

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



INFORMATION OBJECT ADDRESS (two octets)

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



INFORMATION OBJECT ADDRESS (three octets)

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

The third octet is only used in 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.

Object address with two octets are used in the Norwegian user conventions.

4.2.11 Information of elements

Information of elements for all ASDUs i Norwegian user conventions is described in chapter 5.

4.3 Presentation of frame with fixed length, unbalanced mode

8	7	6	5	4	3	2	1	Bit	
0	0	0	1	0	0	0	0		START CHARACTER 10 HEX
RES	PRM	FCB	FCV	FUNCTION					
	1	ACD	DFC	B ³	B ²	B ¹	B ⁰		CONTROL FIELD
B ⁷	B ⁶	B ⁵	B ⁴	B ³	B ²	B ¹	B ⁰		ADRESS FIELD (LINKADDRESS)
0	0	0	0	0	0	0	0		CHECKSUM
0	0	0	1	0	1	1	0		END CHARACTER 16HEX

Figure 1 - Frame with fixed length sent from controlling station

Bits in control field

<i>RES</i>	<i>Reserved</i>
<i>PRM</i>	<i>Primary message = 1 - message from controlling station</i>
<i>FCB</i>	<i>Frame count bit = 0 / 1 alternating bit for successive SEND / CONFIRM</i>
<i>FCV</i>	<i>Frame count bit valid =1 alternating function and FCB bit is valid</i> <i>Frame count bit valid = 0 alternating function and FCB is invalid</i>
<i>DFC</i>	<i>Data flow control = 0 further messages are acceptable</i> <i>Data flow control =1 further messages may case data overflow</i>
<i>ACD</i>	<i>Access demand = 0 no access demand for class 1 data transmission</i> <i>Access demand = 1 access demand for class 1 data transmission</i>

Function code (control-field)

Function code no	Frame type	Service function	FCV
0	SEND/CONFIRM expected	Reset remote link	0
1	SEND/CONFIRM expected	Reset of user process	0
3	SEND/CONFIRM expected	User data	1
4	SEND/NO REPLY expected	User data	0
8	REQUEST for access demand	Expected response specifies access demand	0
9	REQUEST/RESPOND expected	Request status of link	0
10	REQUEST/RESPOND expected	Request user data class 1	1
11	REQUEST/RESPOND expected	Request user data class 2	1

8	7	6	5	4	3	2	1	Bit	
0	0	0	1	0	0	0	0		START CHARACTER 10 HEX
RES	PRM	FCB	FCV	FUNCTION					
	0	ACD	DFC	B ³	B ²	B ¹	B ⁰		CONTROL FIELD
B ⁷	B ⁶	B ⁵	B ⁴	B ³	B ²	B ¹	B ⁰		ADRESS FIELD (LINKADDRESS)
0	0	0	0	0	0	0	0		CHECKSUM
0	0	0	1	0	1	1	0		END CHARACTER 16HEX

Figure 2 - Frame with fixed length sent from controlled station

Bits in control field

<i>RES</i>	<i>Reserved</i>
<i>PRM</i>	<i>Primary message = 0 - message from controlled station</i>
<i>FCB</i>	<i>Frame count bit = 0 / 1 alternating bit for successive SEND / CONFIRM</i>
<i>FCV</i>	<i>Frame count bit valid =1 alternating function and FCB bit is valid</i> <i>Frame count bit valid = 0 alternating function and FCB is invalid</i>
<i>DFC</i>	<i>Data flow control = 0 further messages are acceptable</i> <i>Data flow control =1 further messages may case data overflow</i>
<i>ACD</i>	<i>Access demand = 0 no access demand for class 1 data transmission</i> <i>Access demand = 1 access demand for class 1 data transmission</i>

Function code (control-field)

Function code no	Frame type	Service function
0	CONFIRM	ACK: Positive acknowledgement
1	CONFIRM	NACK: message not accepted, link busy
8	RESPOND	User data
9	RESPOND	NACK: requested data not available
11	RESPOND	Status of link or access demand

4.4 Presentation of frame with fixed length, balanced mode

In balanced transmission mode each station may initiate message transfers. Because such stations may act simultaneously as primary **and** secondary stations, they are called combined stations.

8	7	6	5	4	3	2	1	Bit	
0	0	0	1	0	0	0	0		START CHARACTER 10 HEX
DIR	PRM	FCB	FCV	FUNCTION					
1	1	RES	DFC	B ³	B ²	B ¹	B ⁰		CONTROL FIELD
B ⁷	B ⁶	B ⁵	B ⁴	B ³	B ²	B ¹	B ⁰		ADRESS FIELD (LINKADRESS)
0	0	0	0	0	0	0	0		CHECKSUM
0	0	0	1	0	1	1	0		END CHARACTER 16HEX

Figure 1 - Frame with fixed length sent from controlling station as primary station

Bits in control field

<i>DIR</i>	<i>Physical transmission direction = 1 message from controlling to controlled station</i>
<i>PRM</i>	<i>Primary message = 1 - message from initiating station</i>
<i>FCB</i>	<i>Frame count bit = 0 / 1 alternating bit for successive SEND / CONFIRM</i>
<i>FCV</i>	<i>Frame count bit valid =1 alternating function and FCB bit is valid</i> <i>Frame count bit valid = 0 alternating function and FCB is invalid</i>
<i>DFC</i>	<i>Data flow control = 0 further messages are acceptable</i> <i>Data flow control =1 further messages may case data overflow</i>
<i>RES</i>	<i>Reserved</i>

Function codes of control-field in messages sent from primary (PRM = 1)

Primary (initiating) station is in this example the controlling station

Function code no	Frame type	Service function	FCV
0	SEND/CONFIRM expected	Reset remote link	0
1	SEND/CONFIRM expected	Reset of user process	0
2	SEND/CONFIRM expected	Test function for link	1
3	SEND/CONFIRM expected	User data	1
4	SEND/NO REPLY expected	User data	0
9	REQUEST/RESPOND expected	Request status of link	0

8	7	6	5	4	3	2	1	Bit	
0	0	0	1	0	0	0	0		START CHARACTER 10 HEX
DIR	PRM	FCB	FCV	FUNCTION					
0	0	RES	DFC	B ³	B ²	B ¹	B ⁰		CONTROL FIELD
B ⁷	B ⁶	B ⁵	B ⁴	B ³	B ²	B ¹	B ⁰		ADRESS FIELD (LINKADRESS)
0	0	0	0	0	0	0	0		CHECKSUM
0	0	0	1	0	1	1	0		END CHARACTER 16HEX

Figure 2 - Frame with fixed length sent from controlled station as secondary (responding) station

Bits in control field

<i>DIR</i>	<i>Physical transmission direction = 0 message from controlled to controlling station</i>
<i>PRM</i>	<i>Primary message = 0 - message from responding station</i>
<i>FCB</i>	<i>Frame count bit = 0 / 1 alternating bit for successive SEND / CONFIRM</i>
<i>FCV</i>	<i>Frame count bit valid = 1 alternating function and FCB bit is valid</i> <i>Frame count bit valid = 0 alternating function and FCB is invalid</i>
<i>DFC</i>	<i>Data flow control = 0 further messages are acceptable</i> <i>Data flow control = 1 further messages may cause data overflow</i>
<i>RES</i>	<i>Reserved</i>

Function codes of control-field in messages sent from secondary (PRM = 0)

Balanced mode. Secondary (responding) station is in this example the controlled station

Function code no	Frame type	Service function
0	CONFIRM	ACK: Positive acknowledgement
1	CONFIRM	NACK: message not accepted, link busy
11	RESPOND	Status of link

8	7	6	5	4	3	2	1	Bit	
0	0	0	1	0	0	0	0		START CHARACTER 10 HEX
DIR	PRM	FCB	FCV	FUNCTION					
0	1	RES	DFC	B ³	B ²	B ¹	B ⁰		CONTROL FIELD
B ⁷	B ⁶	B ⁵	B ⁴	B ³	B ²	B ¹	B ⁰		ADRESS FIELD (LINKADDRESS)
0	0	0	0	0	0	0	0		CHECKSUM
0	0	0	1	0	1	1	0		END CHARACTER 16HEX

Figure 3 - Frame with fixed length sent from controlled station as primary station

Bits in control field

<i>DIR</i>	<i>Physical transmission direction = 0 message from controlled to controlling station</i>
<i>PRM</i>	<i>Primary message = 1 - message from initiating station</i>
<i>FCB</i>	<i>Frame count bit = 0 / 1 alternating bit for successive SEND / CONFIRM</i>
<i>FCV</i>	<i>Frame count bit valid = 1 alternating function and FCB bit is valid</i> <i>Frame count bit valid = 0 alternating function and FCB is invalid</i>
<i>DFC</i>	<i>Data flow control = 0 further messages are acceptable</i> <i>Data flow control = 1 further messages may case data overflow</i>
<i>RES</i>	<i>Reserved</i>

Function codes of control-field in messages sent from primary (PRM = 1)

Primary (initiating) station is in this example the controlled station

Function code no	Frame type	Service function	FCV
0	SEND/CONFIRM expected	Reset remote link	0
1	SEND/CONFIRM expected	Reset of user process	0
2	SEND/CONFIRM expected	Test function for link	1
3	SEND/CONFIRM expected	User data	1
4	SEND/NO REPLY expected	User data	0
9	REQUEST/RESPOND expected	Request status of link	0

8	7	6	5	4	3	2	1	Bit
0	0	0	1	0	0	0	0	START CHARACTER 10 HEX
DIR	PRM	FCB	FCV	FUNCTION				
1	0	RES	DFC	B ³	B ²	B ¹	B ⁰	CONTROL FIELD
B ⁷	B ⁶	B ⁵	B ⁴	B ³	B ²	B ¹	B ⁰	ADRESS FIELD (LINKADRESS)
0	0	0	0	0	0	0	0	CHECKSUM
0	0	0	1	0	1	1	0	END CHARACTER 16HEX

Figure 4 - Frame with fixed length sent from controlling station as secondary (responding) station

Bits in control field

<i>DIR</i>	<i>Physical transmission direction = 1 message from controlling to controlled station</i>
<i>PRM</i>	<i>Primary message = 0 - message from responding station</i>
<i>FCB</i>	<i>Frame count bit = 0 / 1 alternating bit for successive SEND / CONFIRM</i>
<i>FCV</i>	<i>Frame count bit valid = 1 alternating function and FCB bit is valid</i> <i>Frame count bit valid = 0 alternating function and FCB is invalid</i>
<i>DFC</i>	<i>Data flow control = 0 further messages are acceptable</i> <i>Data flow control = 1 further messages may cause data overflow</i>
<i>RES</i>	<i>Reserved</i>

Function codes of control-field in messages sent from secondary (PRM = 0)

Balanced mode. Secondary (responding) station is in this example the controlling station

Function code no	Frame type	Service function
0	CONFIRM	ACK: Positive acknowledgement
1	CONFIRM	NACK: message not accepted, link busy
11	RESPOND	Status of link

5 Application layer telegram formats

5.1 Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. The marked functions and ASDUs in the interoperability list on the following pages represent the current requirements for an IEC 60870-5-101 system according to the Norwegian User Conventions. 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. This clause summarises 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 are crossed in the white boxes. Unmarked white boxes represent parameters that are currently not required. However, selections of such parameters can be agreed upon in specific projects. Black check boxes indicates that these options cannot be selected.

Note

- Full specification of a system may require individual selection of additional parameters. Recommended scaling factors for measured values and setpoint commands are described in section 7.8.

5.1.1 Network configuration

(network-specific parameter)

<input checked="" type="checkbox"/>	Point-to-point	<input checked="" type="checkbox"/>	Multi-point-party line
<input checked="" type="checkbox"/>	Multiple point to point	<input type="checkbox"/>	Multi-point-star
<input checked="" type="checkbox"/>	Redundant lines		

5.1.2 Physical layer

(network-specific parameter)

Transmission speed (control direction)

Unbalanced interchange
circuit V.24/V.28
Standard

<input checked="" type="checkbox"/>	100 bit/s
<input checked="" type="checkbox"/>	200 bit/s
<input checked="" type="checkbox"/>	300 bit/s
<input checked="" type="checkbox"/>	600 bit/s
<input checked="" type="checkbox"/>	1200 bit/s

Unbalanced interchange
circuit V.24/V.28
Recommended if > 1200 bit/s

<input checked="" type="checkbox"/>	2400 bit/s
<input checked="" type="checkbox"/>	4800 bit/s
<input checked="" type="checkbox"/>	9600 bit/s

Balanced interchange
circuit X.24/X.27

<input type="checkbox"/>	2400 bit/s	<input type="checkbox"/>	56000 bit/s
<input type="checkbox"/>	4800 bit/s	<input type="checkbox"/>	4000 bit/s
<input type="checkbox"/>	9600 bit/s		
<input type="checkbox"/>	19200 bit/s		
<input type="checkbox"/>	38400 bit/s		

Transmission speed (monitor direction)

Unbalanced interchange
circuit V.24/V.28
Standard

- ☒ 100 bit/s
- ☒ 200 bit/s
- ☒ 300 bit/s
- ☒ 600 bit/s
- ☒ 1200 bit/s

Unbalanced interchange
circuit V.24/V.28
Recommended if > 1200 bit/s

- ☒ 2400 bit/s
- ☒ 4800 bit/s
- ☒ 9600 bit/s

Balanced interchange
circuit X.24/X.27

- ☒ 2400 bit/s
- ☒ 4800 bit/s
- ☒ 9600 bit/s
- ☒ 19200 bit/s
- ☒ 38400 bit/s
- ☒ 56000 bit/s
- ☒ 64000 bit/s

5.1.3 Link layer

(network-specific parameter)

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
- ☒ All data in class 2

Frame length

- ☐ Maximum length L (number of octets)

Address field of the link

- ☒ not present (balanced transmission only)
- ☒ One octet
- ☒ Two octets
- ☒ Structured
- ☒ Unstructured

The maximum frame length can be selected per Controlled Station up to 255

5.1.4 Application layer

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(system-specific parameter)

- ☒ One octet
- ☒ Two octets (Option)

Information object address

(system-specific parameter)

- ☒ One octet
- ☒ Two octets
- ☒ Three octets
- ☒ structured
- ☒ unstructured

Cause of transmission

(system-specific parameter)

- ☒ One octet
- ☒ Two octets (with originator address)

Selection of standard ASDUs

Process information in monitor direction (station-specific parameter)

<input checked="" type="checkbox"/>	<1> := Single-point information	M_SP_NA_1
<input checked="" type="checkbox"/>	<2> := Single-point information with time tag	M_SP_TA_1
<input checked="" type="checkbox"/>	<3> := Double-point information	M_DP_TA_1
<input checked="" type="checkbox"/>	<4> := Double-point information with time tag	M_DP_TA_1
<input checked="" type="checkbox"/>	<5> := Step position information	M_ST_NA_1
<input checked="" type="checkbox"/>	<6> := Step position information with time tag	M_ST_TA_1
<input checked="" type="checkbox"/>	<7> := Bitstring of 32 bit	M_BO_NA_1
<input checked="" type="checkbox"/>	<8> := Bitstring of 32 bit with time tag	M_BO_TA_1
<input checked="" type="checkbox"/>	<9> := Measured value, normalised value	M_ME_NA_1
<input checked="" type="checkbox"/>	<10> := Measured value, normalised value with time tag	M_ME_TA_1
<input type="checkbox"/>	<11> := Measured value, scaled value	M_ME_NB_1
<input checked="" type="checkbox"/>	<12> := Measured value, scaled value with time tag	M_ME_TB_1
<input checked="" type="checkbox"/>	<13> := Measured value, short floating point value	M_ME_NC_1
<input checked="" type="checkbox"/>	<14> := Measured value, short floating point value with time tag	M_ME_TC_1
<input type="checkbox"/>	<15> := Integrated totals	M_IT_NA_1
<input checked="" type="checkbox"/>	<16> := Integrated totals with time tag	M_IT_TA_1
<input checked="" type="checkbox"/>	<17> := Event of protection equipment with time tag	M_EP_TA1
<input checked="" type="checkbox"/>	<18> := Packed start events of protection equipment with time tag	M_EP_TB1
<input checked="" type="checkbox"/>	<19> := Packed output circuit information of protection equipment with time tag	M_EP_TC_1
<input type="checkbox"/>	<20> := Packed single point information with time tag	M_PS_NA_1
<input type="checkbox"/>	<21> := Measured value, normalised value without quality descriptor	M_ME_ND_1
<input checked="" type="checkbox"/>	<30> := Single point information with time tag CP56Time2a	M_SP_TB_1
<input checked="" type="checkbox"/>	<31> := Double point information with time tag CP56Time2a	M_DP_TB_1
<input checked="" type="checkbox"/>	<32> := Step position information with time tag CP56Time2a	M_ST_TB_1
<input type="checkbox"/>	<33> := Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
<input checked="" type="checkbox"/>	<34> := Measured value, normalised value with time tag CP56Time2a	M_ME_TD_1
<input type="checkbox"/>	<35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
<input checked="" type="checkbox"/>	<36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
<input checked="" type="checkbox"/>	<37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
<input type="checkbox"/>	<38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
<input type="checkbox"/>	<39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
<input type="checkbox"/>	<40> := Packed tripping events of protection equipment with time tag CP56Time2a	M_EP_TF_1

Process information in control direction

(station-specific parameter)

<input checked="" type="checkbox"/> <45> := Single command	C_SC_NA_1
<input checked="" type="checkbox"/> <46> := Double command	C_DC_NA_1
<input checked="" type="checkbox"/> <47> := Regulating step command	C_RC_NA_1
<input checked="" type="checkbox"/> <48> := Set point command, normalised value	C_SE_NA_1
<input type="checkbox"/> <49> := Set point command, scaled value	C_SC_NB_1
<input type="checkbox"/> <50> := Set point command, short floating point value	C_SC_NC_1
<input checked="" type="checkbox"/> <51> := Bitstring of 32 bit	C_BO_NA_1

System information in monitor direction

(station-specific parameter)

<input checked="" type="checkbox"/> <70> := End of initialisation	M_EI_NA_1
---	-----------

System information in control direction

(station-specific parameter)

<input checked="" type="checkbox"/> <100> := Interrogation command	C_IC_NA_1
<input type="checkbox"/> <101> := Counter interrogation command	C_CI_NA_1
<input type="checkbox"/> <102> := Read command	C_RD_NA_1
<input checked="" type="checkbox"/> <103> := Clock synchronisation command	C_CS_NA_1
<input checked="" type="checkbox"/> <104> := Test command	C_TS_NB_1
<input checked="" type="checkbox"/> <105> := Reset process command	C_RP_NC_1
<input type="checkbox"/> <106> := Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter)

<input checked="" type="checkbox"/> <110> := Parameter of measured value, normalised value	P_ME_NA_1
<input type="checkbox"/> <111> := Parameter of measured value, scaled value	P_ME_NB_1
<input checked="" type="checkbox"/> <112> := Parameter of measured value, short floating point value	P_ME_NC_1

File Transfer

(station-specific parameter)

<input type="checkbox"/> <120> := File ready	F_FR_NA_1
<input type="checkbox"/> <121> := Section ready	F_SR_NA_1
<input type="checkbox"/> <122> := Call directory, select file, call file, call section	F_SC_NA_1
<input type="checkbox"/> <123> := Last section, last segment	F_LS_NA_1
<input type="checkbox"/> <124> := Ack file, ack section	F_AF_NA_1
<input type="checkbox"/> <125> := Segment	F_SG_NA_1
<input type="checkbox"/> <126> := Directory	F_DR_TA_1

5.1.5 Basic application functions

Station initialisation

(station-specific parameter)

☒ Remote initialisation

General interrogation

(system- or station-specific parameter)

☒ global

☐ group 1

☐ group 2

☐ group 3

☐ group 4

☐ group 5

☐ group 6

☐ group 7

☐ group 8

☐ group 9

☐ group 10

☐ group 11

☐ group 12

☐ group 13

☐ group 14

☐ group 15

☐ group 16

Addresses per group have to be defined

Clock synchronisation

(station-specific parameter)

☒ Clock synchronisation

Command transmission

(object-specific parameter)

☒ Direct single command transmission

☒ Direct double command transmission

☒ Direct regulation command transmission

☒ Direct set point command transmission

☒ No additional definition

☒ Short pulse duration (duration determined by a system parameter in the outstation)

☒ Long pulse duration (duration determined by a system parameter in the outstation)

☐ Persistent output

☒ Select and execute single command

☒ Select and execute double command

☐ Select and execute regulation command

☒ Select and execute set point command

☐ C_SE ACTTERM used

Transmission of integrated totals

(station- or object-specific parameter)

☐ Counter request

☒ 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

Addresses per group have to be defined

Parameter loading

(object-specific parameter)

- ☒ Threshold value
- ☒ Smoothing factor
- ☐ Low limit for transmission of measured value
- ☐ High limit for transmission of measured value

Parameter activation

(object-specific parameter)

- ☒ ~~Act/deact of persistent cyclic or periodic transmission of the addressed object~~

File transfer

(station-specific parameter)

- ☐ File transfer in monitor direction
- ☐ File transfer in control direction

5.2 Definition and presentation of the specific ASDUs

In the following all ASDUs for use in Norway by defined by this user convention.

The LPDUs of the link are defined in chapter 4. These definitions are not repeated in this section.

5.2.1 ASDUs for process information in monitor direction

5.2.1.1 Single-point information without time tag

TYPE IDENT 1: **M_SP_NA_1**

Sequence of information objects (SQ = 0)

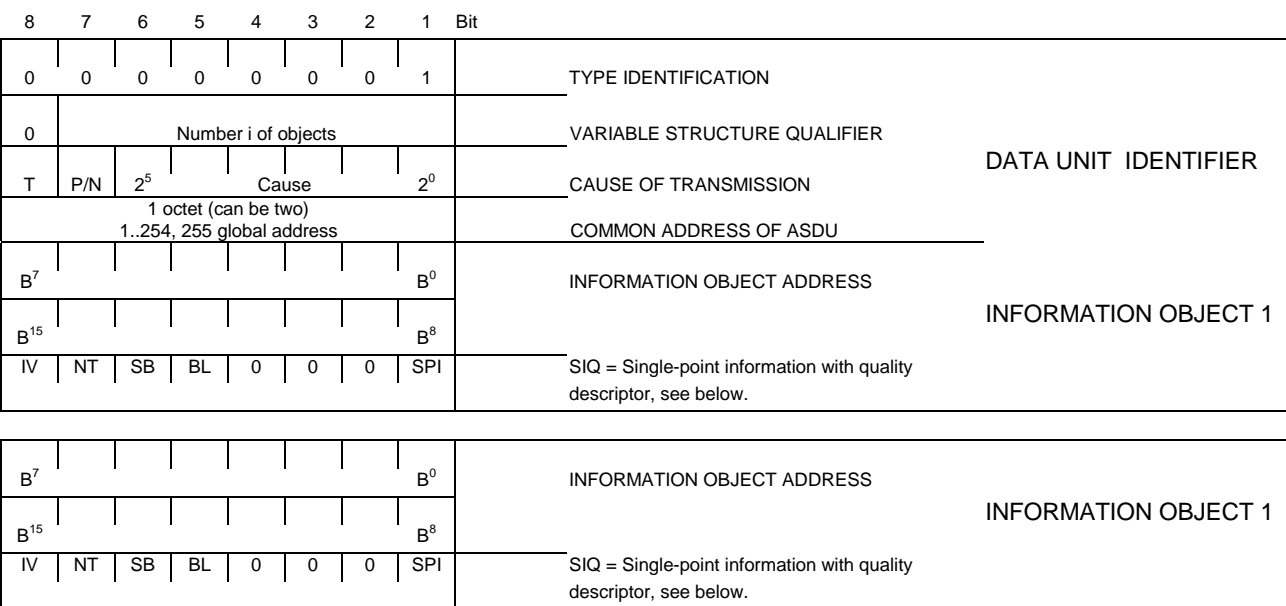


Figure 1 - ASDU: **M_SP_NA_1** Single-point information without time tag

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

CAUSES OF TRANSMISSION used with
TYPE IDENT 1 := M_SP_NA_1

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

CAUSE OF TRANSMISSION

<2>	:=	background scan (If Controlled stations has implemented cyclic transfer)
<3>	:=	spontaneous
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command
<20>	:=	interrogated by general interrogation

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

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

Quality descriptor

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

Sequence of information objects (SQ = 1)

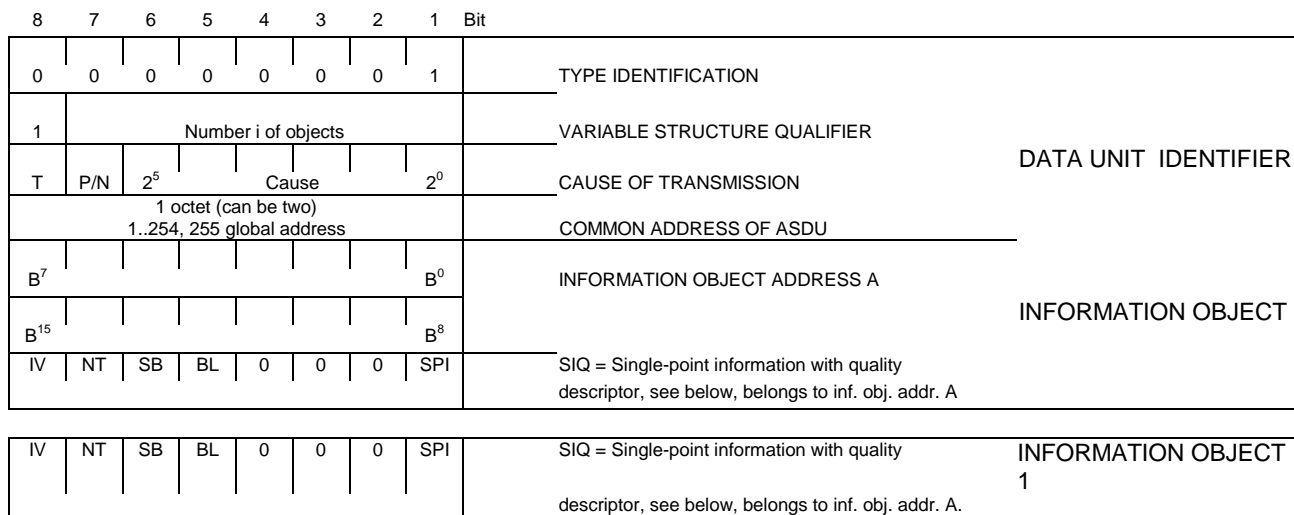


Figure 2 - ASDU: **M_SP_NA_1** Sequence of single-point information without time tag

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

CAUSES OF TRANSMISSION used with
TYPE IDENT 1 := M_SP_NA_1

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

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

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

Quality descriptor

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.2 Single-point information with time tag (not used)

TYPE IDENT 2: **M_SP_TA_1**

Sequence of information objects (SQ = 0)

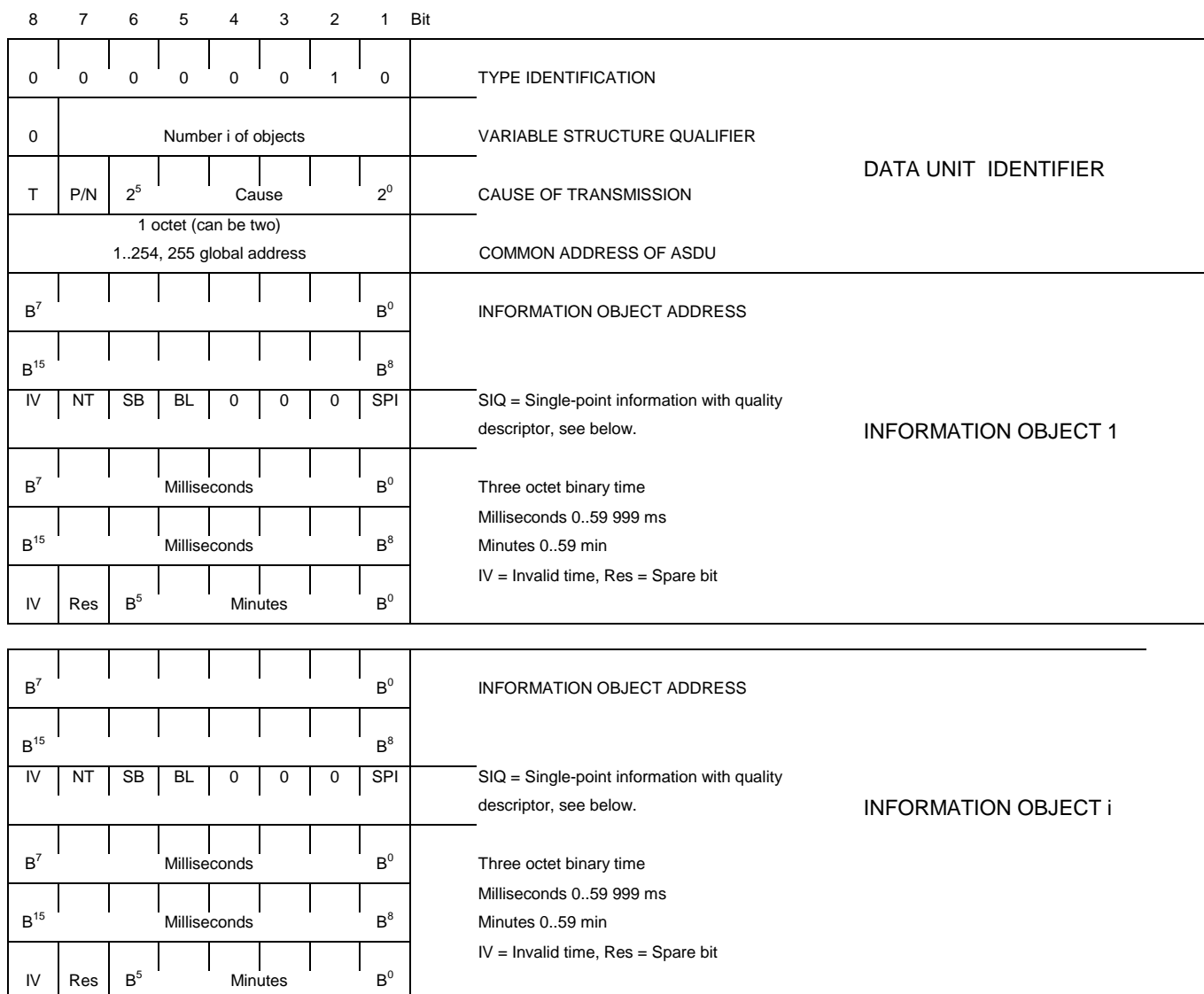


Figure 3 - ASDU: **M_SP_TA_1** Single-point information with time tag

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

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)

<3>	:=	spontaneous
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command
<20>	:=	interrogated by general interrogation

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

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

Quality descriptor

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.3 Double-point information without time tag

TYPE IDENT 3: **M_DP_NA_1**

Sequence of information objects (SQ = 0)

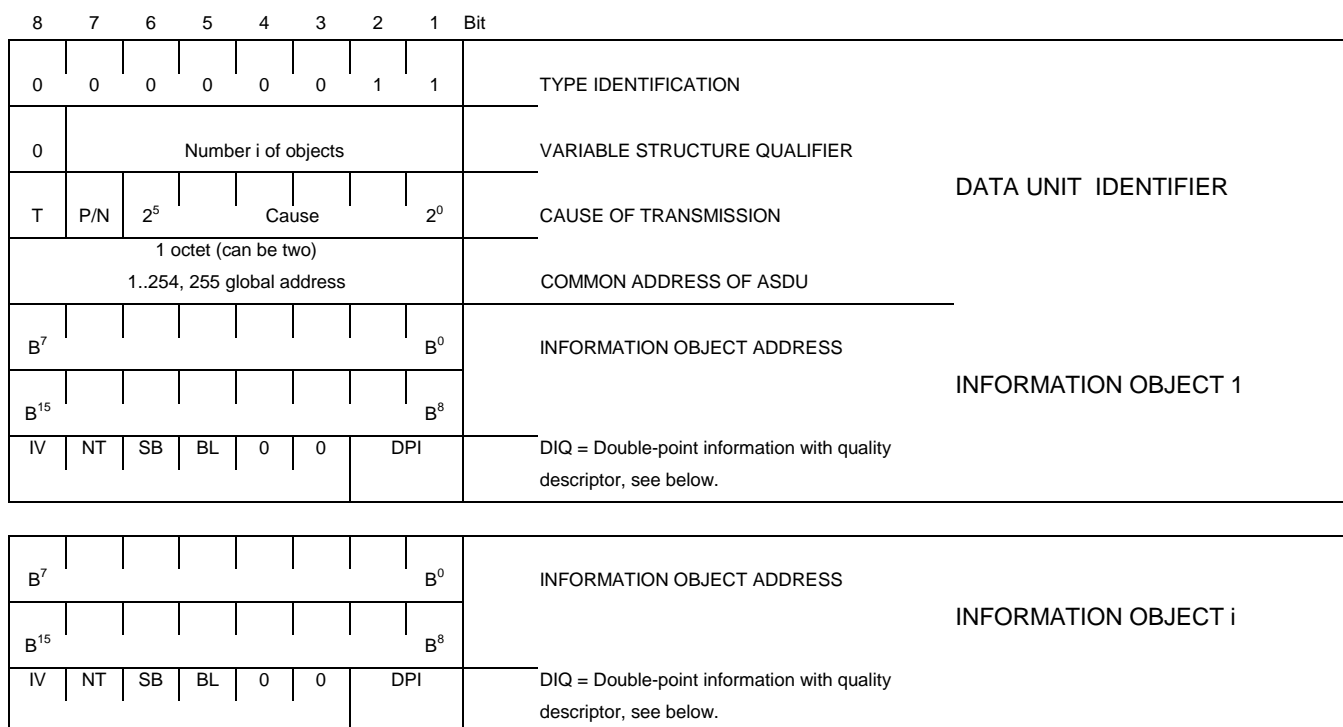


Figure 4 - ASDU: **M_DP_NA_1** Double-point information without time tag

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

CAUSES OF TRANSMISSION used with
TYPE IDENT 3 := M_DP_NA_1

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

CAUSE OF TRANSMISSION

<2> := background scan
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

DIQ := CP8{DPI, RES, BL, SB, NT, IV}
DPI := UI2[1..2]<0..3>
<0> := indeterminate or intermediate state
<1> := determined state OFF
<2> := determined state ON
<3> := indeterminate state

RES = RESERVE:=	BS2[3..4]<0>
BL	:= BS1[5]<0..1>
	<0> := not blocked
	<1> := blocked
SB	:= BS1[6]<0..1>
	<0> := not substituted
	<1> := substituted
NT	:= BS1[7]<0..1>
	<0> := topical
	<1> := not topical
IV	:= BS1[8]<0..1>
	<0> := valid
	<1> := invalid

Definition of quality descriptor (BL,SB,NT,IV) see below.

Quality descriptor (Separate octet)

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

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

Sequence of information objects (SQ = 1)

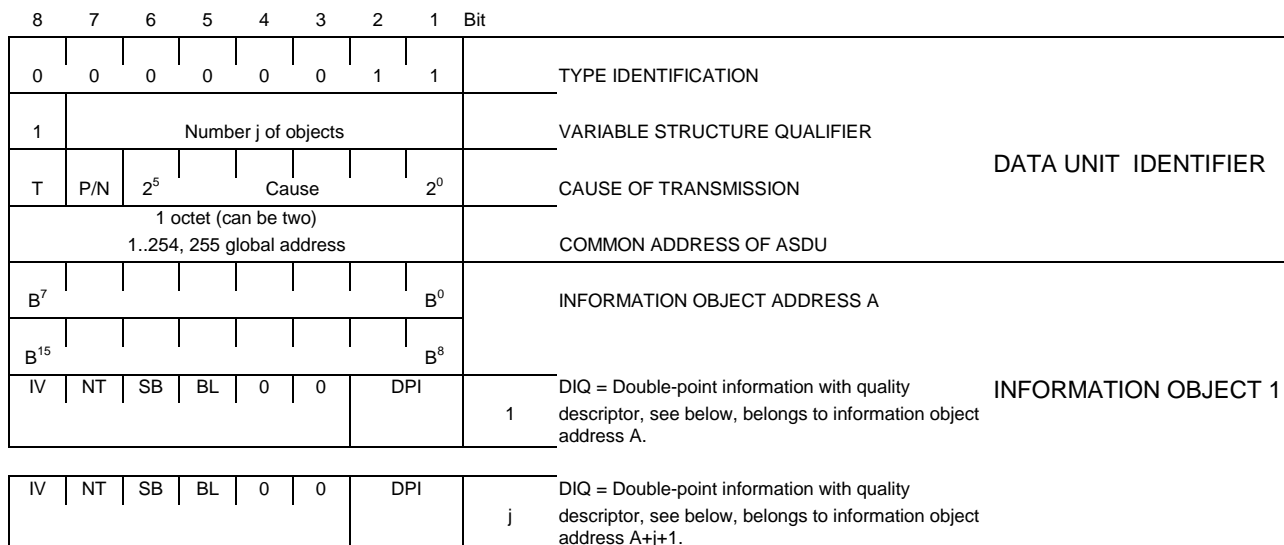


Figure 5 - ASDU: **M_DP_NA_1** Sequence of double-point information without time tag

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

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

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

Definition of quality descriptor (BL,SB,NT,IV) see below.

Quality descriptor (Separate octet)

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

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.4 Double-point information with time tag (not used)

TYPE IDENT 4: **M_DP_TA_1**

Sequence of information objects (SQ = 0)

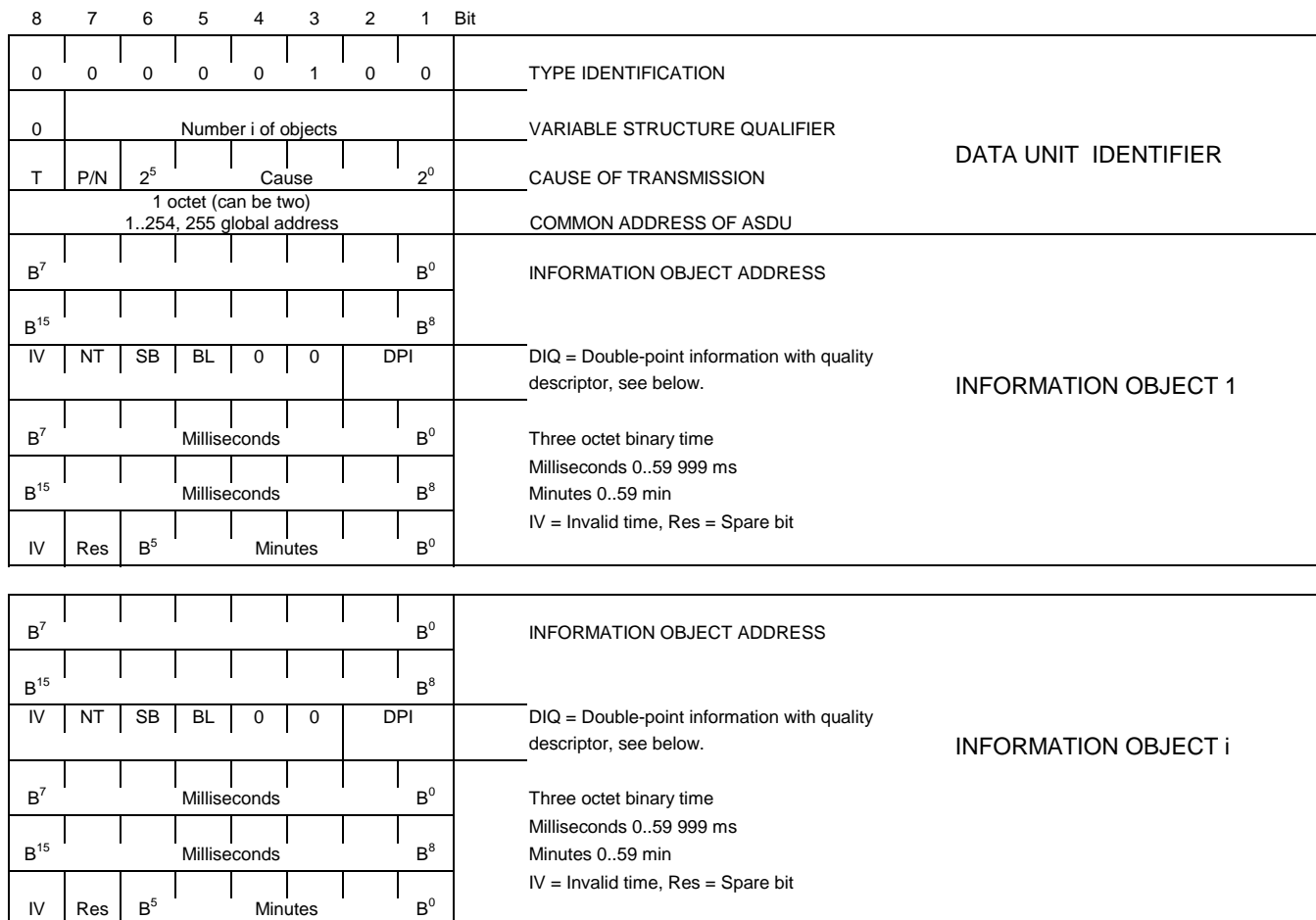


Figure 6 - ASDU: **M_DP_TA_1** Double-point information with time tag

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

T := Test

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

CAUSE OF TRANSMISSION

- <2> := background scan (If Controlled stations has implemented cyclic transfer)
- <3> := spontaneous
- <11> := return information caused by a remote command
- <12> := return information caused by a local command
- <20> := interrogated by general interrogation

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

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

Definition of quality descriptor (BL,SB,NT,IV) see below.

Quality descriptor (Separate octet)

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

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.5 Step position information

TYPE IDENT 5: M_ST_NA_1

Single information object (SQ = 0)

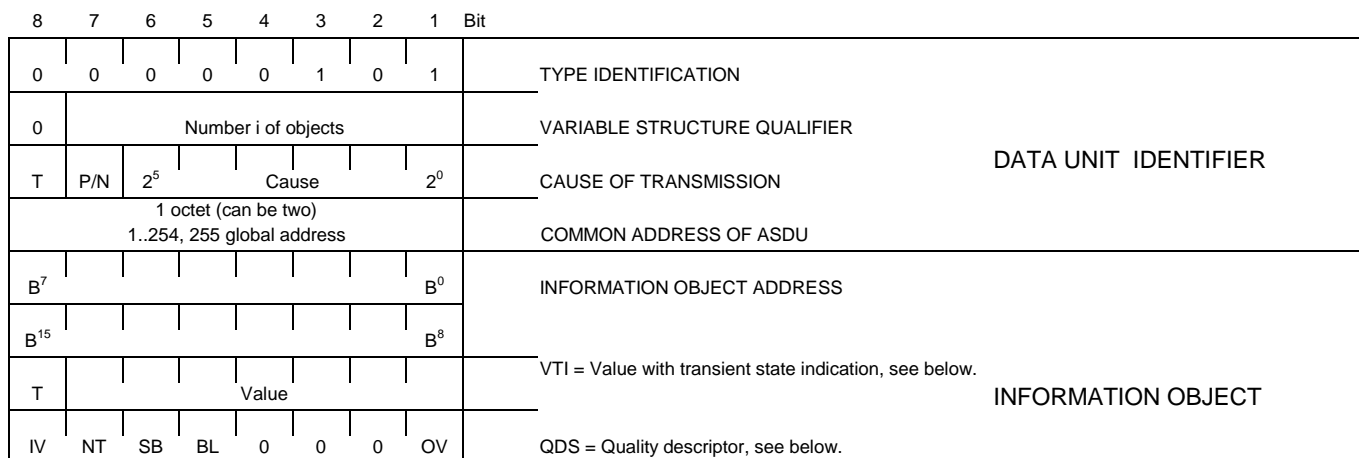


Figure 7 - ASDU: **M_ST_NA_1** Step position information

M_ST_NA_1 := CP{Data unit identifier, Information object address, VTI,QDS}

CAUSES OF TRANSMISSION used with
TYPE IDENT 5 := M_ST_NA_1

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

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

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

OV := OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.6 Bitstring of 32 bit

TYPE IDENT 7: **M_BO_NA_1**

Sequence of information objects (SQ = 0)

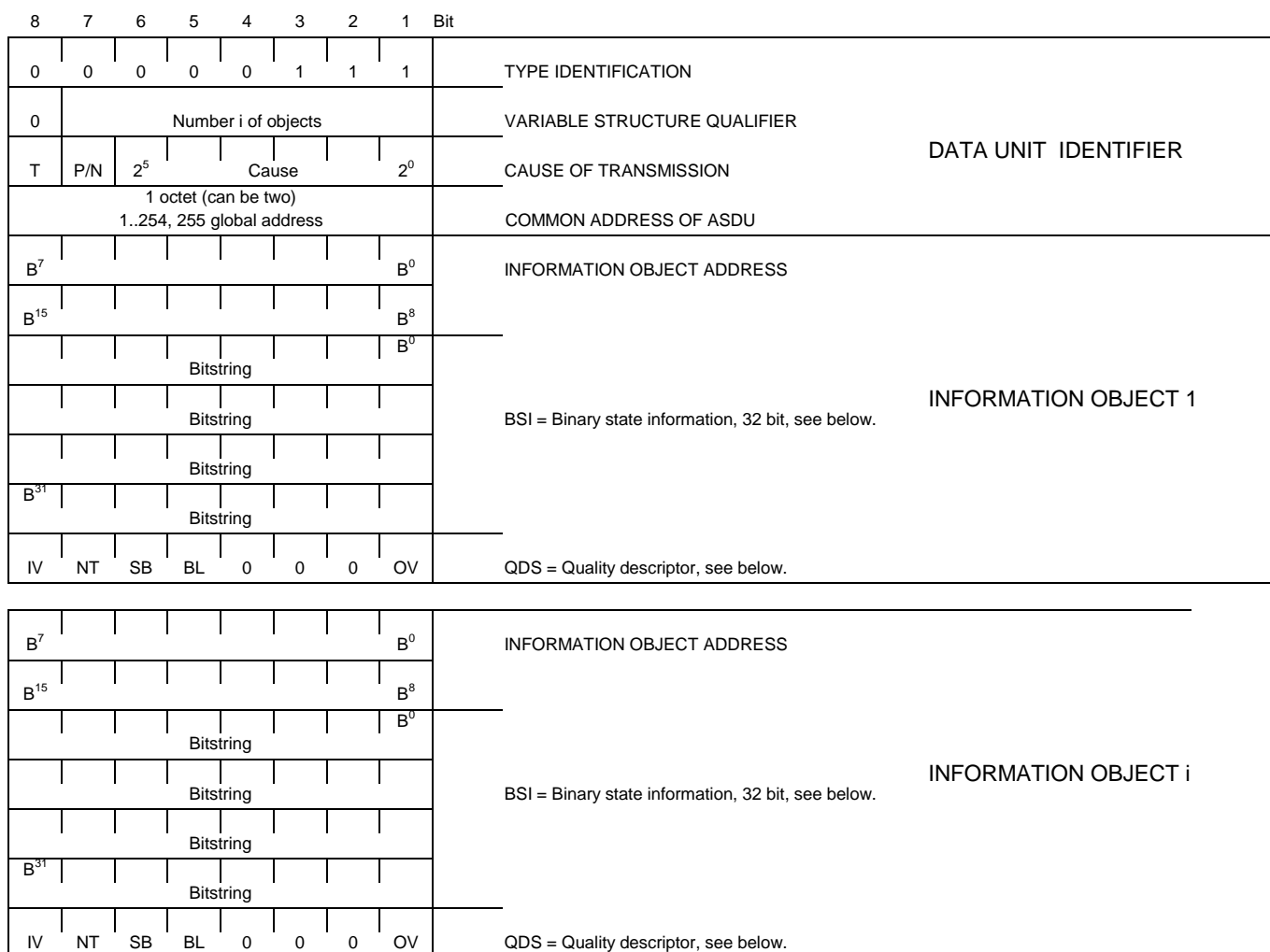


Figure 8 - ASDU: **M_BO_NA_1** Bitstring of 32 bit

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

CAUSES OF TRANSMISSION used with
TYPE IDENT 7 := M_BO_NA_1

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

BSI := 32BS1[1..32]<0..1>

Any of the bits can have any value. The content must be agreed upon by the end users.

QDS := CP8{OV,RES,BL,SB,NT,IV}

OV := BS1[1]<0..1>

<0> := no overflow

<1> := overflow

RES = RESERVE := BS3[2..4]<0>

BL := BS1[5]<0..1>

<0> := not blocked

<1> := blocked

SB := BS1[6]<0..1>

<0> := not substituted

<1> := substituted

NT := BS1[7]<0..1>

<0> := topical

<1> := not topical

IV := BS1[8]<0..1>

<0> := valid

<1> := invalid

OV := OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.7 Measured value, normalised value

TYPE IDENT 9: M_ME_NA_1

Sequence of information objects (SQ = 0)

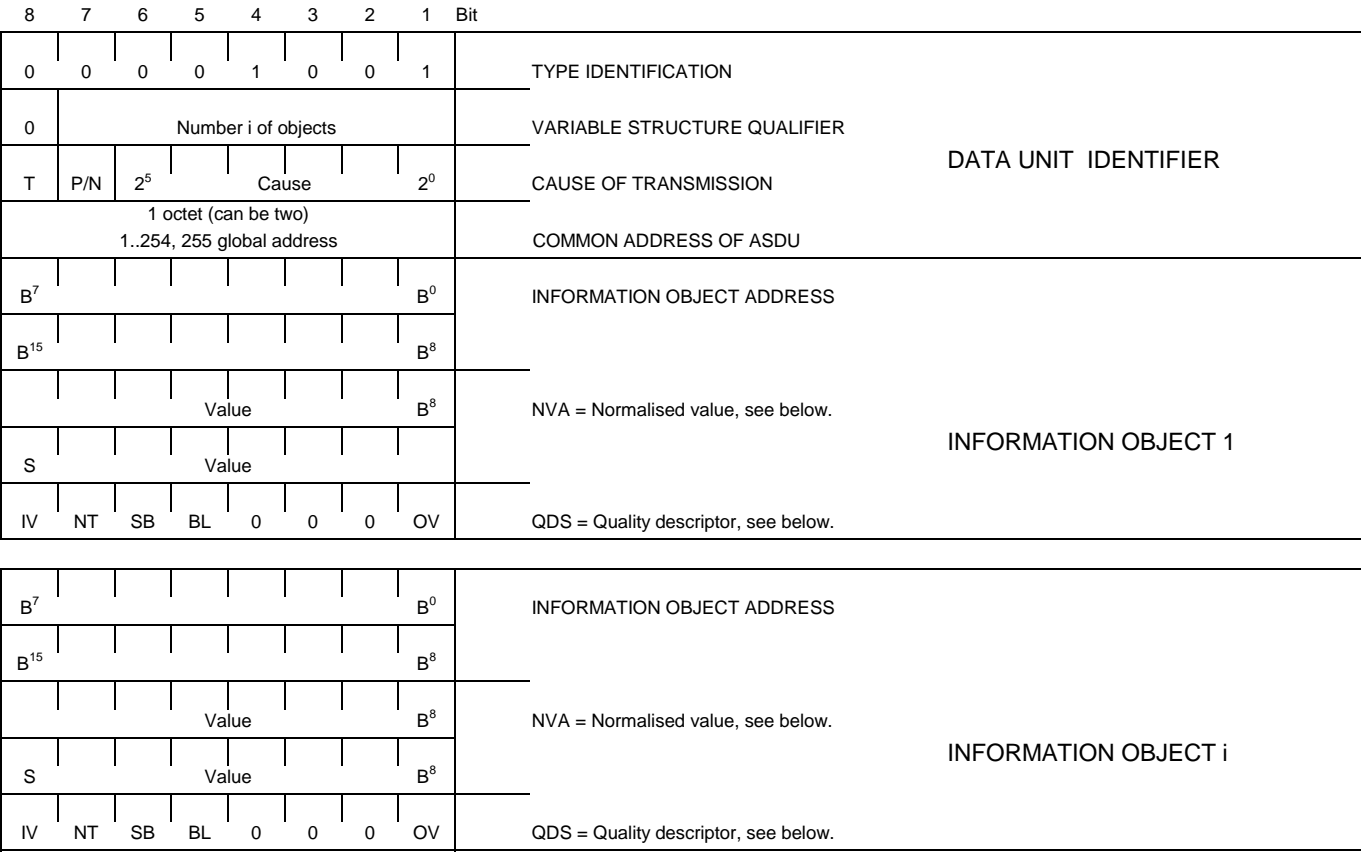


Figure 9 - ASDU: **M_ME_NA_1** Measured value, normalised value

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

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

CAUSE OF TRANSMISSION

<2>	:=	background scan (If Controlled stations has implemented cyclic transfer)
<3>	:=	spontaneous
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command
<20>	:=	interrogated by general interrogation

NVA := F16[1..16]<-1..+1-2⁻¹⁵>

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.

Negative numbers are presented in two's complement.

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

OV := OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

Sequence of information objects (SQ = 1)

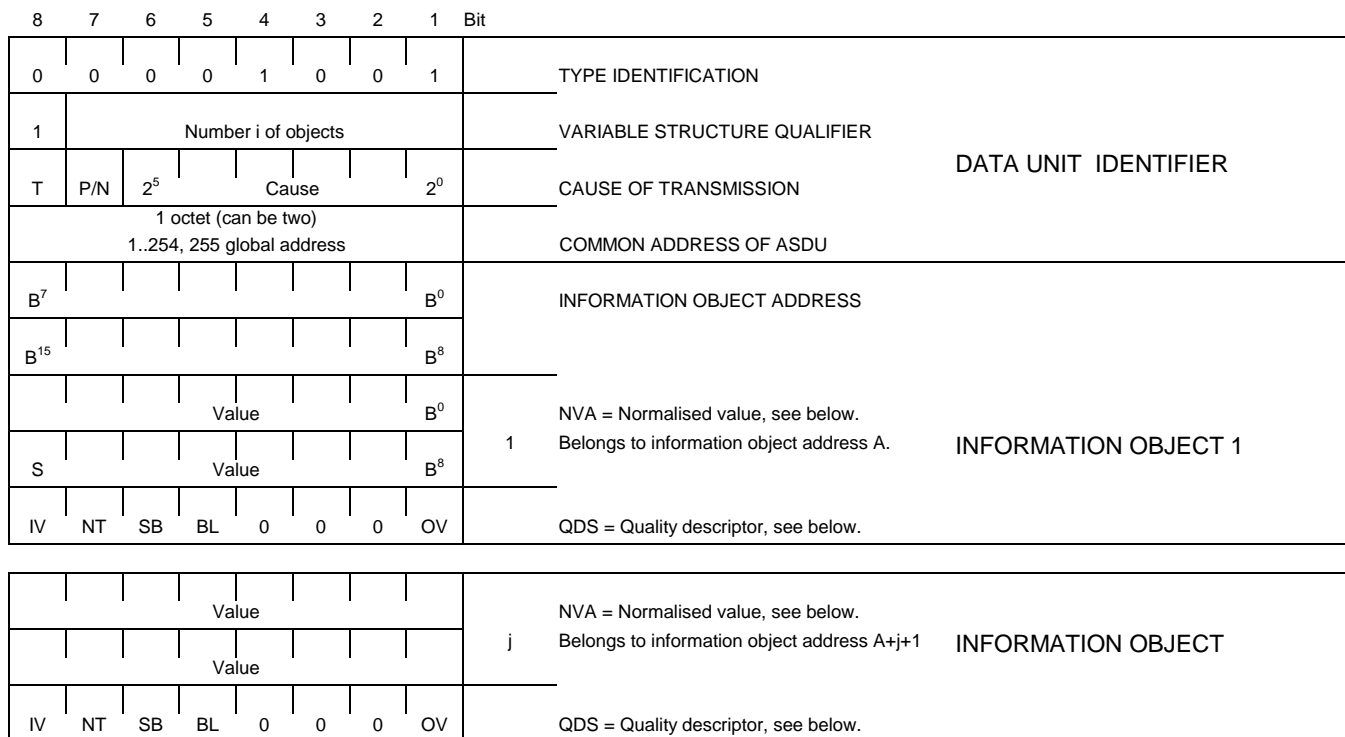


Figure 10 - ASDU: **M_ME_NA_1** Sequence of measured values, normalised values

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

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

NVA := F16[1..16]<-1..+1-2⁻¹⁵>

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.
Negative numbers are presented in two's complement.

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

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.8 Measured value, normalised value with time tag (not used)

TYPE IDENT 10: **M_ME_TA_1**

Sequence of information objects (SQ = 0)

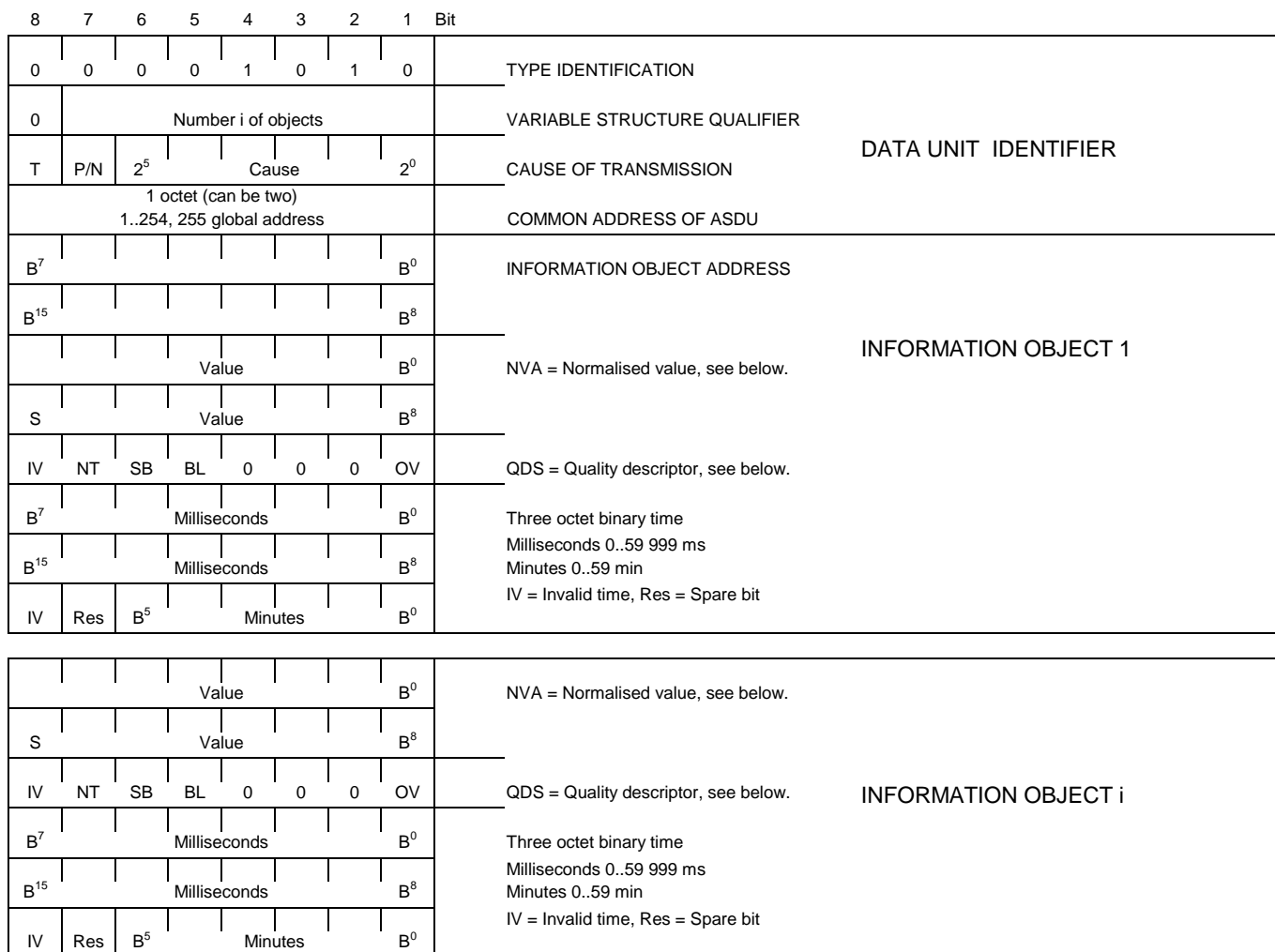


Figure 11 - ASDU: **M_ME_TA_1** Measured value, normalised value with time tag

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

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

CAUSE OF TRANSMISSION
<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

NVA := F16[1..16]<-1..+1-2⁻¹⁵>

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.
Negative numbers are presented in two's complement.

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

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.9 Measured value, short floating point number

TYPE IDENT 13: **M_ME_NC_1**

Sequence of information objects (SQ = 0)

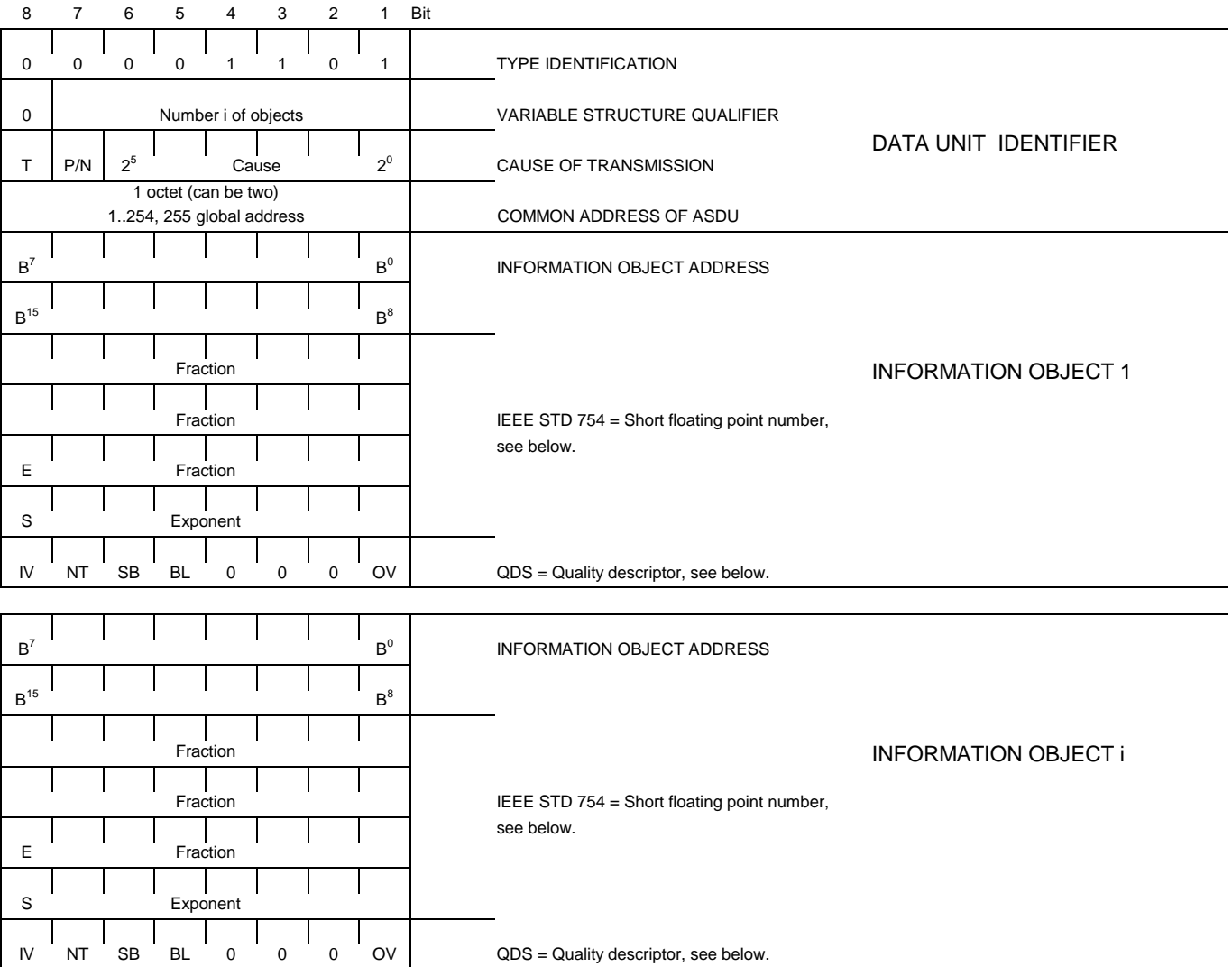


Figure 12 - ASDU: **M_ME_NC_1** Measured value, short floating point number

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

CAUSES OF TRANSMISSION used with

TYPE IDENT 13 := **M_ME_NC_1**

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

R32-IEEE STD 754 := R32.23{Fraction, Exponent, Sign}

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.

Floating point number	:=	R _{i,j} (Fraction, Exponent, Sign)	i = 32 = total size of floating point number
Fraction	:=	F := U _{ij} [1..j] <0..1-2 ^{-j} >	j = 23 = size of fraction
Exponent	:=	E := U _{ii-j-1} [j+1..i-1] <0..2 ^{i-j-1} >	i-j-1 = 7 = size of exponent
Sign	:=	S := BS1[i]	
		S <0> := positive	
		S <1> := negative	

QDS := CP8{OV, RES, BL, SB, NT, IV}

OV := BS1[1] <0..1>

<0> := no overflow

<1> := overflow

RES = RESERVE := BS3[2..4] <0>

BL := BS1[5] <0..1>

<0> := not blocked

<1> := blocked

SB := BS1[6] <0..1>

<0> := not substituted

<1> := substituted

NT := BS1[7] <0..1>

<0> := topical

<1> := not topical

IV := BS1[8] <0..1>

<0> := valid

<1> := invalid

OV := OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

Sequence of information elements (SQ = 1)

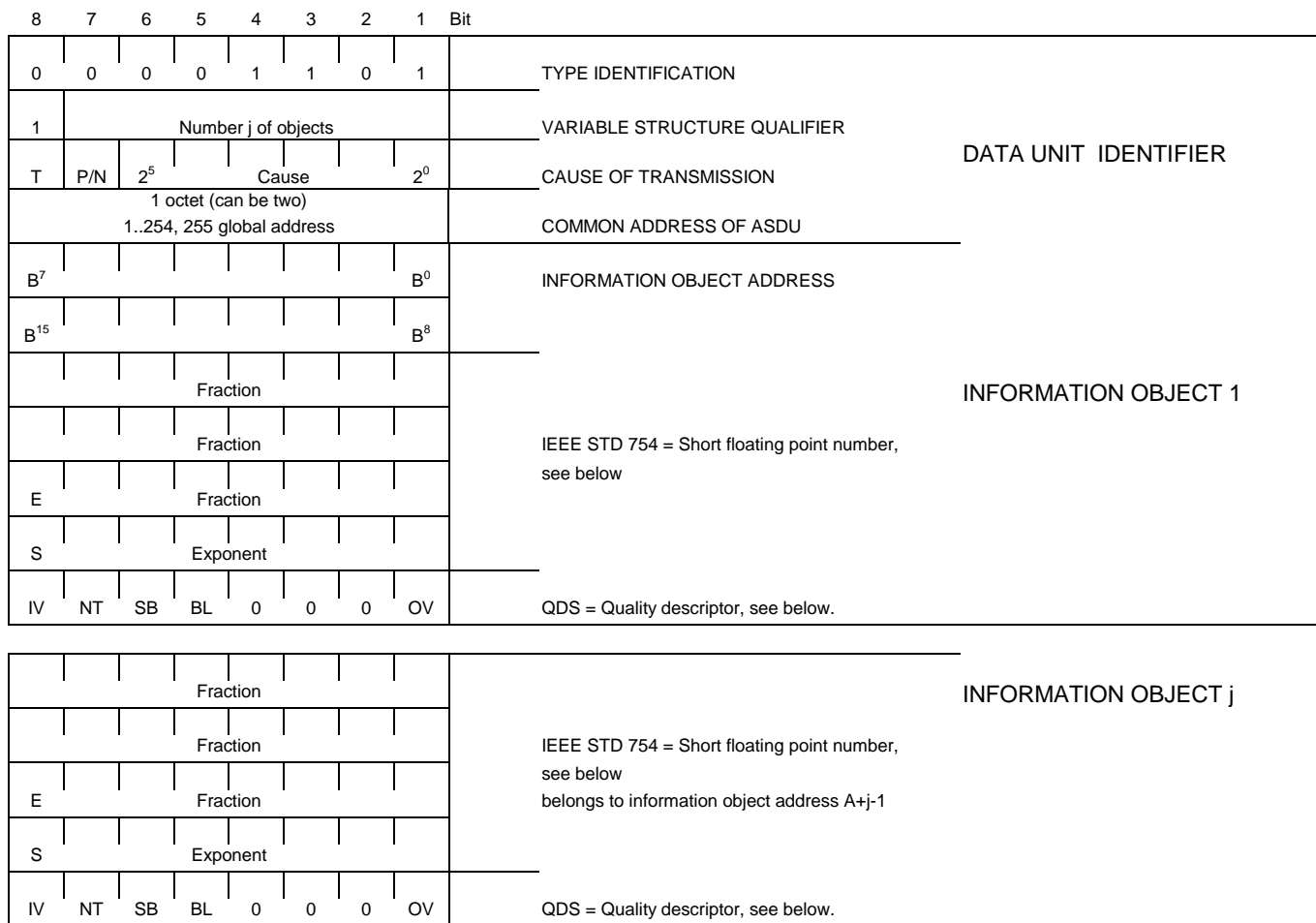


Figure 13 - ASDU: **M_ME_NC_1** Sequence of measured values, short floating point number

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

T := Test

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

CAUSE OF TRANSMISSION

<2>	:=	background scan (If Controlled stations has implemented cyclic transfer)
<3>	:=	spontaneous
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command
<20>	:=	interrogated by general interrogation

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.

Floating point number	:=	Ri,j (Fraction, Exponent, Sign)	i =32= total size of floating point number
Fraction	:=	F := Uij[1..j]<0..1-2 ^{-j} >	j =23= size of fraction
Exponent	:=	E := Uii-j-1[j+1..i-1]<0..2 ^{i-j-1} >	i-j-1 =7= size of exponent
Sign	:=	S := BS1[i]	
		S<0> := positive	
		S<1> := negative	

Quality descriptor:

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

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

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 e.g. by a local lock or a local automatic cause.

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

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 it is unavailable.

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.10 Integrated totals with time tag (not used)

TYPE IDENT 16: M_IT_TA_1

Sequence of information objects (SQ = 0)

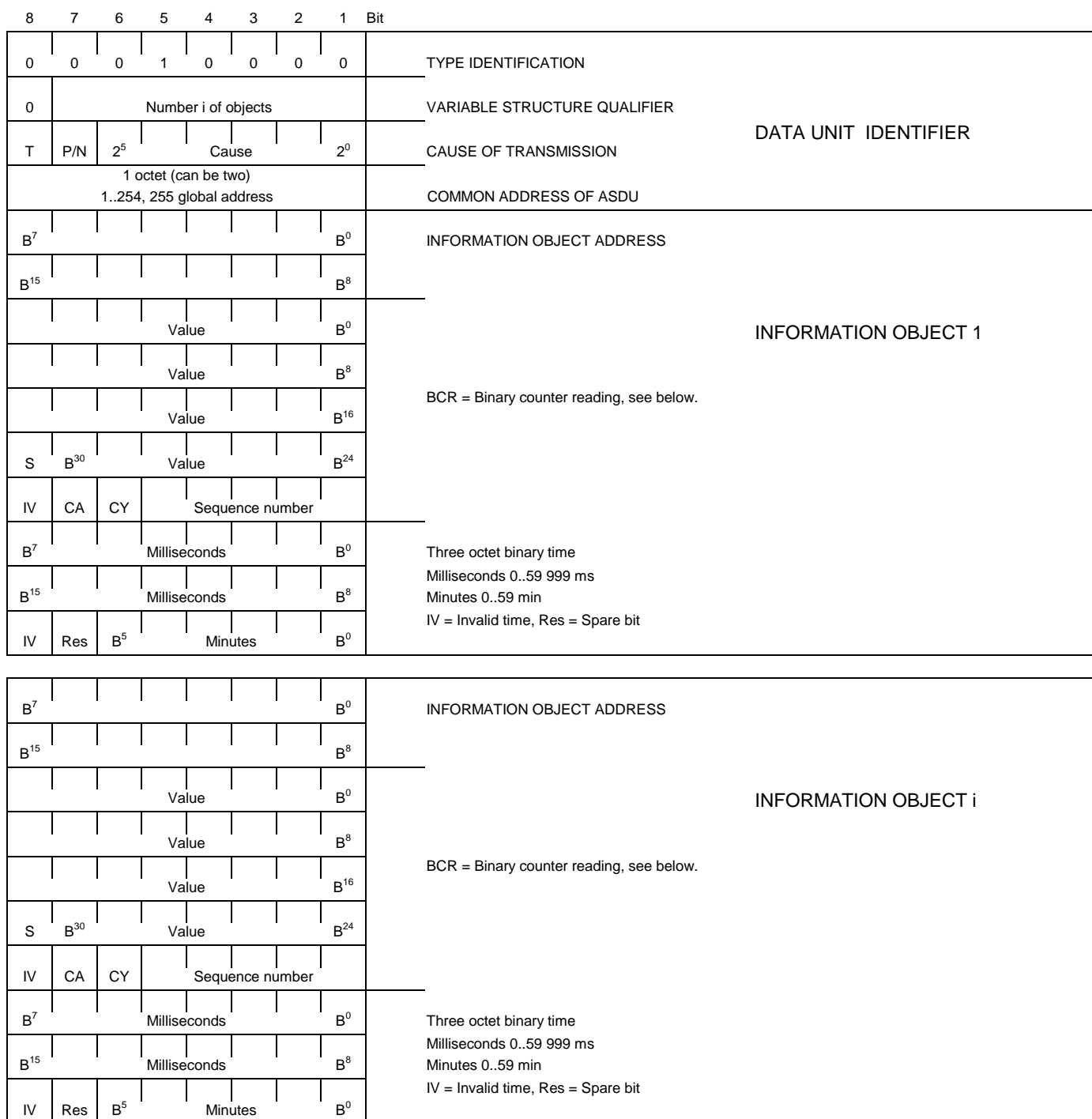


Figure 14 - ASDU: M_IT_TA_1 Integrated totals with time tag

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

BCR	:=	CP40{Counter reading, Sequence notation}
Counter reading	:=	I32[1..32]<-2 ³¹ ..+2 ³¹ -1> Value represented as 32 bit 2' complement
Sequence notation	:=	CP8{SQ,CY,CA,IV}
SQ	:=	UI5[33..37]<0..31>
CY	:=	BS1[38]
	<0>	:= no counter overflow occurred in the corresponding integration period
	<1>	:= counter overflow occurred in the corresponding integration period
CA	:=	BS1[39]
	<0>	:= Counter was not adjusted since last reading
	<1>	:= Counter was adjusted since last reading
IV	:=	BS1[40]
	<0>	:= Counter reading is valid
	<1>	:= Counter reading is invalid
SQ	= sequence number	
CY	= carry	
CA	= counter was adjusted	
IV	= invalid	

5.2.1.11 Single-point information with time tag CP56Time2a

TYPE IDENT 30: **M_SP_TB_1**

Sequence of information objects (SQ = 0)

8	7	6	5	4	3	2	1	Bit		
0	0	0	1	1	1	1	0	TYPE IDENTIFICATION		
0	Number i of objects							VARIABLE STRUCTURE QUALIFIER		
T	P/N	2 ⁵	Cause				2 ⁰	CAUSE OF TRANSMISSION		
1 octet (can be two) 1..254, 255 global address								COMMON ADDRESS OF ASDU		
B ⁷								B ⁰	INFORMATION OBJECT ADDRESS	
B ¹⁵								B ⁸		
IV	NT	SB	BL	0	0	0		SPI	SIQ = Single-point information with quality descriptor, see below.	
B ⁷			Milliseconds					B ⁰	Milliseconds 0..59 999 ms	
B ¹⁵			Milliseconds					B ⁸		
IV	Res1	B ⁵	Minutes					B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min	
SU	Res2		B ⁴	Hours				B ⁰	Hours 0..23 h	
B ²	B ⁰		Day of week		B ⁴	Day of month		B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)	
Res3				B ³	Months			B ⁰	Months 1..12	
Res4	B ⁶	Years						B ⁰	Years 0..99	

B ⁷								B ⁰	INFORMATION OBJECT ADDRESS	
B ¹⁵								B ⁸		
IV	NT	SB	BL	0	0	0		SPI	SIQ = Single-point information with quality descriptor, see below.	
B ⁷			Milliseconds					B ⁰	Milliseconds 0..59 999 ms	
B ¹⁵			Milliseconds					B ⁸		
IV	Res1	B ⁵	Minutes					B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min	
SU	Res2		B ⁴	Hours				B ⁰	Hours 0..23 h	
B ²	B ⁰		Day of week		B ⁴	Day of month		B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)	
Res3				B ³	Months			B ⁰	Months 1..12	
Res4	B ⁶	Years						B ⁰	Years 0..99	

Figure 15 - 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

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 30:= M_SP_TB_1

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

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

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

Quality descriptor

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.12 Double-point information with time tag CP56Time2a

TYPE IDENT 31: **M_DP_TB_1**

Sequence of information objects (SQ = 0)

8	7	6	5	4	3	2	1	Bit		
0	0	0	1	1	1	1	1		TYPE IDENTIFICATION	DATA UNIT IDENTIFIER
0	Number i of objects								VARIABLE STRUCTURE QUALIFIER	
T	P/N	2 ⁵	Cause				2 ⁰	CAUSE OF TRANSMISSION		
1 octet (can be two) 1..254, 255 global address								COMMON ADDRESS OF ASDU		
B ⁷								B ⁰	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT 1
B ¹⁵								B ⁸		
IV	NT	SB	BL	0	0	DPI			DIQ = Double-point information with quality descriptor, see below.	
B ⁷			Milliseconds				B ⁰	Milliseconds 0..59 999 ms		
B ¹⁵			Milliseconds				B ⁸			
IV	Res1	B ⁵	Minutes				B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min		
SU	Res2		B ⁴	Hours			B ⁰	Hours 0..23 h		
B ²	Day of week		B ⁰	B ⁴	Day of month			B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)	
Res3				B ³	Months		B ⁰	Months 1..12		
Res4	B ⁶	Years				B ⁰		Years 0..99		

B ⁷								B ⁰	INFORMATION OBJECT ADDRESS	INFORMATION OBJECT i
B ¹⁵								B ⁸		
IV	NT	SB	BL	0	0	DPI			DIQ = Double-point information with quality descriptor, see below.	
B ⁷			Milliseconds				B ⁰	Milliseconds 0..59 999 ms		
B ¹⁵			Milliseconds				B ⁸			
IV	Res1	B ⁵	Minutes				B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min		
SU	Res2		B ⁴	Hours			B ⁰	Hours 0..23 h		
B ²	Day of week		B ⁰	B ⁴	Day of month			B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)	
Res3				B ³	Months		B ⁰	Months 1..12		
Res4	B ⁶	Years				B ⁰		Years 0..99		

Figure 16 - 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**

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

CAUSE OF TRANSMISSION

<2>	:=	background scan (If Controlled stations has implemented cyclic transfer)
<3>	:=	spontaneous
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command
<20>	:=	interrogated by general interrogation

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

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

Definition of quality descriptor (BL,SB,NT,IV) see below.

Quality descriptor (Separate octet)

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

OV = OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.13 Step position information with time tag CP56Time2a

TYPE IDENT 32: **M_ST_TB_1**

Single information object (SQ = 0)

8	7	6	5	4	3	2	1	Bit		
0	0	1	0	0	0	0	0		TYPE IDENTIFICATION	DATA UNIT IDENTIFIER
0	Number i of objects								VARIABLE STRUCTURE QUALIFIER	
T	P/N	2 ⁵	Cause				2 ⁰	CAUSE OF TRANSMISSION		
1 octet (can be two) 1..254, 255 global address									COMMON ADDRESS OF ASDU	
B ⁷							B ⁰	INFORMATION OBJECT ADDRESS		
B ¹⁵							B ⁸			
T	Value								VTI = Value with transient state indication, see below.	INFORMATION OBJECT
IV	NT	SB	BL	0	0	0	OV	QDS = Quality descriptor, see below.		
B ⁷			Milliseconds				B ⁰	Milliseconds 0..59 999 ms		
B ¹⁵			Milliseconds				B ⁸			
IV	Res1	B ⁵	Minutes				B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min		
SU	Res2		B ⁴	Hours			B ⁰	Hours 0..23 h		
B ²	B ⁰		B ⁴	Day of month			B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)		
Res3				B ³	Months		B ⁰	Months 1..12		
Res4	B ⁶	Years			B ⁰			Years 0..99		

Figure 17 - ASDU: **M_ST_TB_1** Step position information with time tag CP56Time2a

M_ST_TB_1 := CP{Data unit identifier, Information object address, VTI,QDS,CP56Time2a}

CAUSES OF TRANSMISSION used with
TYPE IDENT 32:= M_ST_TB_1

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

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

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

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.14 Measured value, normalised value with time tag CP56Time2a

TYPE IDENT 34: **M_ME_TD_1**

Sequence of information objects (SQ = 0)

8	7	6	5	4	3	2	1	Bit		
0	0	1	0	0	0	1	0		TYPE IDENTIFICATION	
0	Number i of objects								VARIABLE STRUCTURE QUALIFIER	DATA UNIT IDENTIFIER
T	P/N	2 ⁵		Cause			2 ⁰	CAUSE OF TRANSMISSION		
1 octet (can be two) 1..254, 255 global address								COMMON ADDRESS OF ASDU		
B ⁷							B ⁰	INFORMATION OBJECT ADDRESS		
B ¹⁵							B ⁸			
Value									B ⁰	INFORMATION OBJECT 1
S	Value								B ⁸	
IV	NT	SB	BL	0	0	0	OV	QDS = Quality descriptor, see below.		
B ⁷			Milliseconds				B ⁰	Milliseconds 0..59 999 ms		
B ¹⁵			Milliseconds				B ⁸			
IV	Res1	B ⁵	Minutes				B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min		
SU	Res2		B ⁴	Hours			B ⁰	Hours 0..23 h		
B ²		B ⁰		Day of month			B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)		
Day of week			B ⁴	Day of month			B ⁰			
Res3				B ³	Months		B ⁰	Months 1..12		
Res4	B ⁶		Years				B ⁰	Years 0..99		

								B ⁰	NVA = Normalised value, see below.	
S								B ⁸		
IV	NT	SB	BL	0	0	0	OV	QDS = Quality descriptor, see below.	INFORMATION OBJECT i	
B ⁷			Milliseconds				B ⁰	Milliseconds 0..59 999 ms		
B ¹⁵			Milliseconds				B ⁸			
IV	Res1	B ⁵	Minutes				B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min		
SU	Res2		B ⁴	Hours			B ⁰	Hours 0..23 h		
B ²		B ⁰		Day of month			B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)		
Day of week			B ⁴	Day of month			B ⁰			
Res3				B ³	Months		B ⁰	Months 1..12		
Res4	B ⁶		Years				B ⁰	Years 0..99		

Figure 18 - ASDU: **M_ME_TD_1** Measured value, normalised 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

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

CAUSE OF TRANSMISSION

<2> := background scan (If Controlled stations has implemented cyclic transfer)
<3> := spontaneous
<11> := return information caused by a remote command
<12> := return information caused by a local command
<20> := interrogated by general interrogation

NVA := F16[1..16]<-1..+1-2⁻¹⁵>

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.
Negative numbers are presented in two's complement.

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

OV := OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.15 Measured value, short floating point number with time tag CP56Time2a

TYPE IDENT 36: **M_ME_TF_1**

Sequence of information objects (SQ = 0)

8	7	6	5	4	3	2	1	Bit	
0	0	1	0	0	1	0	0		TYPE IDENTIFICATION
0	Number i of objects								VARIABLE STRUCTURE QUALIFIER
T	P/N	Cause					2 ⁰		CAUSE OF TRANSMISSION
1 octet (can be two) 1..254, 255 global address									COMMON ADDRESS OF ASDU
B ⁷								B ⁰	INFORMATION OBJECT ADDRESS
B ¹⁵								B ⁸	
Fraction									IEEE STD 754 = Short floating point number, see below.
Fraction									
E	Fraction								
S	Exponent								
IV	NT	SB	BL	0	0	0	0	OV	QDS = Quality descriptor, see below.
B ⁷			Milliseconds					B ⁰	Milliseconds 0..59 999 ms
B ¹⁵			Milliseconds					B ⁸	
IV	Res1	B ⁵	Minutes					B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min
SU	Res2		B ⁴	Hours				B ⁰	Hours 0..23 h
B ²	B ⁰		B ⁴	Day of month				B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)
Res3			B ³	Months				B ⁰	Months 1..12
Res4	B ⁶	Years					B ⁰	Years 0..99	

B ⁷								B ⁰	INFORMATION OBJECT ADDRESS
B ¹⁵								B ⁸	
Fraction									IEEE STD 754 = Short floating point number, see below.
Fraction									
E	Fraction								
S	Exponent								
IV	NT	SB	BL	0	0	0	0	OV	QDS = Quality descriptor, see below.
B ⁷			Milliseconds					B ⁰	Milliseconds 0..59 999 ms
B ¹⁵			Milliseconds					B ⁸	
IV	Res1	B ⁵	Minutes					B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min
SU	Res2		B ⁴	Hours				B ⁰	Hours 0..23 h
B ²	B ⁰		B ⁴	Day of month				B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)
Res3			B ³	Months				B ⁰	Months 1..12
Res4	B ⁶	Years					B ⁰	Years 0..99	

Figure 19 - 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

<2>	:=	background scan (If Controlled stations has implemented cyclic transfer)
<3>	:=	spontaneous
<11>	:=	return information caused by a remote command
<12>	:=	return information caused by a local command
<20>	:=	interrogated by general interrogation

R32-IEEE STD 754 := R32.23{Fraction,Exponent,Sign}

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.

Floating point number	:=	Ri.j (Fraction, Exponent, Sign)	i = total size of floating point number
Fraction	:=	F := Uij[1..j]<0..1-2 ^{-j} >	j = size of fraction
Exponent	:=	E := Uii-j-1[j+1..i-1]<0..2 ^{i-j-1} >	i-j-1 = size of exponent
Sign	:=	S := BS1[i]	
		S<0> := positive	
		S<1> := negative	

$$\mathbf{QDS} := \text{CP8}\{\text{OV}, \text{RES}, \text{BL}, \text{SB}, \text{NT}, \text{IV}\}$$
$$OV := BS1[1] \langle 0..1 \rangle$$

$\langle 0 \rangle$:=	no overflow
---------------------	----	-------------

```
<1>      :=      overflow
```

RES = RESERVE:= BS3[2..4]<0>

```
BL := BS1[5]<0..1>
```

<0> := not blocked

```
<1>      :=      blocked
```

$$SB \quad := \quad BS1[6]<0..1>$$

<0> := not substituted

$$\langle 1 \rangle := \text{substituted}$$
$$NT := BS1[7] \langle 0..1 \rangle$$

$\langle 0 \rangle := \text{topical}$

<1>	:=	not topical
-----	----	-------------

$$\text{IV} \quad := \quad \text{BS1}[8] < 0..1 >$$

$\langle 0 \rangle$:= valid

<1> := invalid

OV := OVERFLOW/NO OVERFLOW

The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue 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 e.g. by a local lock or a local automatic cause.

SB = SUBSTITUTED/NOT SUBSTITUTED

The value of the INFORMATION OBJECT is provided by 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 it is unavailable.

IV = INVALID/VALID

A value is valid if it was correctly acquired. After the acquisition function recognises 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.

5.2.1.16 Integrated totals with time tag CP56Time2a

TYPE IDENT 37: M_IT_TB_1

Sequence of information objects (SQ = 0)

8	7	6	5	4	3	2	1	Bit		
0	0	1	0	0	1	0	1		TYPE IDENTIFICATION	
0	Number i of objects								VARIABLE STRUCTURE QUALIFIER	
T	P/N	2 ⁵		Cause			2 ⁰		CAUSE OF TRANSMISSION	DATA UNIT IDENTIFIER
1 octet (can be two) 1..254, 255 global address									COMMON ADDRESS OF ASDU	
B ⁷								B ⁰	INFORMATION OBJECT ADDRESS	
B ¹⁵								B ⁸		
Value								B ⁰		INFORMATION OBJECT 1
Value								B ⁸		
Value								B ¹⁶		
S	B ³⁰	Value					B ²⁴			
IV	CA	CY	Sequence number							
B ⁷			Milliseconds					B ⁰	Milliseconds 0..59 999 ms	
B ¹⁵			Milliseconds					B ⁸		
IV	Res1	B ⁵	Minutes					B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min	
SU	Res2		B ⁴	Hours				B ⁰	Hours 0..23 h	
B ²		B ⁰	B ⁴	Day of month				B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)	
Res3				B ³	Months			B ⁰	Months 1..12	
Res4	B ⁶		Years					B ⁰	Years 0..99	

B ⁷								B ⁰	INFORMATION OBJECT ADDRESS	
B ¹⁵								B ⁸		
Value								B ⁰		INFORMATION OBJECT i
Value								B ⁸		
Value								B ¹⁶		
S	B ³⁰	Value					B ²⁴			
IV	CA	CY	Sequence number							
B ⁷			Milliseconds					B ⁰	Milliseconds 0..59 999 ms	
B ¹⁵			Milliseconds					B ⁸		
IV	Res1	B ⁵	Minutes					B ⁰	IV = Invalid time, Res = Spare bit Minutes 0..59 min	
SU	Res2		B ⁴	Hours				B ⁰	Hours 0..23 h	
B ²		B ⁰	B ⁴	Day of month				B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)	
Res3				B ³	Months			B ⁰	Months 1..12	
Res4	B ⁶		Years					B ⁰	Years 0..99	

Figure 20 - 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

BCR := CP40{Counter reading, Sequence notation}

Counter reading := I32[1..32]<-2³¹..+2³¹-1> Value represented as 32 bit 2 complement.

Sequence notation := CP8{SQ,CY,CA,IV}

SQ := UI5[33..37]<0..31>

CY := BS1[38]

<0> := no counter overflow occurred in the corresponding integration period

<1> := counter overflow occurred in the corresponding integration period

CA := BS1[39]

<0> := Counter was not adjusted since last reading

<1> := Counter was adjusted since last reading

IV := BS1[40]

<0> := Counter reading is valid

<1> := Counter reading is invalid

SQ = sequence number

CY = carry

CA = counter was adjusted

IV = invalid

5.2.2 ASDUs for process information in control direction

5.2.2.1 Single command

TYPE IDENT 45: **C_SC_NA_1**

Single information object (SQ = 0)

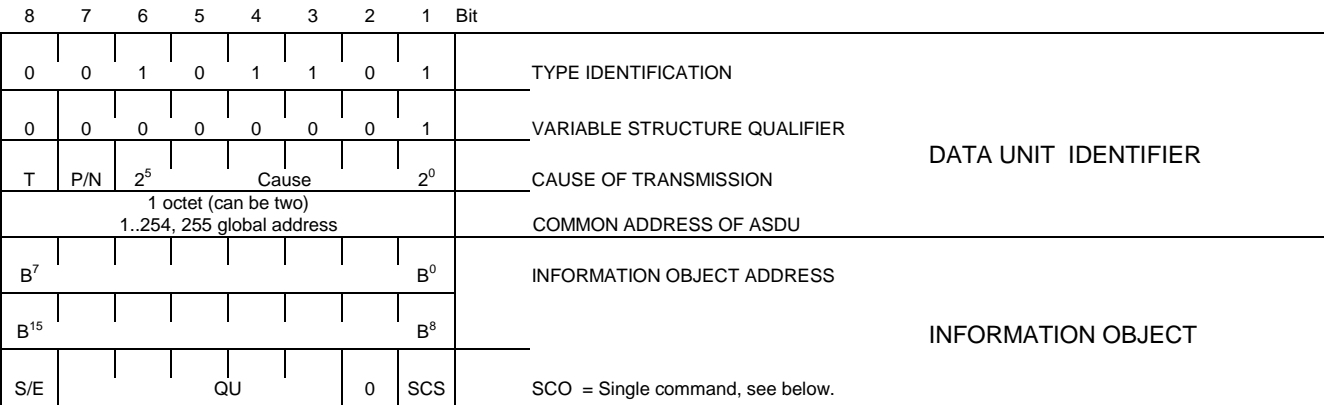


Figure 21 - ASDU: **C_SC_NA_1** Single command

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

in monitor direction:

<7> := activation confirmation

<10> := activation termination

SCO := CP8{SCS,BS1,QOC}

SCS=Single command state := BS1[1]<0..1>

<0> := OFF

<1> := ON

BS1[2]<0>OC := CP6[3..8]{QU,S/E} see QOC below.

QOC := CP6{QU, S/E}

QU := UI5[3..7]<0..31>

<0> := no additional definition *

<1> := short pulse duration (circuit-breaker), duration determined by a system parameter in the outstation

<2> := long duration pulse, 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 **

<16..31>:= reserved for special use (private range)

S/E := BS1[8]<0..1>

<0> := Execute

<1> := Select

5.2.2.2 Double command

TYPE IDENT 46: C_DC_NA_1

Single information object (SQ = 0)

8	7	6	5	4	3	2	1	Bit	
0	0	1	0	1	1	0	1		TYPE IDENTIFICATION
0	0	0	0	0	0	0	1		VARIABLE STRUCTURE QUALIFIER
T	P/N	2 ⁵					2 ⁰		CAUSE OF TRANSMISSION
1 octet (can be two) 1..254, 255 global address									COMMON ADDRESS OF ASDU
B ⁷							B ⁰		INFORMATION OBJECT ADDRESS
B ¹⁵							B ⁸		INFORMATION OBJECT
S/E			QU			DCS			DCO = Double command, see below.

Figure 22 - 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

in monitor direction:

<7> := activation confirmation

<10> := activation termination

DCO := CP8{DCS, QOC}

DCS=Double command state := UI2[1..2]<0..3>

<0> := not permitted

<1> := OFF

<2> := ON

<3> := not permitted

QOC := CP6[3..8]{QU, S/E} see QOC below

QOC := CP6{QU, S/E}

QU := UI5[3..7]<0..31>

<0> := no additional definition *

<1> := short pulse duration (circuit-breaker), duration determined by a system parameter in the outstation

<2> := long duration pulse, 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 **

<16..31>:= reserved for special use (private range)

S/E := BS1[8]<0..1>

<0> := Execute

<1> := Select

5.2.2.3 Regulating step command

TYPE IDENT 47: **C_RC_NA_1**

Single information object (SQ = 0)

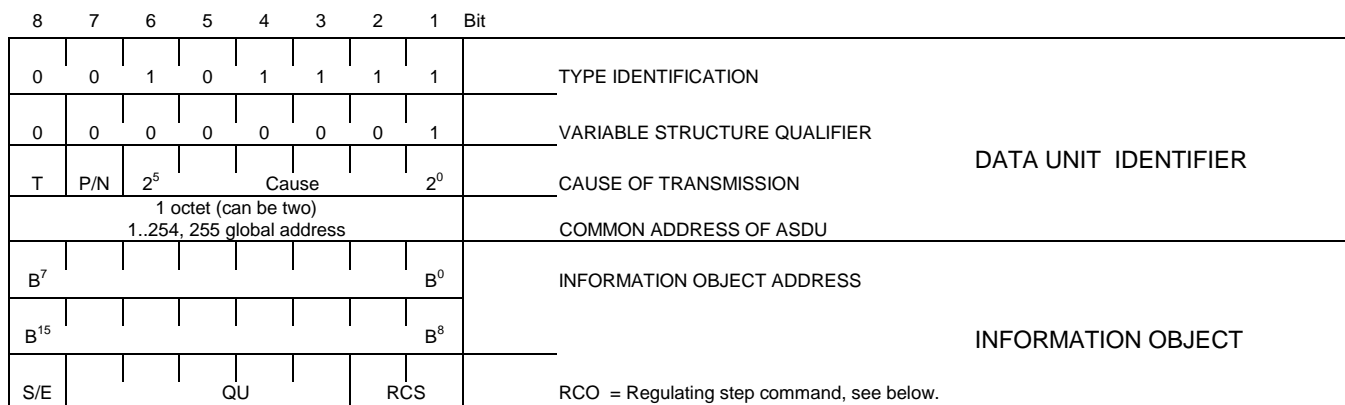


Figure 23 - ASDU: **C_RC_NA_1** Regulating step command

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

in monitor direction:

<7> := activation confirmation

<10> := activation termination

RCO := CP8{RCS,QOC}

RCS=Regulating step

command state := UI2[1..2]<0..3>

<0> := not permitted

<1> := next step LOWER

<2> := next step HIGHER

<3> := not permitted

QOC := CP6[3..8]{QU,S/E}

see below QOC

QOC := CP6{QU, S/E}

QU := UI5[3..7]<0..31>

<0> := no additional definition *

<1> := short pulse duration (circuit-breaker), duration determined by a system parameter in the outstation

<2> := long duration pulse, 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 **

<16..31>:= reserved for special use (private range)

S/E := BS1[8]<0..1>

<0> := Execute

<1> := Select

5.2.2.4 Set-point command, normalised value

TYPE IDENT 48: C_SE_NA_1

Single information object (SQ = 0)

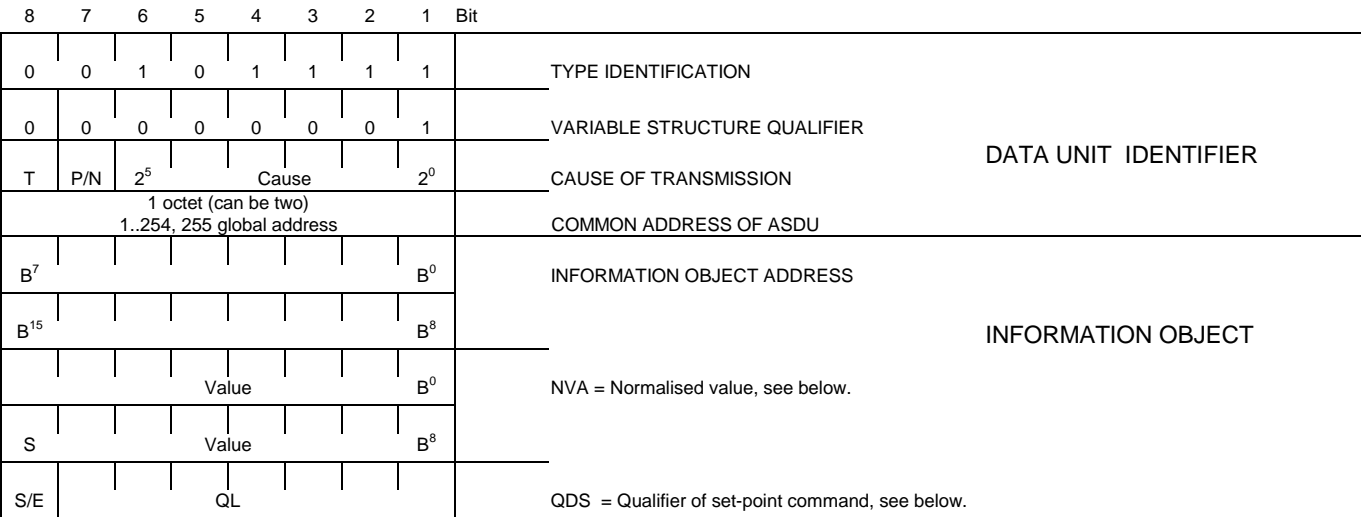


Figure 24 - ASDU: C_SE_NA_1 Set-point command, normalised value

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

in monitor direction:

<7> := activation confirmation

<10> := activation termination

NVA := F16[1..16]<-1..+1-2⁻¹⁵>

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.
Negative numbers are presented in two's complement.

QOS := CP8{QL, S/E}
QL := UI7[1..7]<0..127>
<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>
<0> := Execute
<1> := Select

5.2.2.5 Bitstring of 32 bit

TYPE IDENT 51: C_BO_NA_1

Single information object (SQ = 0)

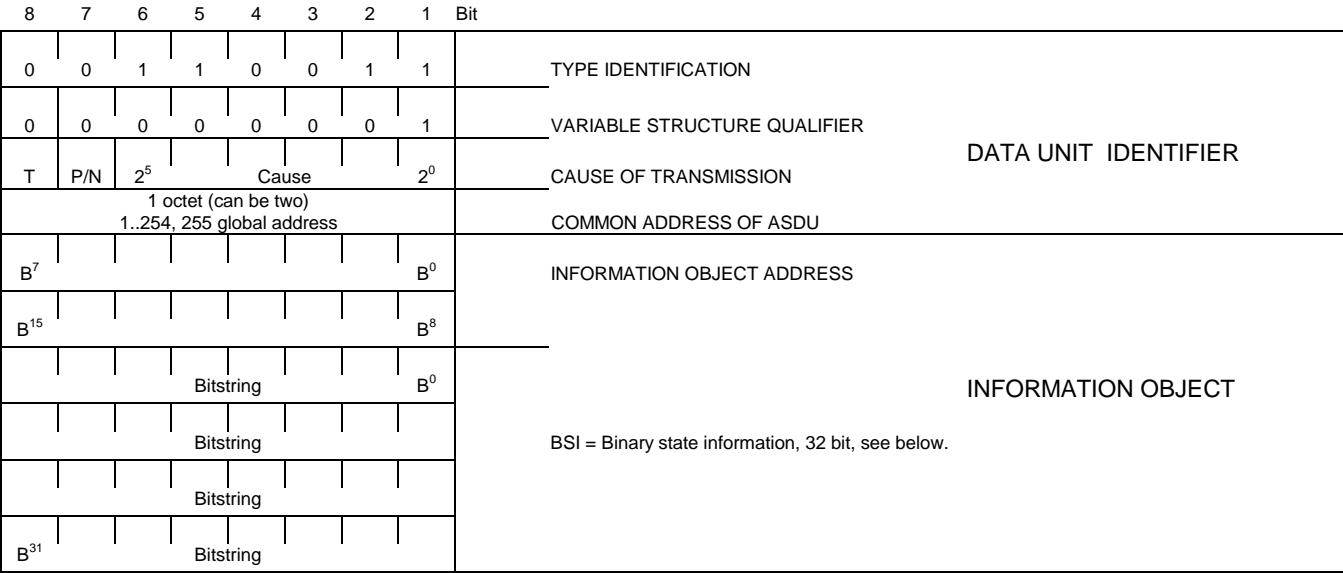


Figure 25 - ASDU: C_BO_NA_1 Bitstring of 32 bit

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

in monitor direction:

<7> := activation confirmation

BSI := 32BS1[1..32]<0..1>

5.2.3 ASDUs for system information in monitor direction

5.2.3.1 End of initialisation

TYPE IDENT 70: **M_EI_NA_1**

Single information object (SQ = 0)

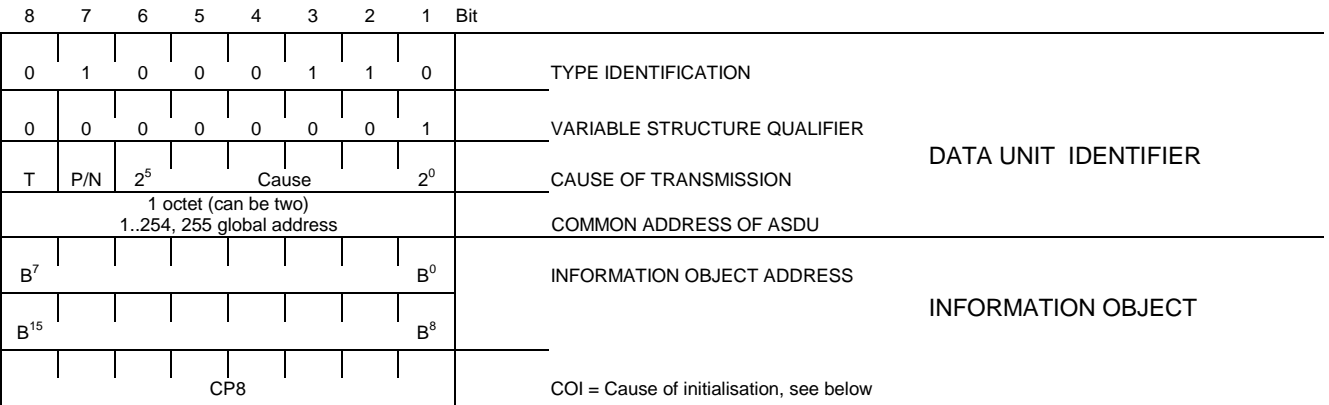


Figure 26 - ASDU: **M_EI_NA_1** End of initialisation

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> := initialised

COI := CP8{UI7[1..7],BS1[8]}

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>

<0> := initialisation with unchanged local parameters

<1> := initialisation after change of local parameters

5.2.4 ASDUs for system information in control direction

5.2.4.1 Interrogation command

TYPE IDENT 100: C_IC_NA_1

Single information object (SQ = 0)

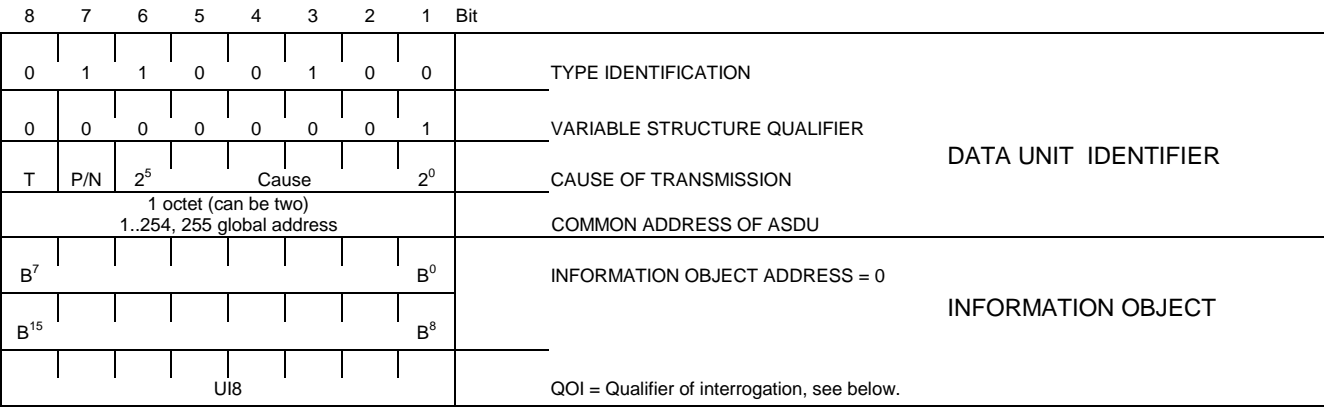


Figure 27 - ASDU: C_IC_NA_1 Interrogation command

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

in monitor direction:

<7> := activation confirmation

<10> := activation termination

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

<20> := Station interrogation (global)

5.2.4.2 Clock synchronisation command

TYPE IDENT 103: C_CS_NA_1

Single information object (SQ = 0)

8	7	6	5	4	3	2	1	Bit	
0	1	1	0	0	1	1	1		TYPE IDENTIFICATION
0	0	0	0	0	0	0	1		VARIABLE STRUCTURE QUALIFIER
T	P/N	2 ⁵ Cause				2 ⁰			CAUSE OF TRANSMISSION
1 octet (can be two) 1..254, 255 global address									COMMON ADDRESS OF ASDU
B ⁷								B ⁰	INFORMATION OBJECT ADDRESS = 0
B ¹⁵								B ⁸	
B ⁷								B ⁰	Milliseconds 0..59 999 ms
B ¹⁵								B ⁸	
IV	Res1	B ⁵ Minutes				B ⁰			IV = Invalid time, Res = Spare bit Minutes 0..59 min
SU	Res2		B ⁴ Hours				B ⁰		Hours 0..23 h
B ²		B ⁰		B ⁴ Days of month				B ⁰	Days of month 1..31 Days of week 1..7 (Not used = 0)
Res3				B ³ Months		B ⁰			Months 1..12
Res4	B ⁶		Years				B ⁰		Years 0..99

Figure 28 - ASDU: C_CS_NA_1 Clock synchronisation 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

In addition to the procedure shown in 6.7 of IEC/DIS 870-5-5, C_CS_NA_1 may be used in 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 1h in an outstation without ambiguity.

Seven octet binary time

CP56Time2a := CP56{milliseconds,minutes,res1,invalid,hours,res2,summer time, day of month, day of week,months,res3,years,res4}

Day of week is not used in this companion standard and set to 0.

5.2.4.3 Test command

TYPE IDENT 104: C_TS_NA_1

Single information object (SQ = 0)

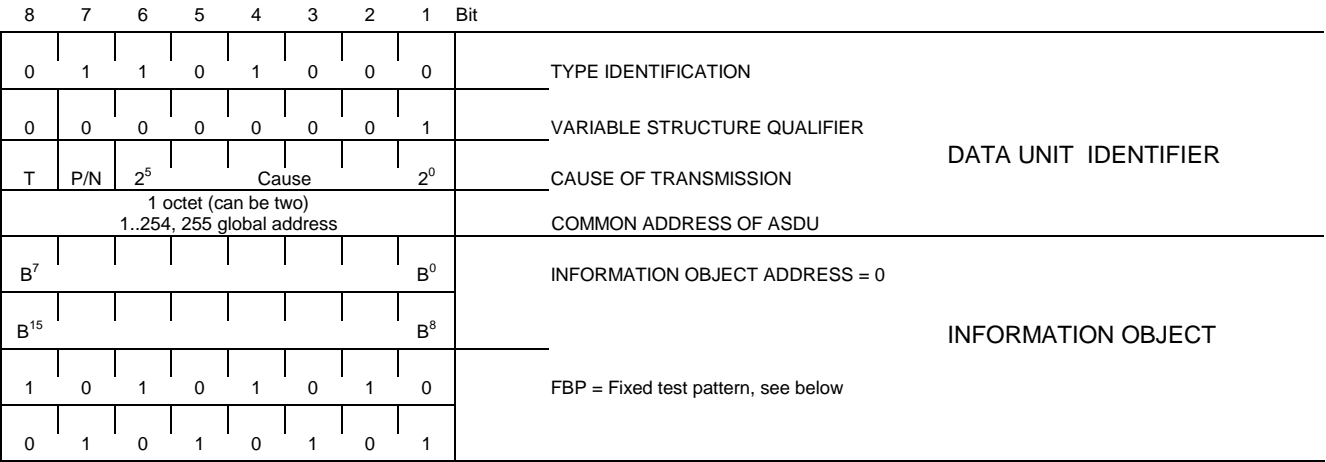


Figure 29 - ASDU: C_TS_NA_1 Test command

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

Fix test bit pattern , two Octets

FBP := UI16[1..16] <55AAH>

5.2.4.4 Reset process command

TYPE IDENT 105: C_RP_NA_1

Single information object (SQ = 0)

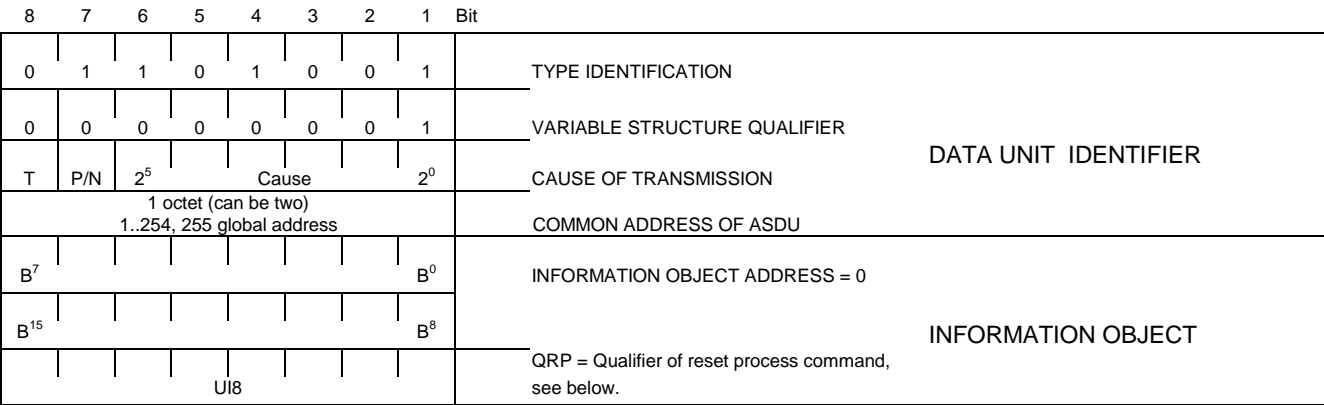


Figure 30 - ASDU: C_RP_NA_1 Reset process command

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

QRP := UI8[1..8]<0..255>
 <0> := not used
 <1> := general reset of process
 <2> := reset of pending information with time tag of the event buffer

5.2.5 ASDUs for parameter in control direction

5.2.5.1 Parameter of measured values, normalised value

TYPE IDENT 110: P_ME_NA_1

Single information object (SQ = 0)

8	7	6	5	4	3	2	1	Bit		
0	1	1	0	1	0	0	1		TYPE IDENTIFICATION	
0	0	0	0	0	0	0	1		VARIABLE STRUCTURE QUALIFIER	
T	P/N	2 ⁵		Cause			2 ⁰		CAUSE OF TRANSMISSION	DATA UNIT IDENTIFIER
1 octet (can be two) 1..254, 255 global address									COMMON ADDRESS OF ASDU	
B ⁷							B ⁰		INFORMATION OBJECT ADDRESS = 0	
B ¹⁵							B ⁸			INFORMATION OBJECT
				Value			B ⁰		NVA = Normalised value, see below.	
S				Value			B ⁸			
				UI8					QPM = Qualifier of parameter of measured values, see below.	

Figure 32 - ASDU: P_ME_NA_1 Parameter of measured values, normalised 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

NVA := F16[1..16]<-1..+1-2⁻¹⁵>

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. Negative numbers are presented in two's complement.

QPM := CP8{KPA,LPC,POP}

KPA = kind of parameter := UI6[1..6]<0..63>

<0> := not used

<1> := threshold value

<2> := smoothing factor (filter time constant)

LPC = local parameter change:= BS1[7]<0..1>

<0> := no change

<1> := change

POP = parameter in operation:= BS1[8]<0..1>

<0> := operation

<1> := not in operation

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

Smoothing factor is filter constant used for the analogue input boards,

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

5.2.5.2 Parameter of measured values, short floating point number

TYPE IDENT 112: P_ME_NC_1

Single information object (SQ = 0)

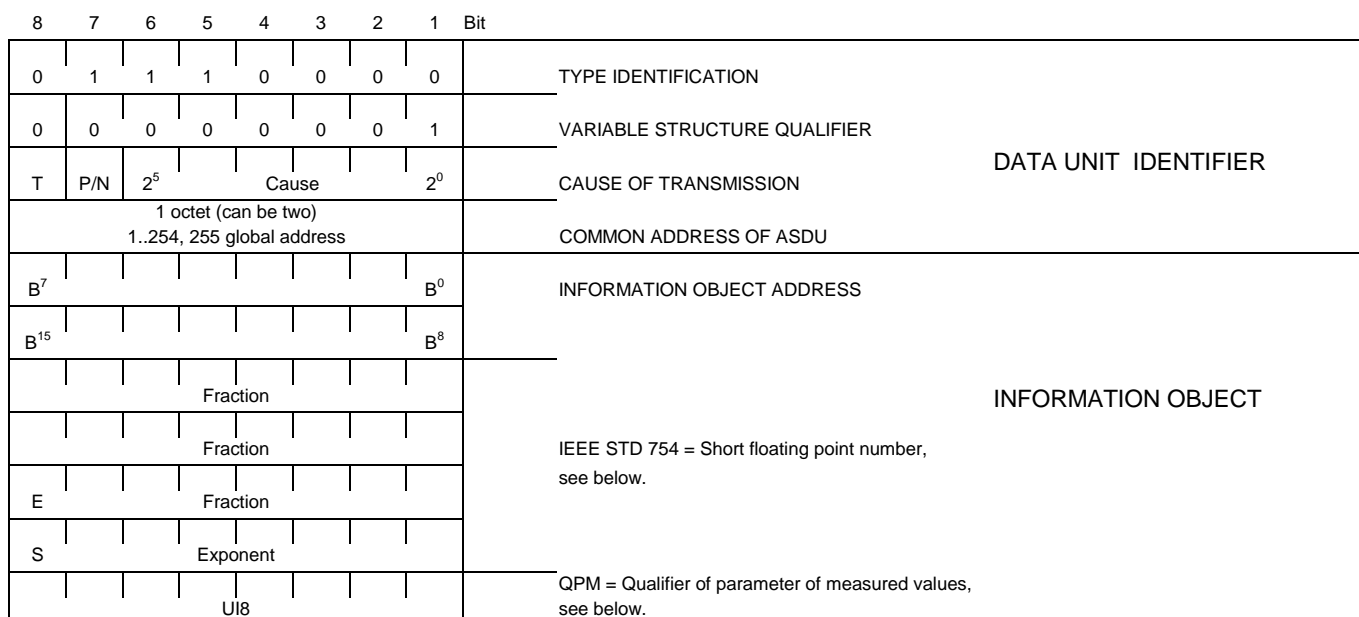


Figure 33 - ASDU: P_ME_NC_1 Parameter of measured values, short floating point number

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

R32-IEEE STD 754 := R32.23{Fraction,Exponent,Sign}

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.

Floating point number := Ri.j (Fraction, Exponent, Sign) i =32= total size of floating point number
 Fraction := F := Uij[1..j]<0..1-2^{-j}> j = 23= size of fraction
 Exponent := E := Uii-j-1[j+1..i-1]<0..2^{i-j-1}> i-j-1 =7= size of exponent
 Sign := S := BS1[i] S<0> := positive
 S<1> := negative

QPM := CP8{KPA,LPC,POP}

KPA = kind of parameter := UI6[1..6]<0..63>

<0> := not used

<1> := threshold value

<2> := smoothing factor (filter time constant)

LPC = local parameter change:= BS1[7]<0..1>

<0> := no change

<1> := change

POP = parameter in operation:= BS1[8]<0..1>

<0> := operation

<1> := not in operation

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

Smoothing factor is filter constant used for the analogue input boards,

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

6 Communication procedures

Table 6.1 shows a list of all basic communication procedures (basic application functions) that are offered in the IEC 870-5-101 companion standard. The subset of these procedures that are applicable to the Norwegian User Conventions are listed in bold types.

Table 6.1 Communication procedures specified in IEC 870-5-101

1. **Station initialisation**
2. Data acquisition by polling
3. Cyclic data transmission
4. **Acquisition of events**
5. **General interrogation**
6. **Clock synchronisation**
7. **Command transmission**
8. **Transmission of integrated totals**
9. **Parameter loading**
10. **Test procedure**
11. File transfer
12. Acquisition of transmission delay

The relevant basic communication procedures are described in more detail in section 6.1, illustrated by separate sequence diagrams for unbalanced and balanced communication systems. Note that only the telegrams that apply to the described procedure are shown in the diagrams. Additional telegrams (e.g. event telegrams) may be transmitted in between the procedure telegrams.

The basic communication procedures as described are error free procedures. If communication errors (e.g. disturbed frames) occur during the execution of a basic procedure, a corresponding exception procedure is necessary to handle the error situations. The different exception procedures are described in section 6.2.

The IEC 870-5-101 companion standard specifies a fixed link time-out interval to be used for repeated frame transmissions. Link time-outs are indicated with bold vertical lines in the communication procedure diagrams. The time-out interval and maximum number of retries are configurable and appropriate values will depend on the transmission system.

6.1 Basic procedures

6.1.1 Station initialisation

6.1.1.1 Local initialisation of the controlling station in unbalanced transmission systems

The initialisation of the controlling station starts e.g. with power off/on. Any data requested right before the initialisation cannot be received by the controlling station because it is no longer available.

The link of the controlling station then establishes connection with the link of the controlled station by transmitting a "Request status of link" that is answered by a "Status of link" response from the controlled station. The controlling station then transmits a "Reset of remote link" that is answered by an "ACK", which confirms the start condition of the link layer of the controlled station.

After the initialisation the controlling station is updated by issuing a general interrogation command to the controlled station. If appropriate, the time of the two stations is then synchronised by a clock synchronisation command.

The sequential procedure for local initialisation of the controlling station is shown in fig. 6.1. Note that the link telegrams that are used are fixed frame telegrams (ref. sec. 4.1) with Primary Message bit (PRM) and Function Code (FC) as indicated.

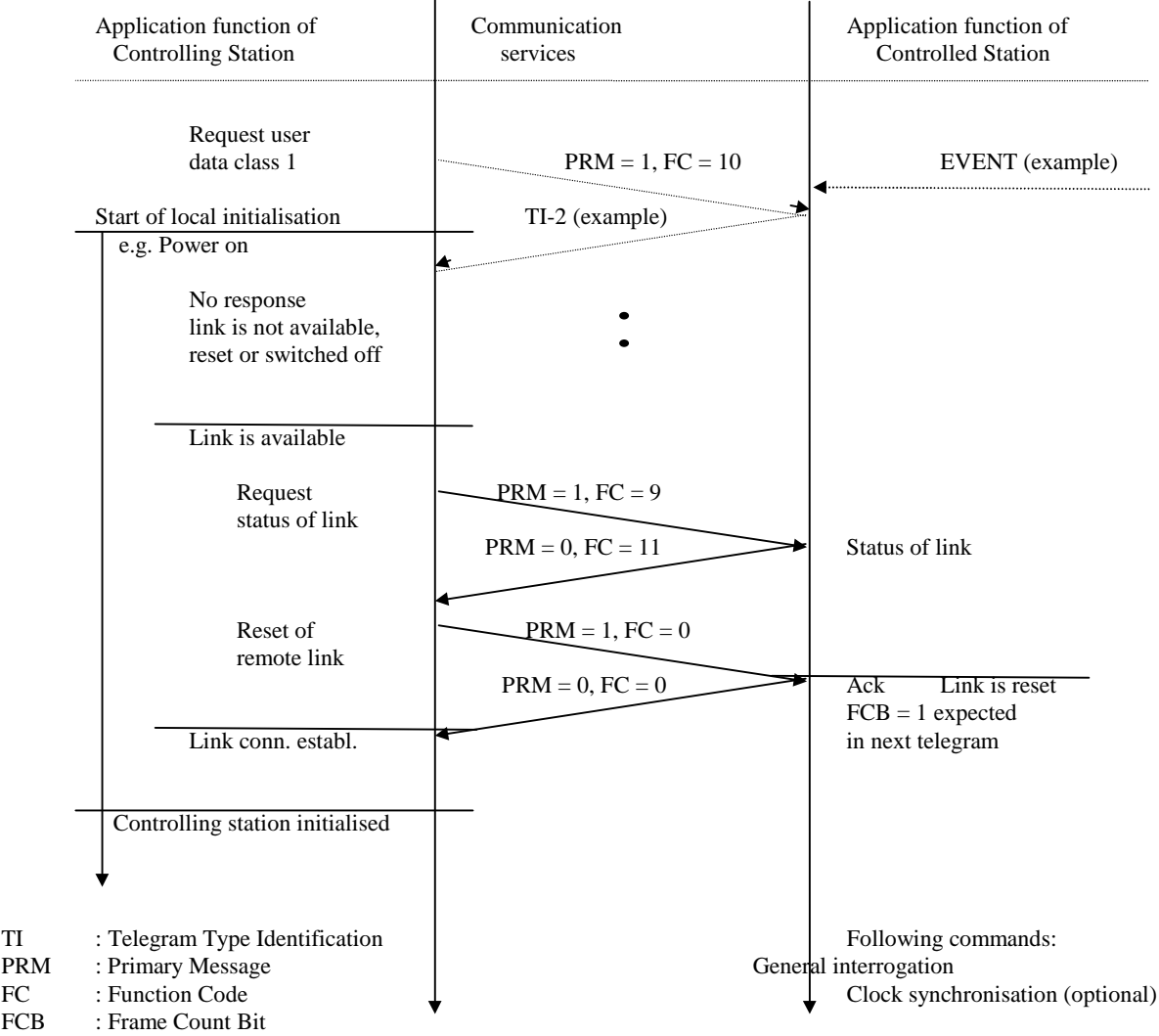


Fig. 6.1 Local initialisation of controlling station - unbalanced systems

6.1.1.2 Local initialisation of the controlled station in unbalanced transmission systems

The initialisation of the controlled station starts e.g. with power off/on. If operations with the controlling station are going on, this station detects that its link is disconnected from the controlled station due to unconfirmed services.

After the maximum number of retries, the controlling station tries to re-establish the link connection by transmitting "Request status of link" at specified time-out intervals. When the link of the controlled station is available, it confirms this condition by a "Status of link" response to the controlling station. The controlling station then transmits a "Reset of remote link" that is answered by an "ACK", which confirms the reset condition of the link of the controlled station.

To establish connection between the application functions of the two stations, an END OF INITIALIZATION message is transmitted from the controlled station after a complete initialisation of the application function in the controlled station is performed.

After the initialisation the controlling station is updated by issuing a general interrogation command to the controlled station. If appropriate, the time of the two stations is then synchronised by a clock synchronisation command.

The sequential procedure for initialisation of the controlled station is shown in fig. 6.2. Note that the link telegrams that are used are fixed frame telegrams (ref. sec. 4.1) with Primary Message bit and Function Code as indicated.

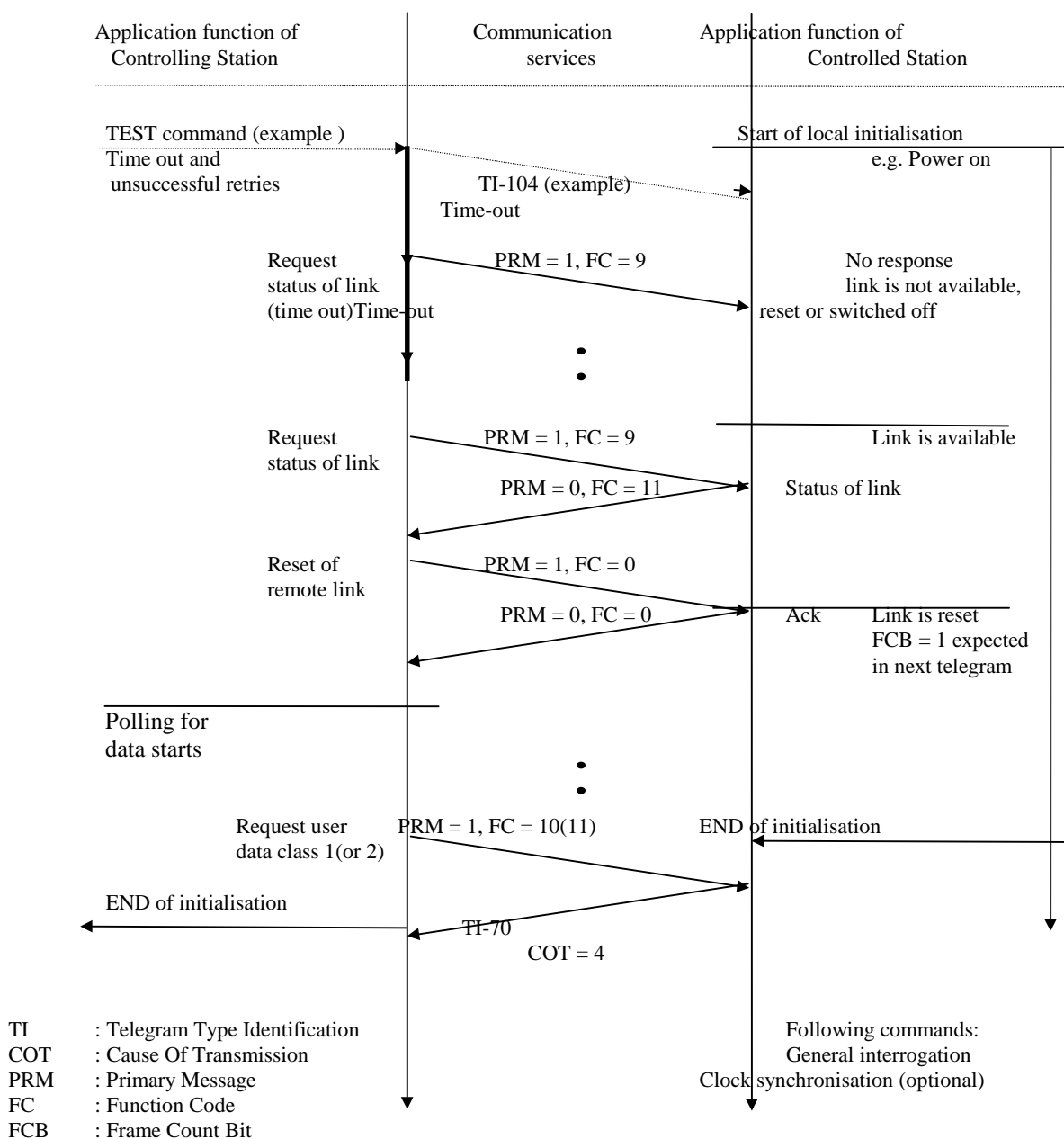


Fig. 6.2 Local initialisation of controlled station - unbalanced systems

6.1.1.3 Remote initialisation of the controlled station in unbalanced transmission systems

The remote initialisation of the controlled station is started with a RESET command message from the controlling station. The controlled station responds with a RESET confirmation message, whereafter all application processes above layer 7 of the ISO/EPA model are reset and initialised. Any messages pending transmission are discarded.

The link of the controlling station then requests the status of the link of the controlled station. When the link of the controlled station is available it answers with "Status of link", and polling for data starts.

If an optional "Reset of remote link" telegram is transmitted after the "Request status of link" telegram, a reset of the complete controlled station has been performed.

After the initialisation the controlling station is updated by issuing a general interrogation command to the controlled station. If appropriate, the time of the two stations is then synchronised by a clock synchronisation command.

The sequential procedure for initialisation of the controlled station is shown in fig. 6.3. Note that the link telegrams that are used are fixed frame telegrams (ref. sec. 4.1) with Primary Message bit and Function Code as indicated.

Note also that this remote initialisation procedure specifies restart of the application processes (above layer 7) when the Remote Initialisation application function is available. In case of unavailability the complete application user process (application layer, application functions and application processes) may be restarted using the link service function "Reset of user process" (not shown in fig. 6.3).

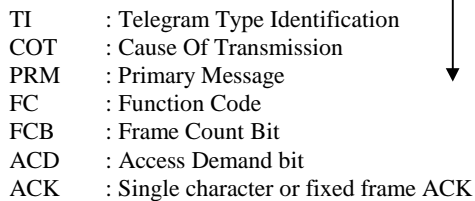


Fig. 6.3 Remote initialisation of controlled station - unbalanced systems

6.1.1.4 Local initialisation of the controlling station in balanced transmission systems

The initialisation of the controlling station starts e.g. with power off/on. The controlled station detect that the link of the controlling station is disconnected due to unconfirmed services.

The controlled station then tries to establish the link by transmitting "Request status of link" at specified time out intervals. When the link layer of the controlling station is available, it confirms this condition by a "Status of link" response to the controlled station. The controlled station then transmits a "Reset of remote link" that is answered by an "ACK", which confirms the reset condition of the link layer of the controlling station.

Then the controlling station synchronises its link with the controlled station by transmitting "Request status of link" and "Reset of remote link". The controlled station responds with "Status of link" and "ACK" respectively, and when the "ACK" is received in the controlling station the link connection is established in both directions.

After the initialisation the controlling station is updated by issuing a general interrogation command to the controlled station. If appropriate, the time of the two stations is then synchronised by a clock synchronisation command.

The sequential procedure for local initialisation of the controlling station is shown in fig. 6.4. Note that the link telegrams that are used are fixed frame telegrams (ref. sec. 4.1) with Primary Message bit (PRM) and Function Code (FC) as indicated.

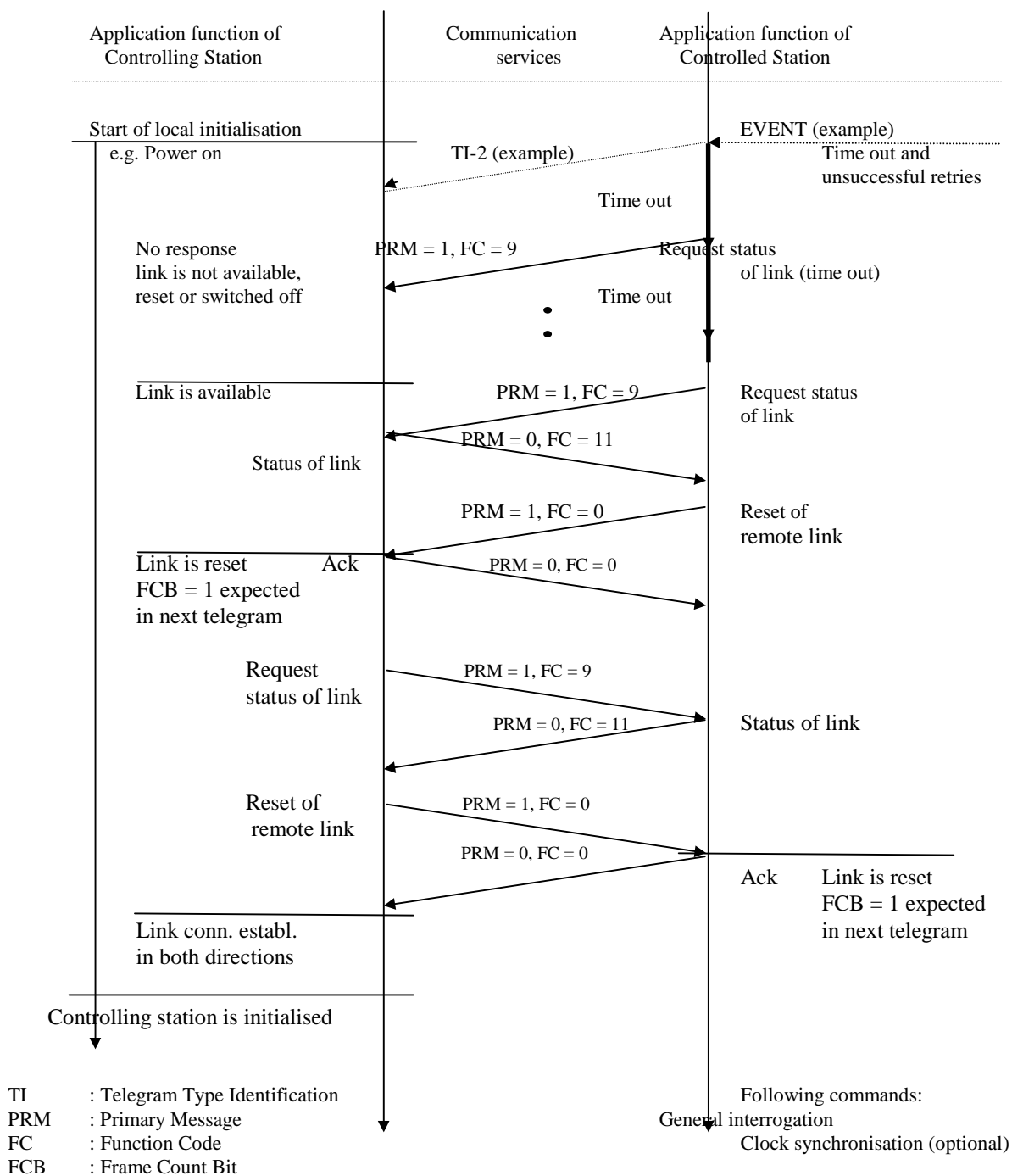


Fig. 6.4 Local initialisation of controlling station - balanced systems

6.1.1.5 Local initialisation of the controlled station in balanced transmission systems

The initialisation of the controlled station starts e.g. with power off/on. If operations with the controlling station are going on, this station detects that its link is disconnected from the controlled station due to unconfirmed services.

After a number of unsuccessful retries, the controlling station tries to re-establish the link connection by transmitting "Request status of link" at specified time-out intervals. When the link layer of the controlled station is available, it confirms this condition by a "Status of link" response to the controlling station. The controlling station then transmits a "Reset of remote link" that is answered by an "ACK", which confirms the reset condition of the link layer of the controlled station

Then the controlled station synchronises its link with the controlling station by transmitting "Request status of link" and "Reset of remote link". The controlling station responds with "Status of link" and "ACK" respectively, and when the "ACK" is received in the controlled station the link connection is established in both directions.

The initialisation procedure is then completed by an END OF INITIALIZATION message issued by the controlled station.

After the initialisation the controlling station is updated by issuing a general interrogation command to the controlled station. If appropriate, the time of the two stations is then synchronised by a clock synchronisation command.

The sequential procedure for initialisation of the controlled station is shown in fig. 6.5. Note that the link telegrams that are used are fixed frame telegrams (ref. sec. 4.1) with Primary Message bit and Function Code as indicated.

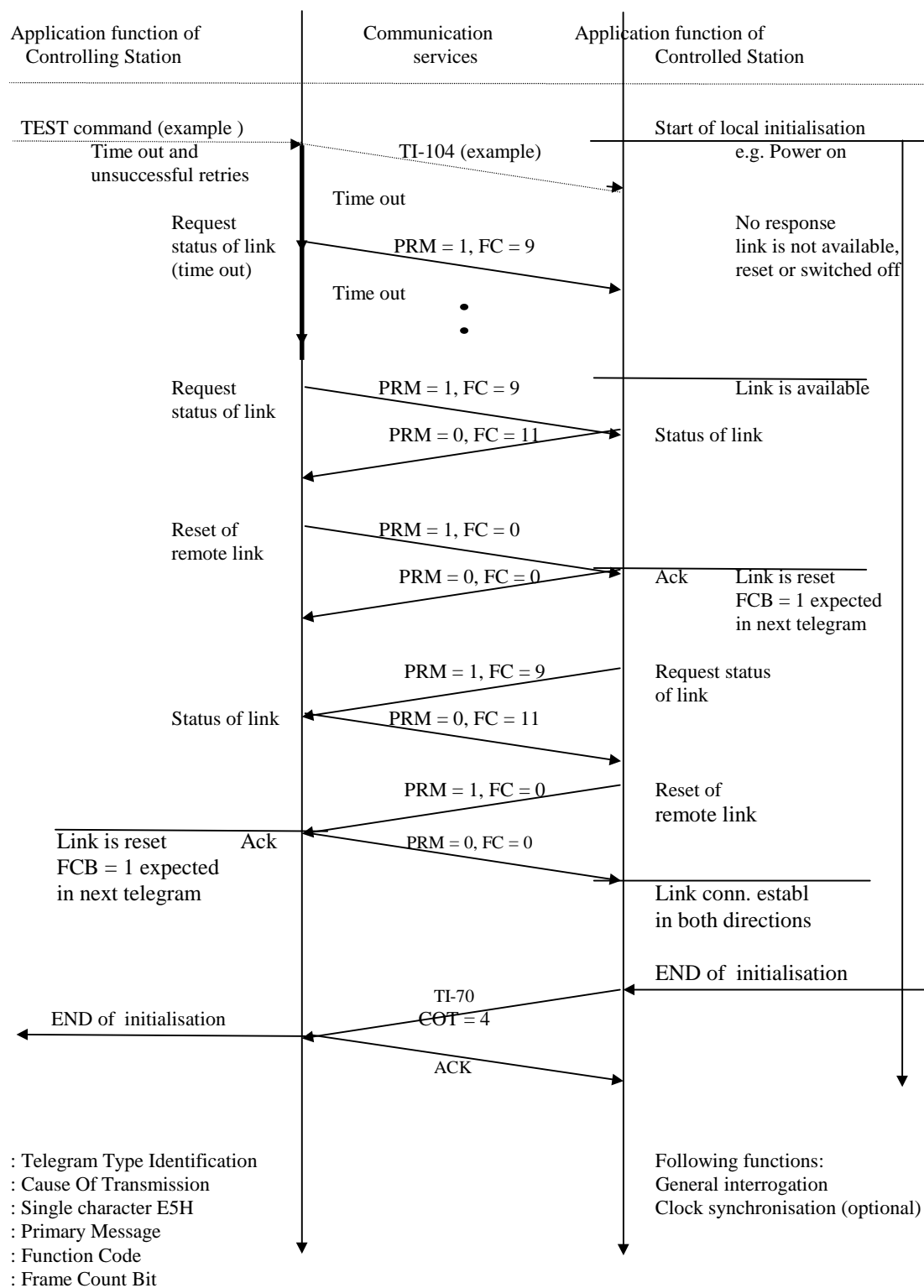


Fig. 6.5 Local initialisation of controlled station - balanced systems

6.1.1.6 Remote initialisation of the controlled station in balanced transmission systems

The remote initialisation of the controlled station is started with a RESET command message from the controlling station. The controlled station responds with a RESET confirmation message, whereafter all application processes above layer 7 of the ISO/EPA model are reset and initialised. Any messages pending transmission are discarded.

A link synchronisation procedure identical to the local initialisation procedure of the controlled station then follows, except that the "Reset of remote link" telegram from the controlling station is optional. If this telegram is used, a remote initialisation of the complete controlled station is performed.

The remote initialisation procedure is then completed by an END OF INITIALIZATION message issued by the controlled station.

After the initialisation the controlling station is updated by issuing a general interrogation command to the controlled station. If appropriate, the time of the two stations is then synchronised by a clock synchronisation command.

The sequential procedure for initialisation of the controlled station is shown in fig. 6.6. Note that the link telegrams that are used are fixed frame telegrams (ref. sec. 4.1) with Primary Message bit and Function Code as indicated.

Note also that this remote initialisation procedure specifies restart of the application processes (above layer 7) when the Remote Initialisation application function is available. In case of unavailability the complete application user process (application layer, application functions and application processes) may be restarted using the link service function "Reset of user process" (not shown in fig. 6.6).

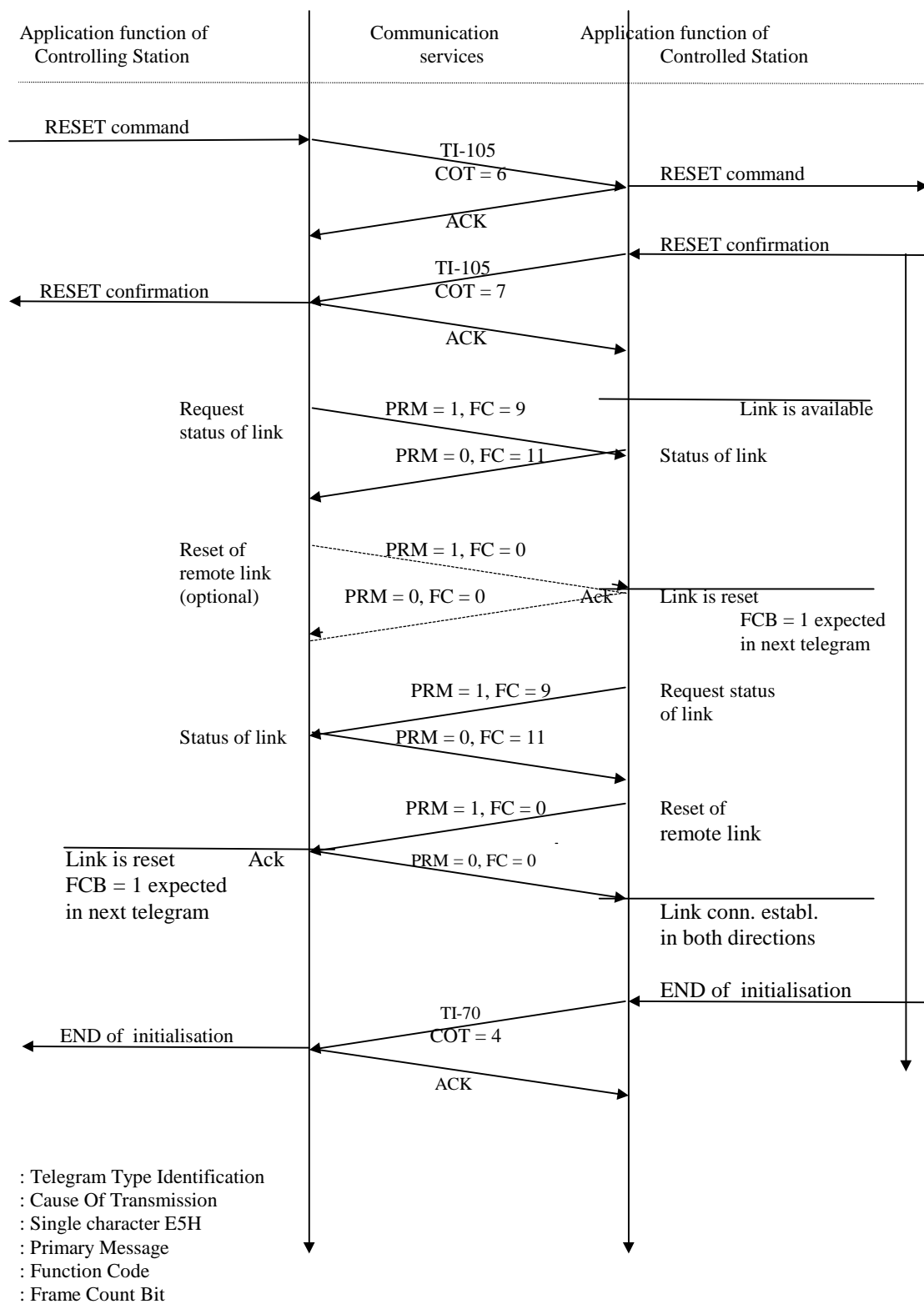


Fig. 6.6 Remote initialisation of controlled station - balanced systems

6.1.2 Data acquisition by polling

Reference is made to sec. 6.2 in document IEC 870-5-5.

The Norwegian User Convention specifies data to be acquired from the controlled station solely by means of general interrogation or event transfer, in order to reduce the traffic on the communication line. This communication procedure is therefore not further described in this document.

6.1.3 Cyclic data transmission

Reference is made to sec. 6.3 in document IEC 870-5-5.

Cyclic data transmission would typically be used to transfer measured values from the controlled station, but the Norwegian User Convention specifies measured values to be transferred as events as a result of a deadband crossing (ref. previous section). Hence this communication procedure is not further specified in this document.

It should be noted, however, that the link is prepared for this procedure even in unbalanced mode, as the IEC 870-5-101 companion standard specifies the link to poll for class 2 (cyclic) data.

6.1.4 Acquisition of events

Events occur spontaneously at the application level of the local (controlled) station. The local process requires an event buffer to collect events that may appear faster than their transmission to the remote (controlling) station can be accomplished.

6.1.4.1 Acquisition of events in unbalanced transmission systems

Fig. 6.7 shows the sequential procedure for event acquisition in unbalanced transmission systems.

The IEC 870-5 family of protocols specifies two classes of data, class 1 and class 2 data. The IEC 870-5-101 companion standard also specifies the link service "Request user data class 2" to be used for polling local (controlled) stations. Normally class 1 contains spontaneous data while class 2 contains cyclic data (recommended in document IEC 870-5-2). Two consequences are then possible in each local station when the poll telegram is received:

CASE 1: No spontaneous data are available

In this case the link layer of the controlled station responds by a NACK, i.e. either the single character E5H or the fixed frame telegram "Requested data not available", and the controlling station continues its poll procedure by polling the next controlled station.

CASE 2: Spontaneous data (events) are available

In this case the controlled station also responds by the fixed frame NACK telegram "Requested data not available", but this time with the ACD (Access Demand) bit set, indicating that spontaneous data are available and waiting for transfer. The controlling station then sends a "Request user data class 1" telegram, and the controlled station responds by transmitting an event ASDU.

The returned ASDU may contain all or some of the events that are available in the controlled station when it was polled, depending on the number and type of events present, and the maximum number of events allowed in one event ASDU (blocking).

The link transmission procedures used for event acquisition in unbalanced transmission systems are always request/respond procedures.

NOTE - If only spontaneous data is used for data transfer from the controlled station, a more efficient poll procedure is achieved by defining all data as class 2 data and having the link requesting only class 2 data. The corresponding event transfer procedure in this case is shown in fig. 6.8

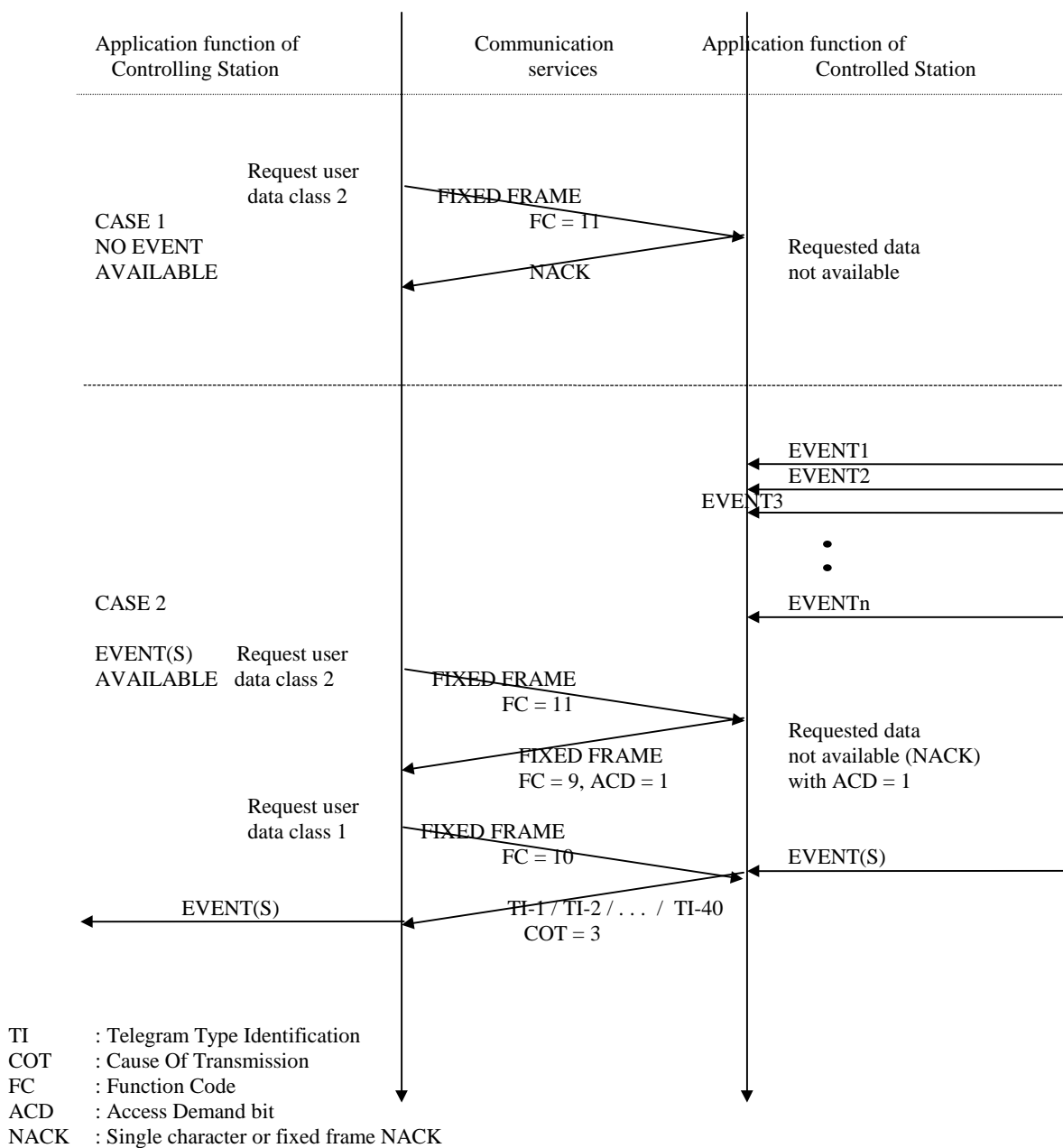


Fig. 6.7 Acquisition of events (defined as class 1 data) in unbalanced transmission systems

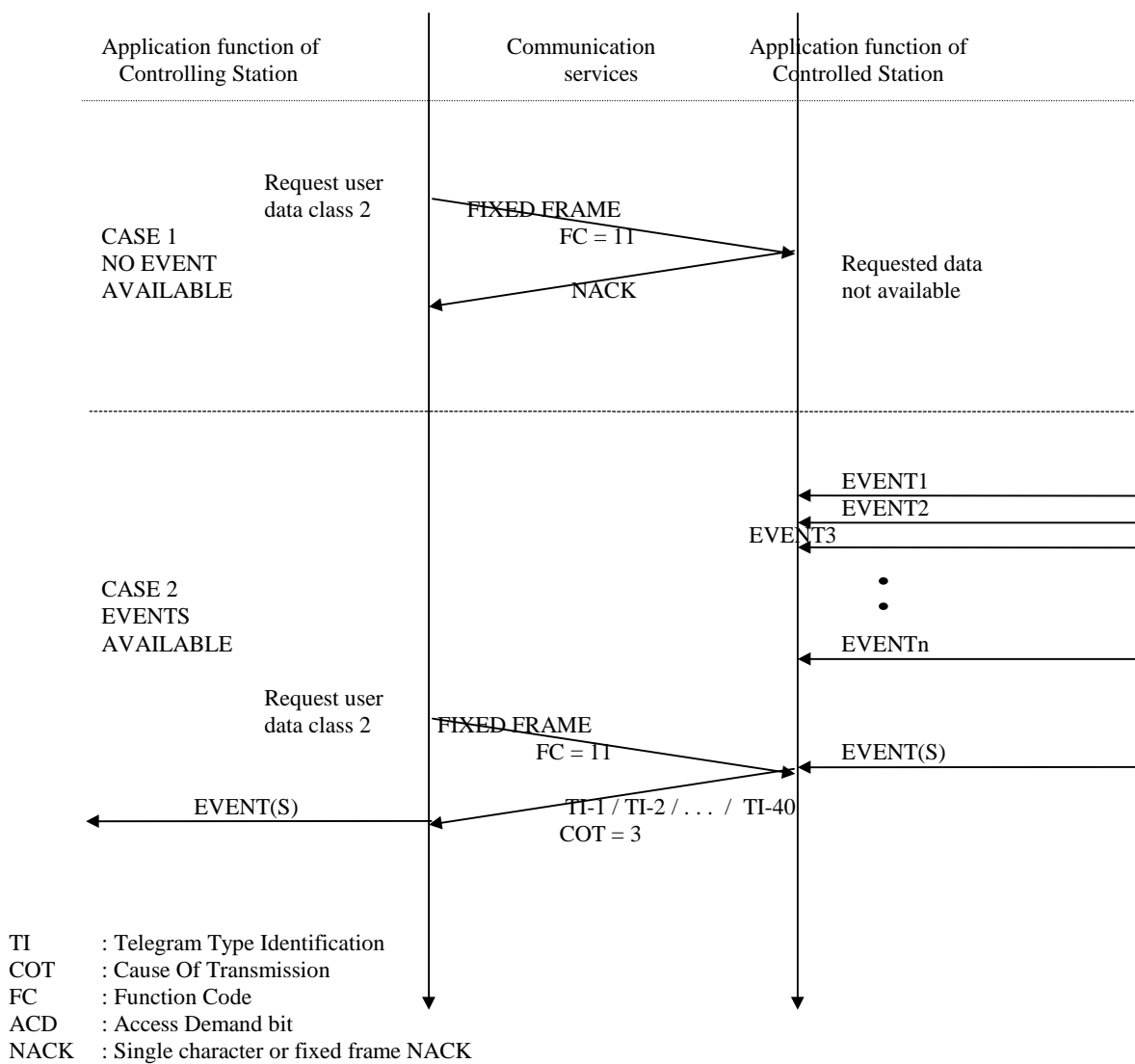


Fig. 6.8 Acquisition of events (defined as class 2 data) in unbalanced transmission systems

6.1.4.2 Acquisition of events in balanced transmission systems

Fig. 6.9 shows the sequential procedure for event acquisition in balanced transmission systems.

Events that arrive in the controlled station are transmitted to the controlling station as soon as possible after they appear. Events that arrive faster than transmission to the controlling station can be accomplished are buffered in the controlled station.

Buffered events may be transferred in the same event ASDU (blocking). The maximum number of events in an event ASDU is determined by the configured maximum frame length of the system.

The link transmission procedures used for event acquisition in balanced systems are always send/confirm procedures. This means that each transferred event telegram is followed by a single character ACK from the controlling station.

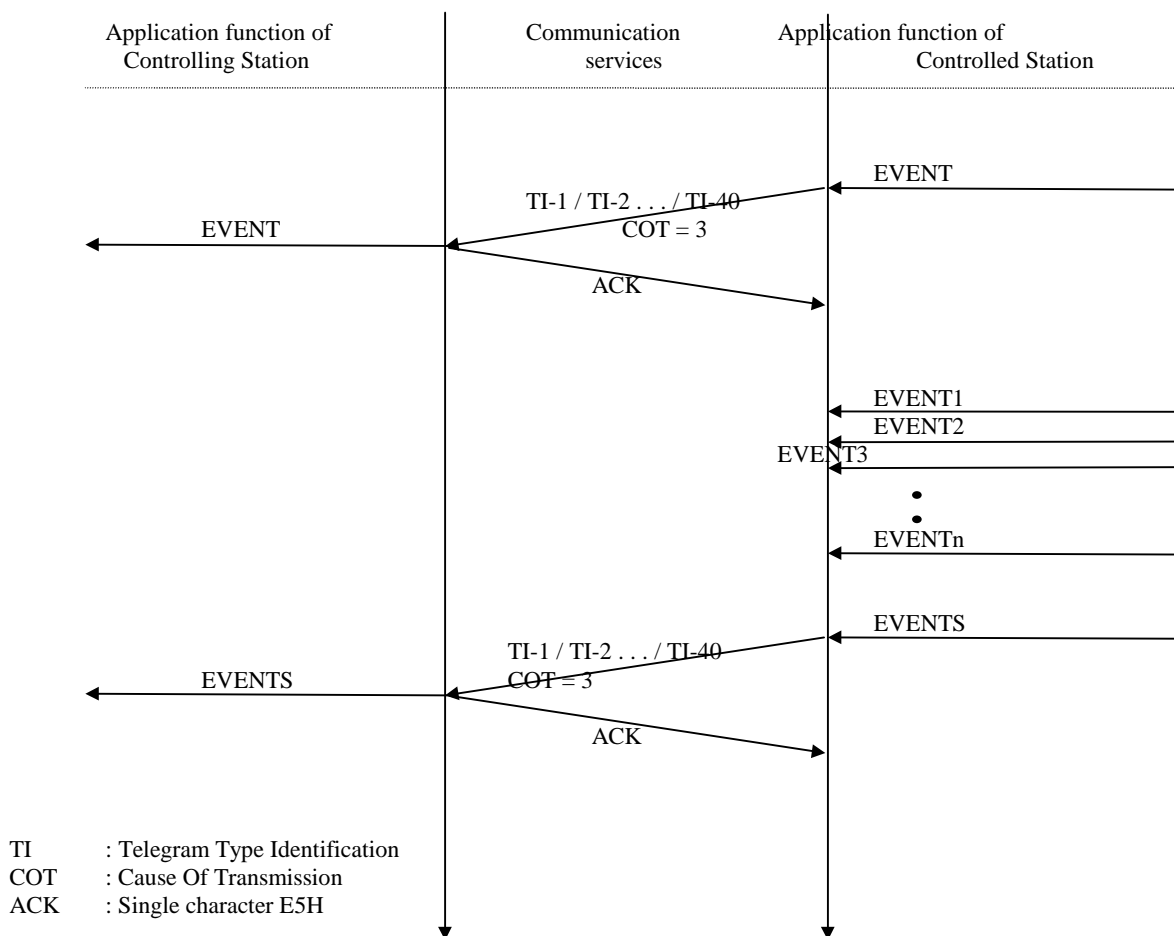


Fig. 6.9 Acquisition of events in balanced transmission systems

6.1.5 General interrogation

The general interrogation application function is used to update the controlling station after the internal station initialisation procedure or when the controlling station detects a loss of information.

The general interrogation function of the controlling station requests the controlled station to transmit the actual values of all its process variables. The interrogation procedure completes when the controlling station receives an End of Interrogation message.

The interrogation procedure can be interrupted by events which may eventually occur in the controlled station. Care is then required to avoid any confusion which may be caused by receiving interrogated information which has been made stale by an event.

Fig. 6.10 shows the sequential procedure of general interrogation in unbalanced transmission systems, while the corresponding procedure for balanced systems is shown in fig. 6.11. The information transfer is triggered by an INTERROGATION command message from the controlling station to the controlled station, which responds with an INTERROGATION confirmation message.

The controlled station transmits the interrogated information by means of one or more monitored information ASDUs. The last information ASDU is then followed by an INTERROGATION termination message (End Of Interrogation), indicating that all information has been transferred.

NOTE 1 - Normally spontaneous data (including interrogation responses) are defined as class 1 data and are acquired by the "Request user data class 1" link telegram when the ACD bit is set. However, if all data are defined as class 2 data (ref. sec. 6.1.2.1), responses (when available) to any command are acquired by the "Request user data class 2" telegram, regardless of the ACD bit.

NOTE 2 - Event telegrams normally have higher priority than response telegrams to any command, and hence event telegrams may arrive in between response telegrams in both unbalanced and balanced systems. Fig. 6.12 illustrates a communication sequence (for a balanced system) where interrogation responses are mixed with events.

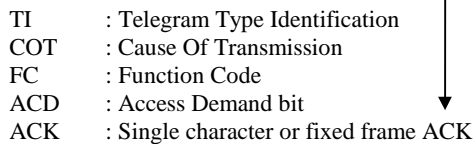


Fig 6.10 *Interrogation procedure - unbalanced systems*

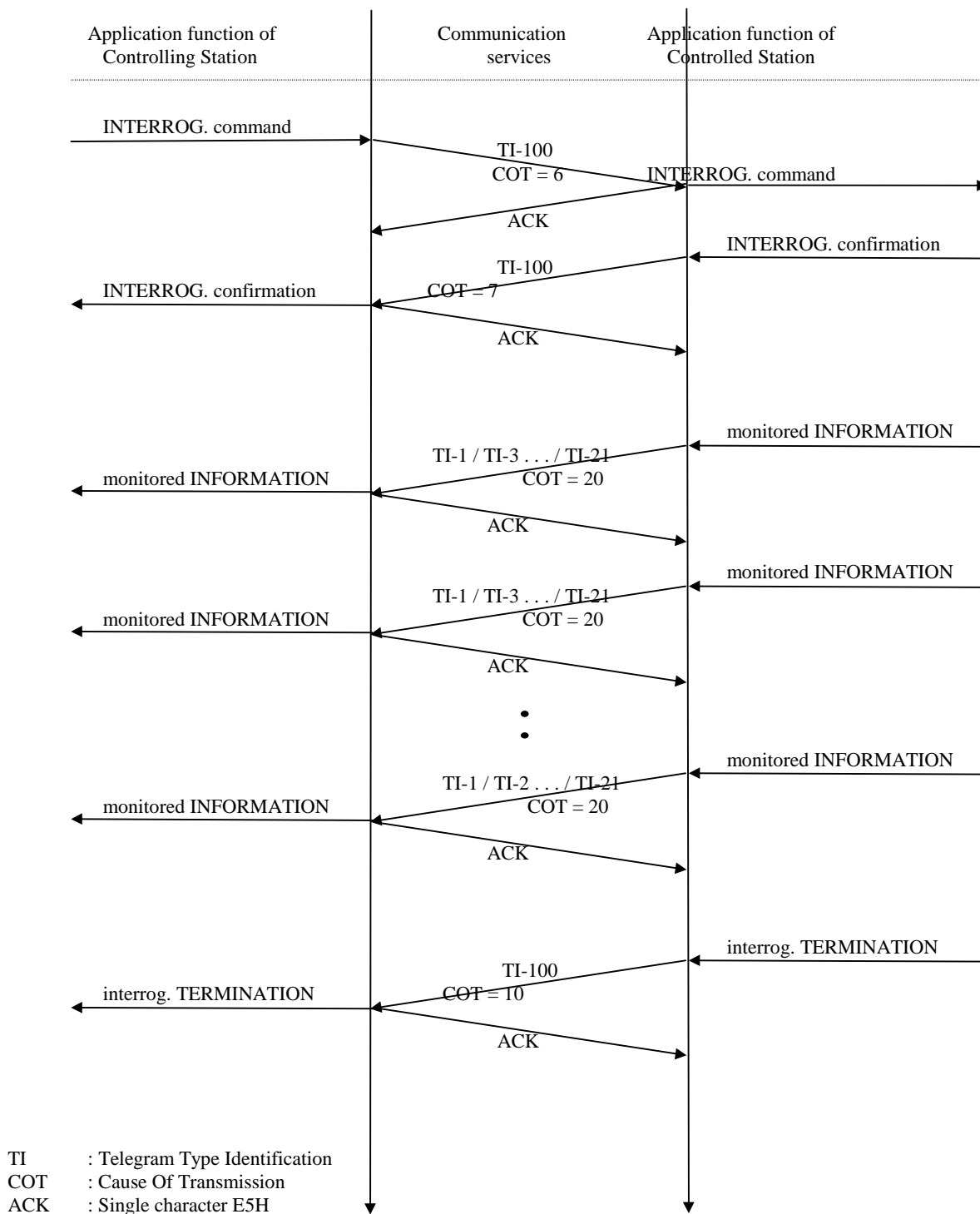


Fig 6.11 Interrogation procedure - balanced systems

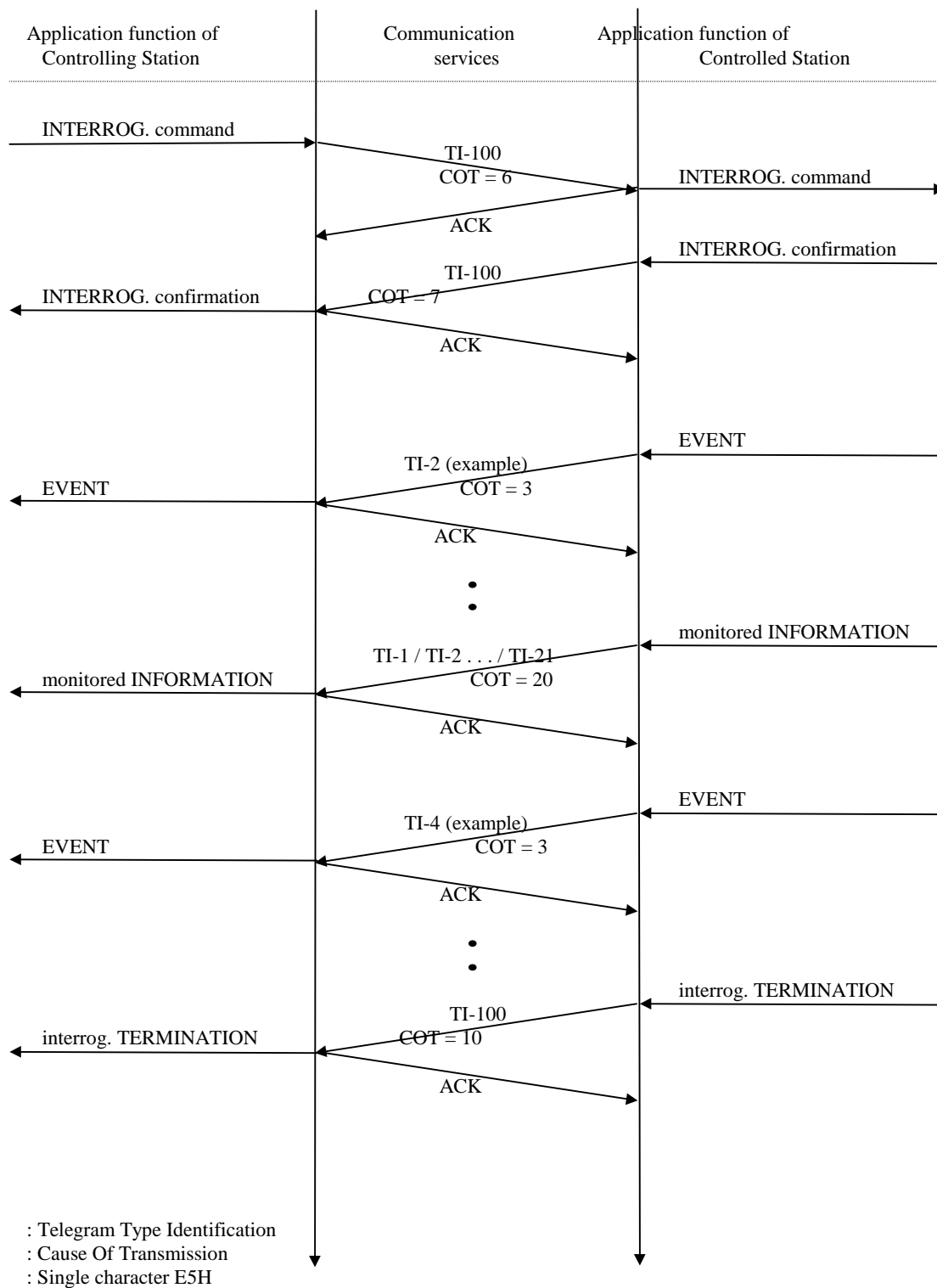


Fig 6.12 Interrogation procedure - events arrive in between interrogation responses

6.1.6 Clock synchronisation

Clocks of controlled stations are initially synchronised by the controlling station after initialisation and then re-synchronised periodically.

Fig. 6.13 and 6.14 show the sequential procedures for clock synchronisation in unbalanced and balanced transmission systems respectively. A CLOCK SYNCHRONIZATION command message containing the full current clock time is sent from the controlling station. The actual time that is transferred is the time when the first bit of the clock synchronisation telegram is transmitted.

The time information must be corrected by the controlling station according to the sum of the transmission delay and transmission time before the synchronisation command is sent.

After the execution of the clock synchronisation the controlled station generates a confirmation message which contains the local time before synchronisation.

It must be noted that when this procedure is used for time synchronisation the accuracy of the synchronisation will always depend on the characteristics of the transmission line.

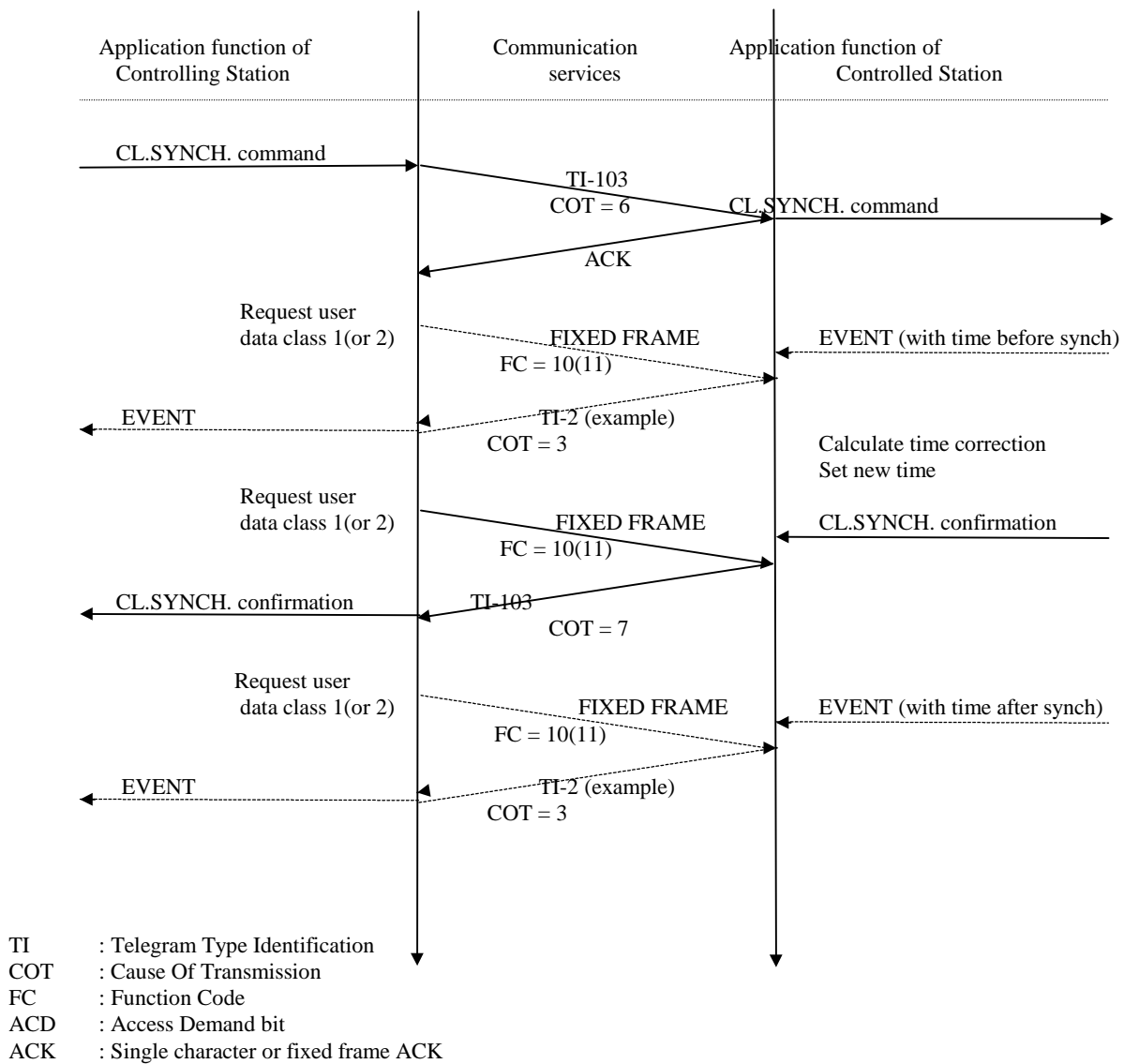


Fig. 6.13 Clock synchronisation procedure - unbalanced systems

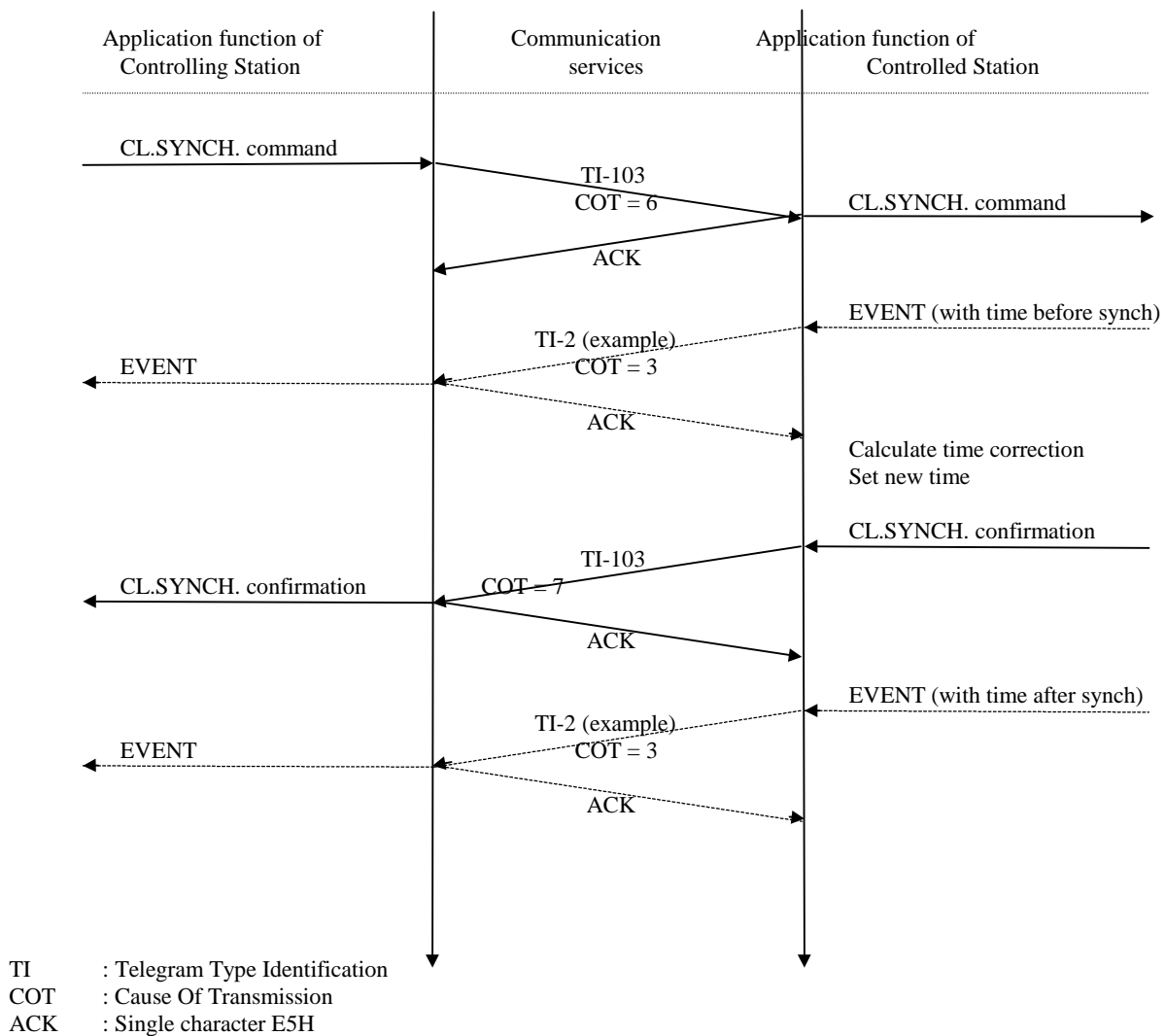


Fig. 6.14 Clock synchronisation procedure - balanced systems

6.1.7 Command transmission

Commands are used in telecontrol systems to cause a change of state of an operational equipment. There are two standard procedures for command transmission:

1. Select and execute command
2. Direct command

Select/execute and direct commands may be assigned individually and independently to each commanded object in the controlled station (by system configuration parameters in the controlling station).

Select and execute command

The select and execute command is used by the controlling station to:

- Prepare for a specific control operation in the controlled station
- Check that the control operation has been prepared (may be performed by the operator).
- Execute the prepared operation if checks are positive

The sequential procedure for a select and execute command is shown in fig. 6.15 and 6.16 for unbalanced and balanced systems respectively. The controlling station sends a SELECT command message to the controlled station, which responds by a SELECT confirmation message if it is ready to accept the announced command. This procedure is non interruptible and the time from the SELECT command to the SELECT confirmation is controlled by a configurable time-out interval.

A successful select procedure may then be deactivated by a "Break off command". This command is transmitted by a BREAK OFF command message and the controlled station responds by a BREAK OFF confirmation message. The time between these messages is controlled by a timeout.

If appropriate, an EXECUTE command message is sent to the controlled station, which responds by an EXECUTE confirmation message (positive if the specified control action is about to begin, otherwise negative). This procedure is also non interruptible and the time from the EXECUTE command to the EXECUTE confirmation is controlled by a configurable time-out interval.

An EXECUTE termination message is issued from the controlled station when the command application procedure is completed successfully. The addressed equipment should now change its state, and the new state is indicated to the controlling station by a spontaneous data message (EVENT) when reached.

The Norwegian user convention does not specify in which sequence the termination message and the change of state event should arrive. Hence the application in the controlling station must check that the command has been properly executed.

If an EXECUTE command message is not received in the controlled station within a certain time interval after a SELECT message, the select/execute procedure will time out in the controlled station. This time-out interval shall be configurable to a maximum of 60 seconds.

Direct command

Direct commands are used for immediate control operations, and the sequential procedure is identical to the procedure that starts with the EXECUTE command message in fig. 6.15 and 6.16

Having received the EXECUTE command message, the application function of the controlled station checks whether the addressed command output is not blocked, i.e. that it is ready for execution. If the check is positive, a positive EXECUTE confirmation message is returned and the operation starts. Otherwise a negative confirmation message is returned.

General Comments

While waiting for a SELECT / BREAK OFF / EXECUTE confirmation no new SELECT / BREAK OFF / EXECUTE command is sent. This rule is applicable per controlled station.

When a select and execute command (single or double command, TI-45 or TI-46) has been given by the user process, no new select and execute or direct command (except TI-47, TI-48 and TI-51) is treated by the protocol until the ongoing select and execute command has reached any of the following states:

1. The SELECT command is completed and has been followed by an EXECUTE
2. Timeout between the command and the command confirmation has occurred in any of the stages
3. A negative command confirmation has been received (P/N=1)
4. The select and execute command has been deactivated (BREAK OFF command given)

These rules are also applicable per controlled station. The aim is to have only one selected point in a controlled station at a time, for security reasons. However, regulating step commands, set point commands and bit string commands (TI-47, TI-48 and TI-51) must be allowed in between single and double commands

If a command transmission request from the user process can't be treated for the moment it is queued and treated later.

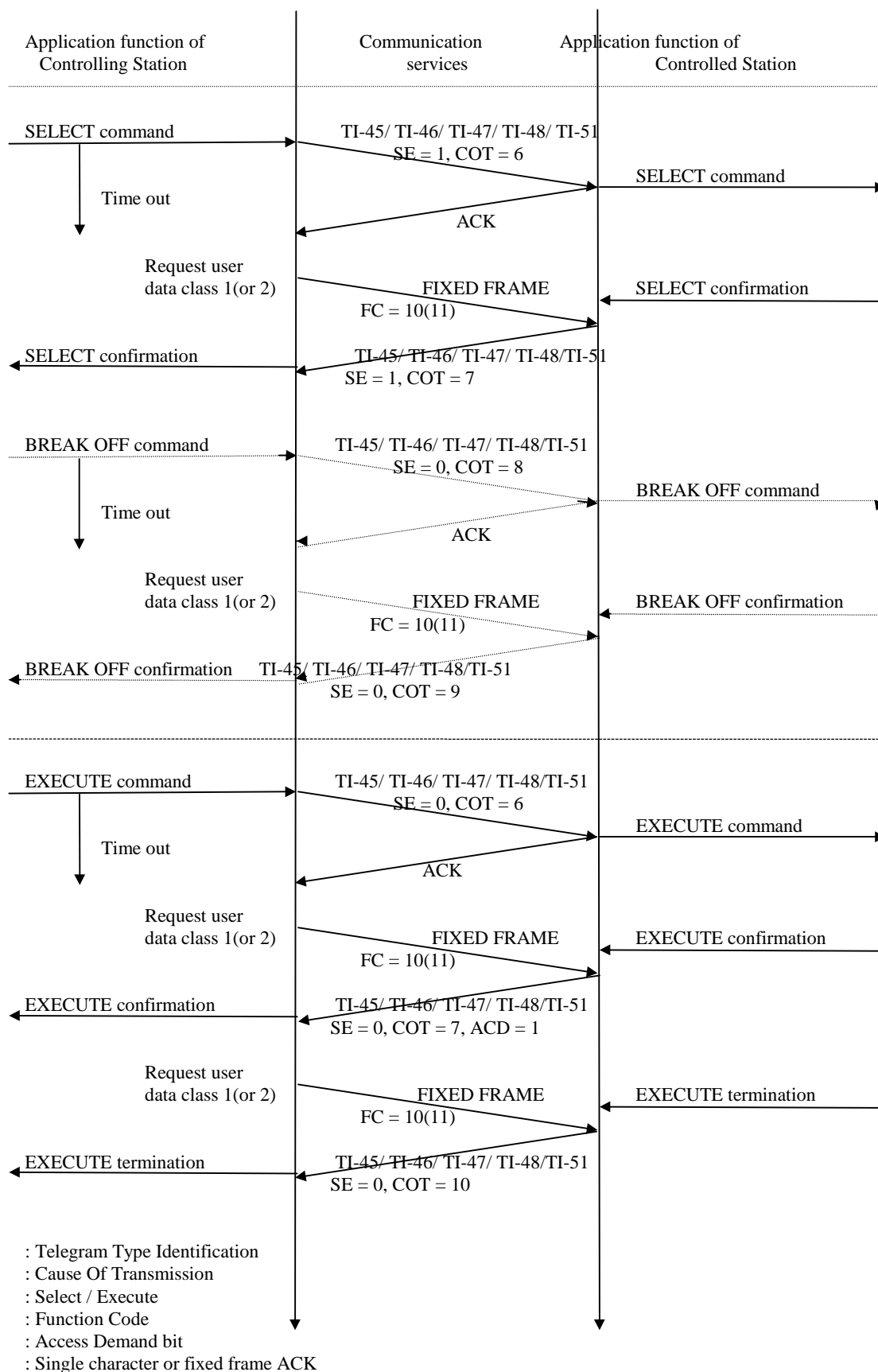


Fig. 6.15 Command transmission procedure - unbalanced systems

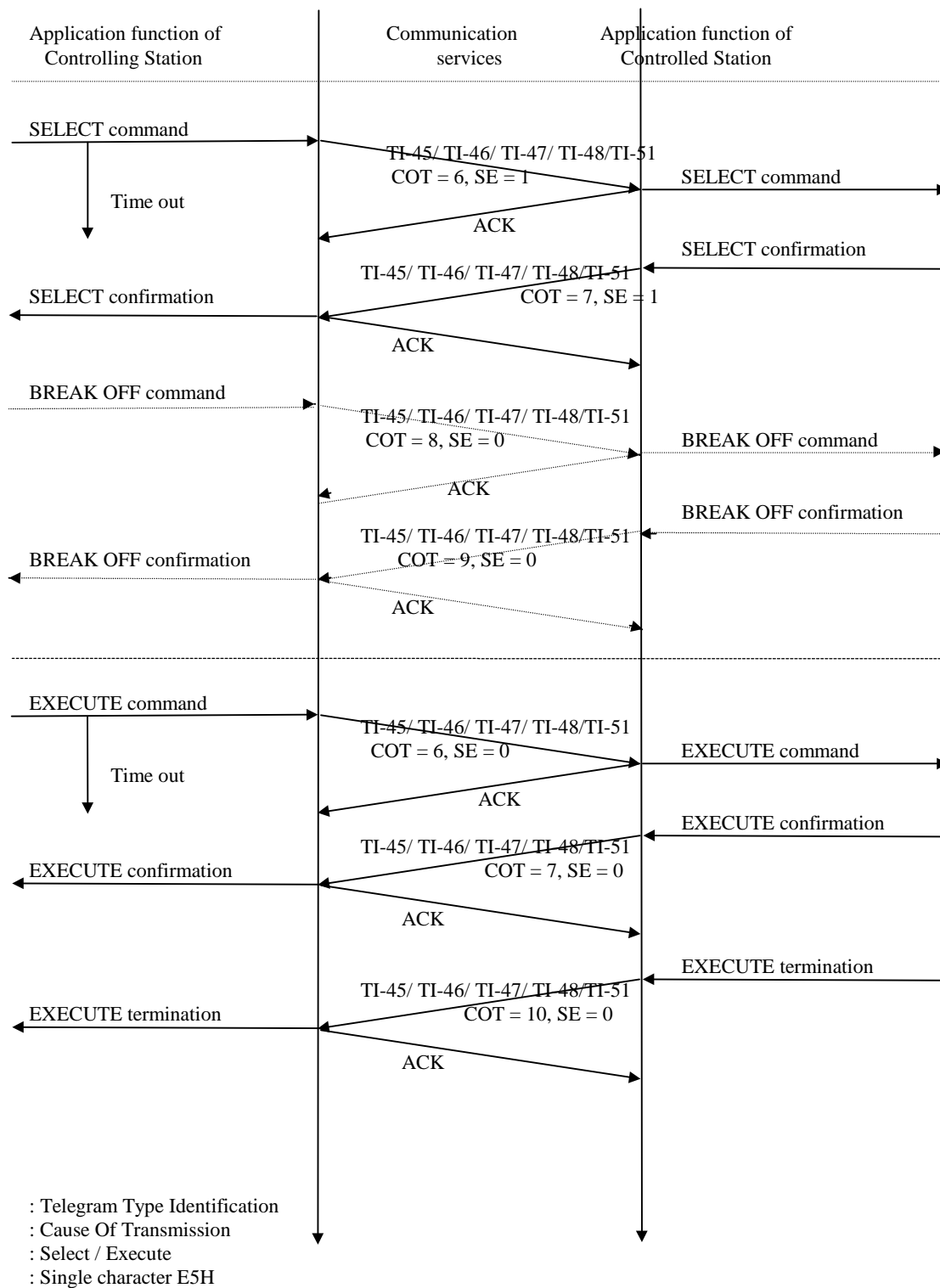
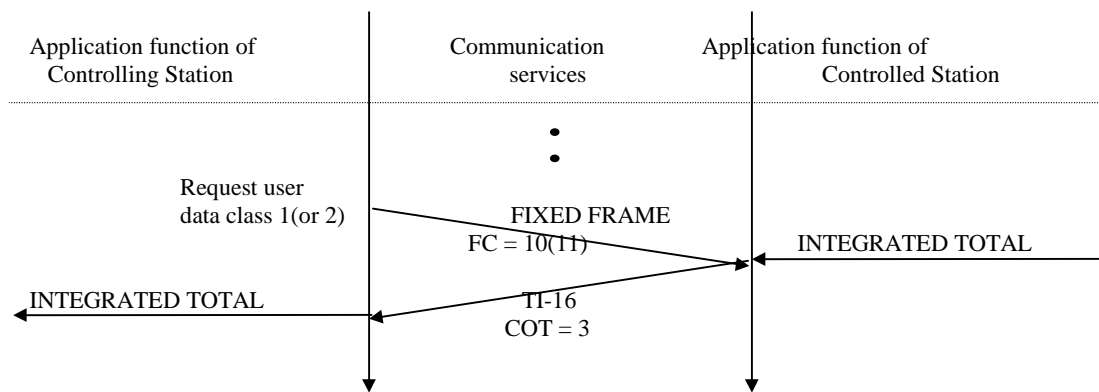


Fig. 6.16 Command transmission procedure - balanced systems

6.1.8 Transmission of integrated totals

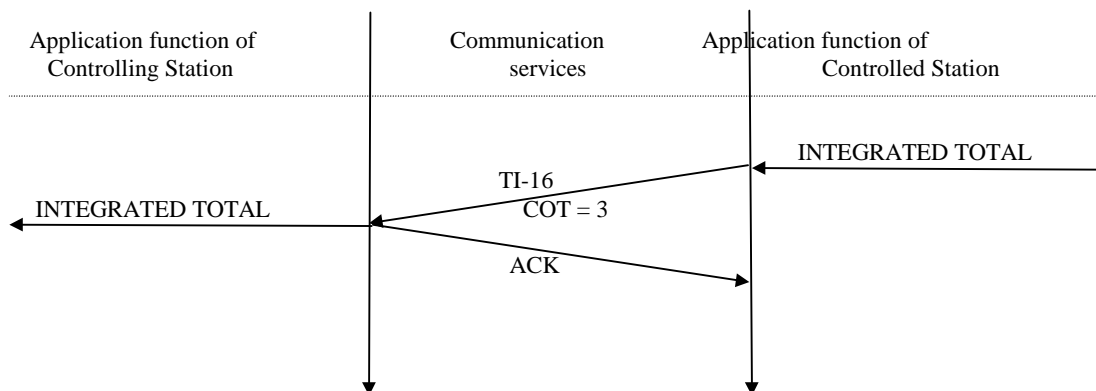
Integrated totals are values that are integrated over a specified period of time. The Norwegian User Convention specifies counter values to be memorised (frozen) in buffers, without the counters being reset, before transmission to the controlling station. Incremented values per period are then calculated in the controlling station.

The Norwegian User Convention also specifies integrated totals to be acquired as ordinary events in the controlling station, as indicated in fig. 6.17 and 6.18 for unbalanced and balanced systems respectively.



TI : Telegram Type Identification
COT : Cause Of Transmission
FC : Function Code

Fig. 6.17 *Transmission of integrated totals - unbalanced systems*



TI : Telegram Type Identification
COT : Cause Of Transmission
ACK : Single character E5H

Fig. 6.18 *Transmission of integrated totals - balanced systems*

6.1.9 Parameter loading

Parameter loading is used to change predefined parameters, e.g. deadband values that define when analogue measurements are to be transmitted. Parameters can only be transmitted from the controlling station as a result of an operator command.

To load a new parameter value, the controlling station sends a PARAMETER LOAD command message to the controlled station, which immediately activates the received parameter.

The parameter load command is then acknowledged by the controlled station by transmitting a PARAMETER LOAD confirmation message, which contains the actual parameter value (new or old) that is currently in operation.

Information Object Addresses (IOAs) of parameters should be equal to the IOAs of the measured values to which they are related.

The sequential procedure is shown in fig. 6.19 for unbalanced transmission systems and in fig. 6.20 for balanced transmission systems.

NOTE - Downloaded parameters must be stored in permanent memory to ensure that correct parameter values are reloaded when the controlled station is restarted.

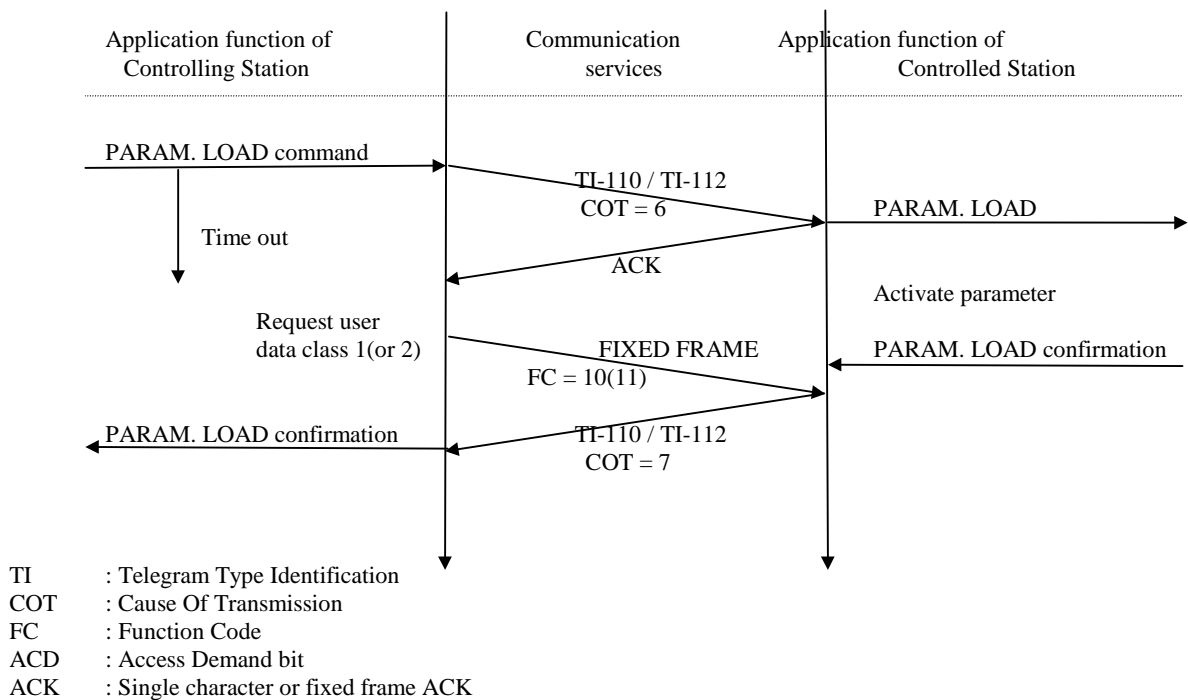


Fig. 6.19 Parameter loading - unbalanced systems

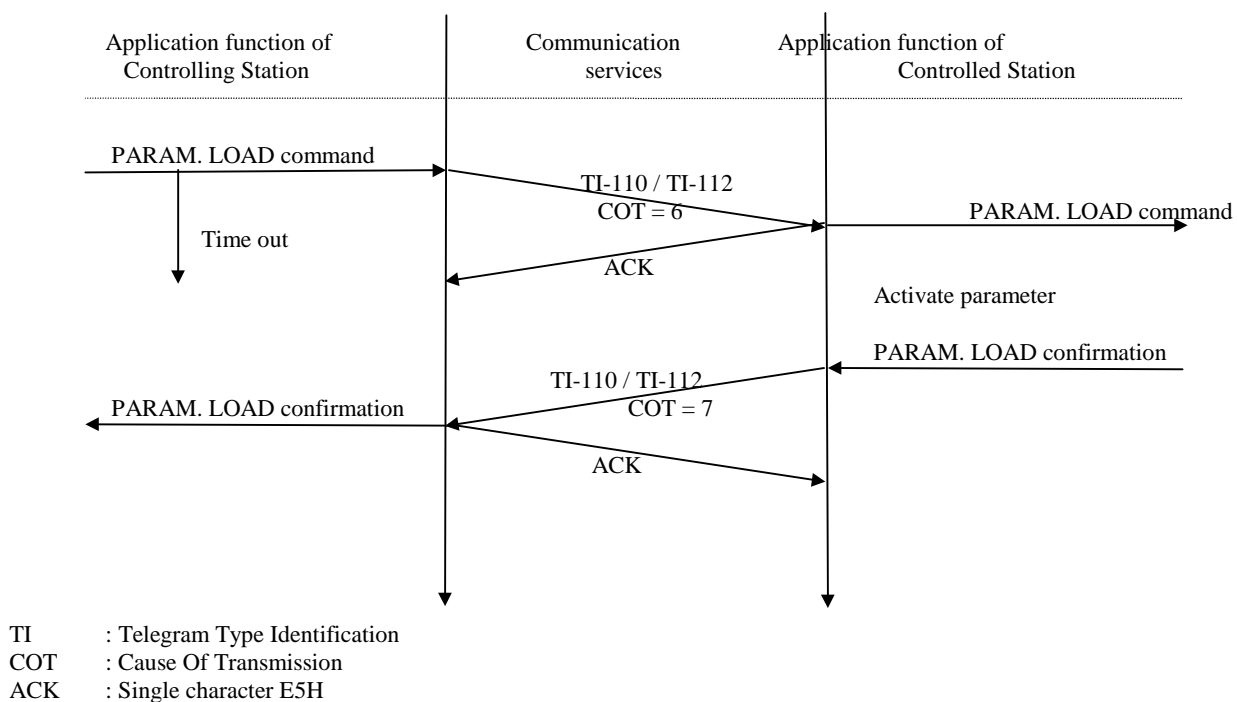


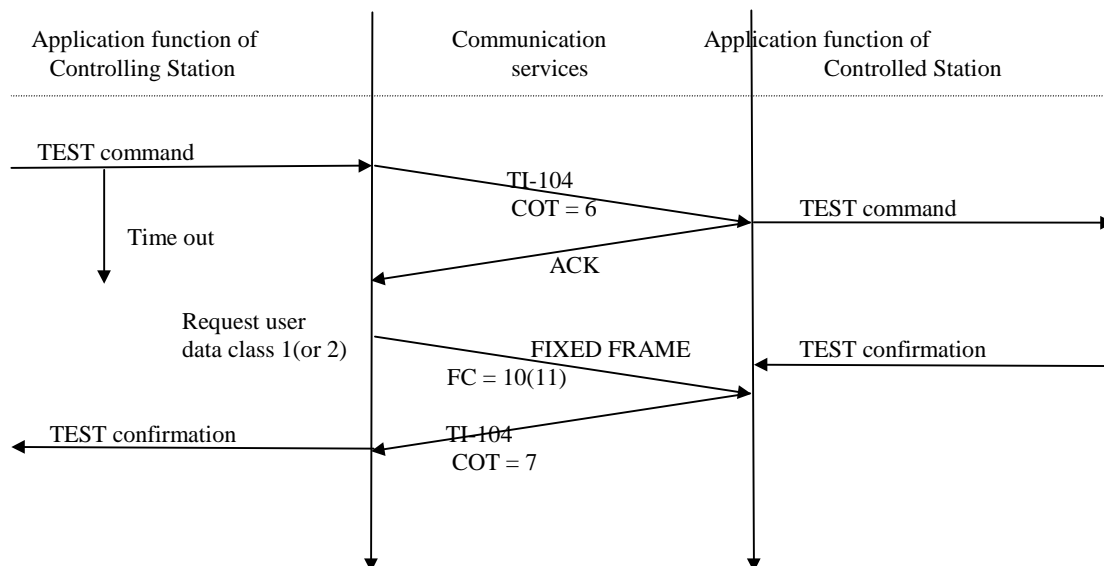
Fig. 6.20 Parameter loading - balanced systems

6.1.10 Test procedure

The test procedure is used to check the complete loop from the controlling station to the controlled station and back.

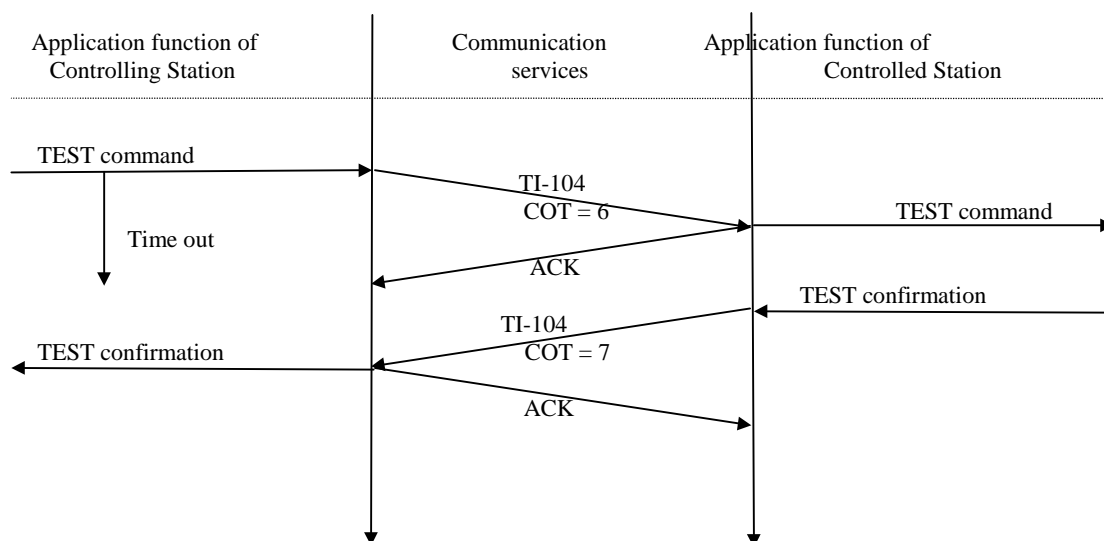
A test command is initiated by the controlling station by sending a TEST command message. This ASDU is mirrored by the controlled station as a TEST confirmation message. The controlling station compares the transmitted TEST message to the mirrored message, and if the messages are identical the test result is positive.

The sequential procedure is shown in fig 6.21 for unbalanced transmission systems and in fig. 6.22 for balanced transmission systems.



TI : Telegram Type Identification
COT : Cause Of Transmission
FC : Function Code
ACD : Access Demand bit

Fig. 6.21 Test procedure - unbalanced systems



TI : Telegram Type Identification
COT : Cause Of Transmission
ACK : Single character or fixed frame ACK

Fig. 6.22 Test procedure - balanced systems

6.1.11 File transfer

Reference is made to sec. 6.12 in document IEC 870-5-5.

File transfer is not included in the current revision of the Norwegian User Convention and is therefore not further described in this document.

6.1.12 Acquisition of transmission delay

Reference is made to sec. 6.13 in document IEC 870-5-5.

Acquisition of transmission delay is an alternative procedure for determining the time correction in clock synchronisation commands. This procedure is not covered by the Norwegian User Convention and is therefore not further described in this document.

6.2 Exception procedures

6.2.1 Unbalanced transmission systems

6.2.1.1 Disturbed send/confirm procedure

Transmission of data in control direction (commands, parameters etc.) is always done by means of send/confirm link procedures in both unbalanced and balanced transmission systems. Fig. 6.23 illustrates disturbed send/confirm procedures in unbalanced systems using transmission of a TEST command in a party line configuration as an example.

In case 1 the SEND frame directed to station n is corrupted, and hence there is no CONFIRM to the TEST command. The controlling station repeats the SEND frame with an unaltered frame count bit (FCB) in the control field of the link after time out.

In case 2 the CONFIRM frame directed to station $n+1$ is corrupted, and the controlling station also in this case repeats the SEND frame with unaltered frame count bit (FCB) after time out. The controlled station detects that the new frame is a repetition because of the unchanged frame count bit, and thus discards the data and transmits the previous CONFIRM frame again.

Note that the send/confirm procedure including repetitions is completed before the next controlled station is addressed.

The number of repetitions before addressing the next station is a configurable parameter.

6.2.1.2 Disturbed request/respond procedure

Data acquisition in monitoring direction (events, command confirmations, monitored information etc.) is always done by means of request/respond link procedures in unbalanced transmission systems. Fig. 6.24 illustrates disturbed request/respond procedures in unbalanced systems using acquisition of EVENTS in a party line configuration as an example.

In case 1 the REQUEST frame directed to station n is disturbed and hence no RESPOND frame is received. The controlling station repeats the REQUEST frame with an unaltered frame count bit (FCB) to the same controlled station after time out.

In case 2 the RESPOND frame directed to station $n+1$ is disturbed, causing the controlling station to repeat the REQUEST frame to the same controlled station with unaltered frame count bit (FCB) after time out. The controlled station always keeps a copy of the last transmitted RESPOND frame, and because of the unchanged frame count bit it recognises the new REQUEST frame as a repetition and transmits the previously transmitted response again.

6.2.1.3 Data flow control

Fig. 6.25 shows an example of data flow control in control direction in unbalanced systems.

A TEST command frame is erroneously sent from the controlling station although an overflow condition exists in the controlled station. The frame is not accepted by the controlled station, and a NACK (negative acknowledgement, message not accepted) is returned to the controlling station. A notification is given to the application function of the, and the TEST command is retried later with success.

In general, if overflow occurs in control direction, the DFC bit should be set in responses from the controlled station, and the controlling station should start to transmit "Request status of Link" cyclically to detect when the DFC bit is reset. If overflow occurs in monitoring direction, the controlling station should pause the polling procedure until the overflow condition ceases.

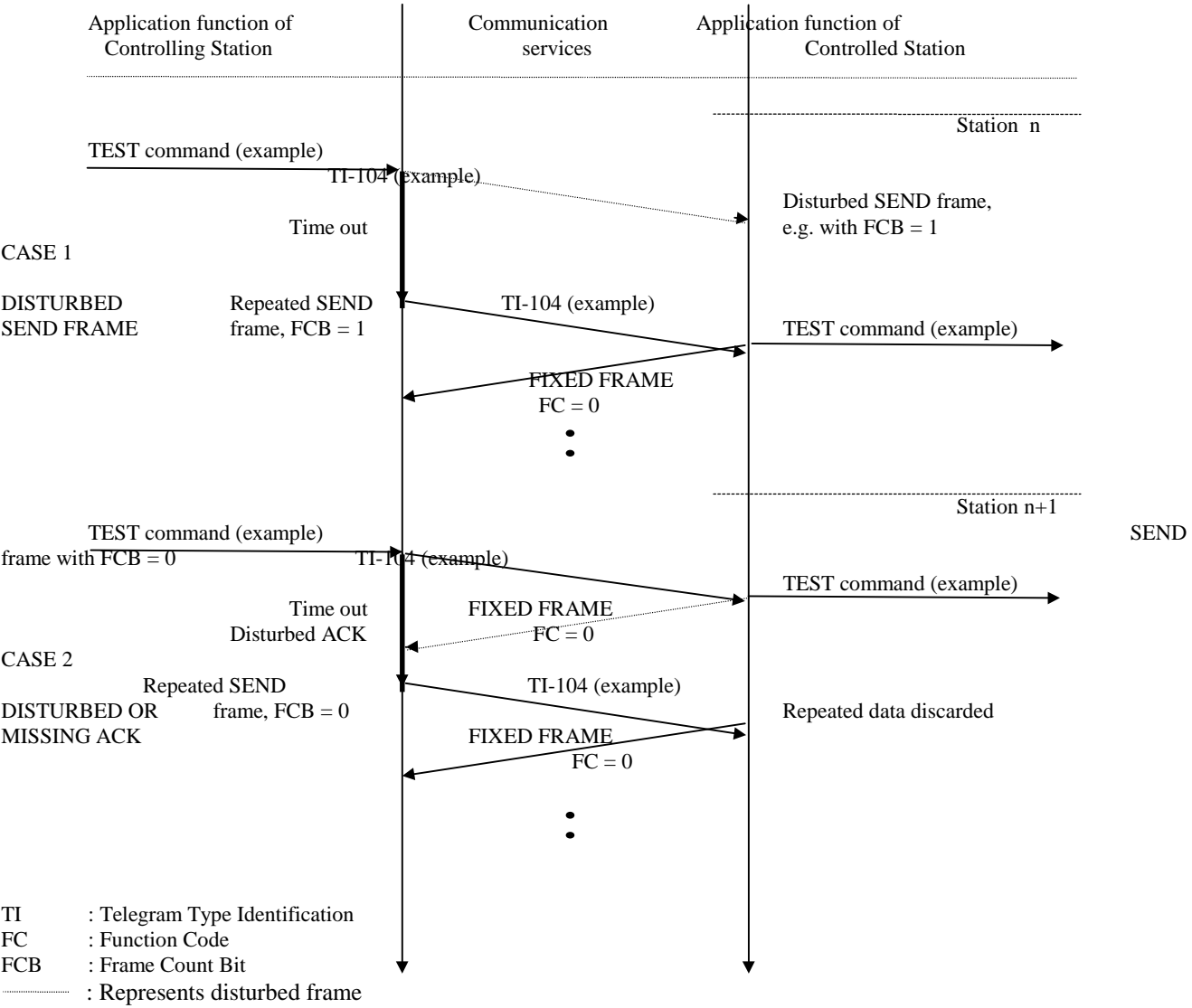


Fig. 6.23 Disturbed send/confirm procedures - unbalanced systems

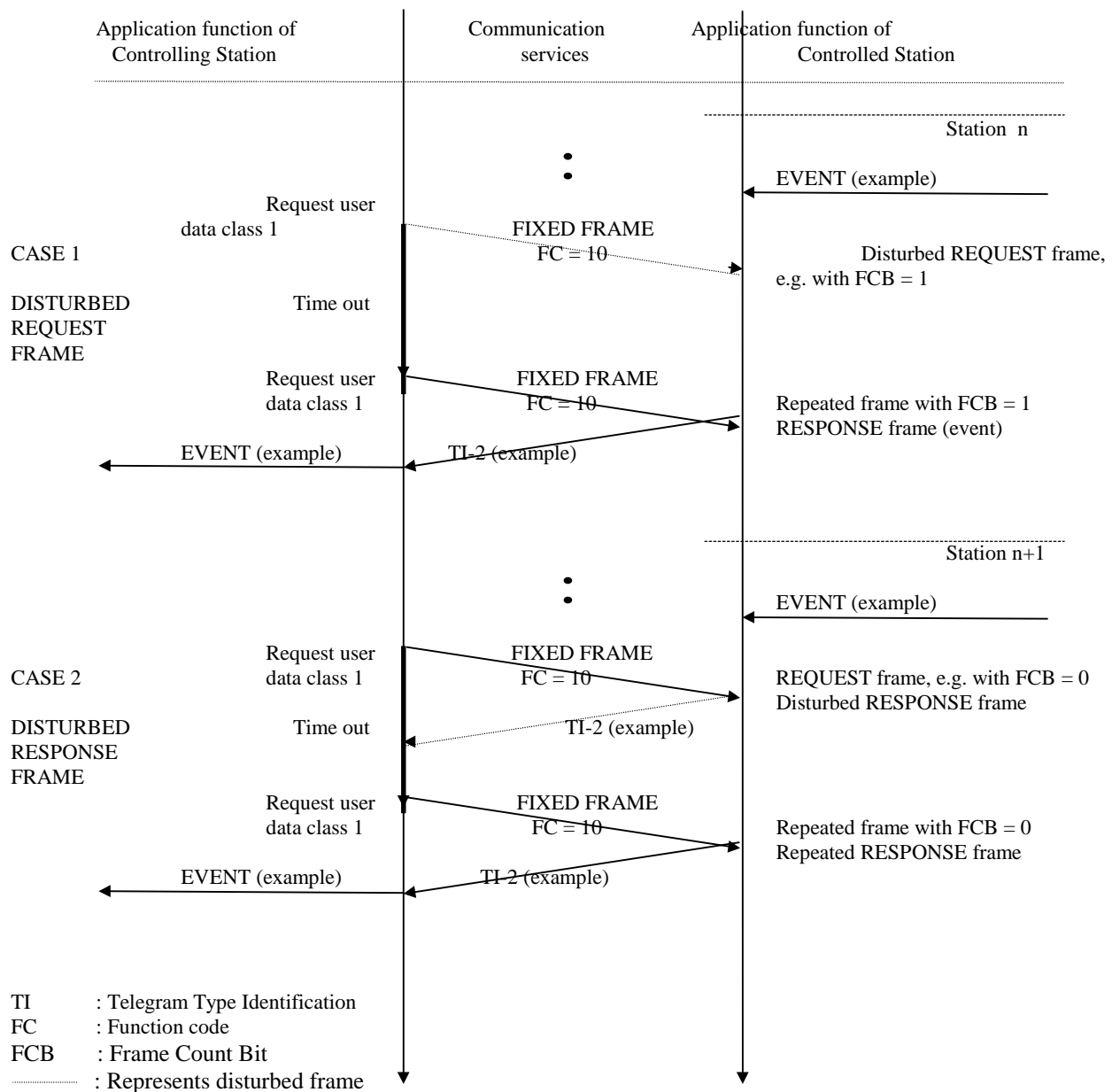


Fig 6.24 Disturbed request/respond procedure - unbalanced systems

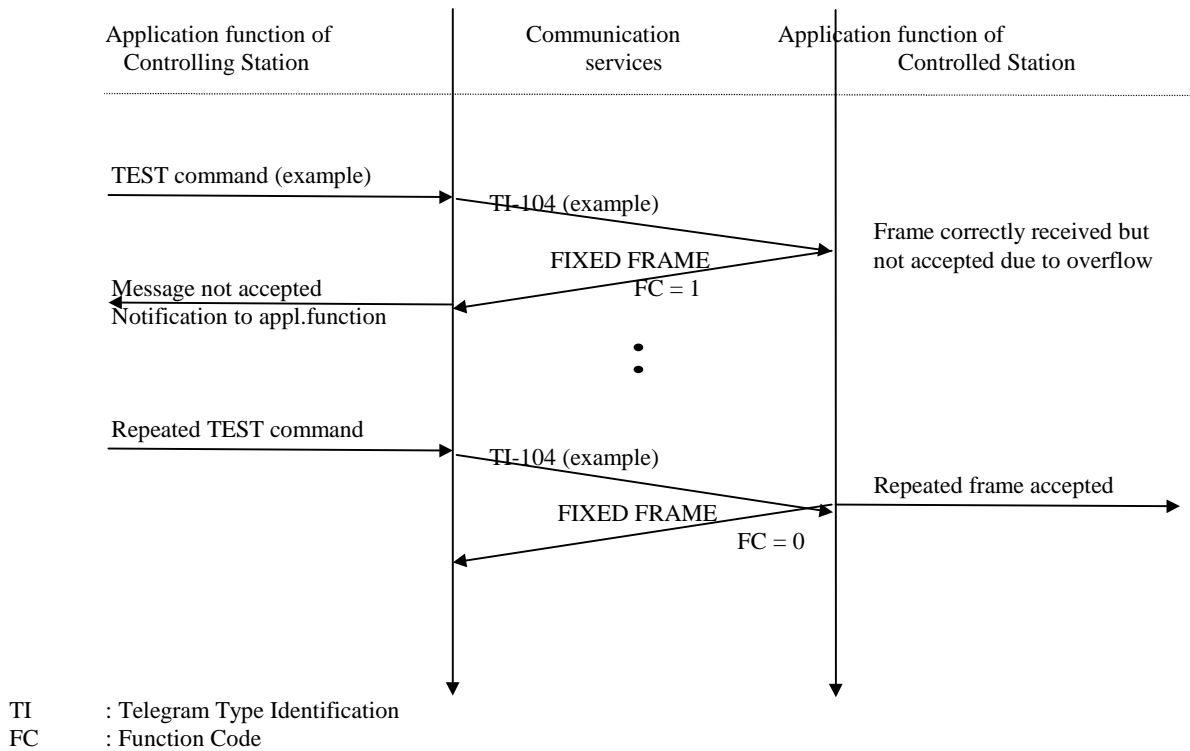


Fig 6.25 Data flow control - unbalanced systems

6.2.1.4 Communication recovery.

If a telegram transfer in either control (send/confirm procedure) or monitoring direction (request/respond procedure) cannot be accomplished within the configured maximum number of retries, the reason might be that either the controlled station or the communication line is down.

The first case requires a station initialisation procedure as described in section 6.1.1.5, while this section describes the similar procedure to recover from a communication line fault.

The recovery procedure is shown in fig. 6.26. The faulty (e.g. disconnected) line causes the TEST command send/confirm procedure to time out due to a missing ACK. This send confirm procedure is retried the configured number of times, before the controlling station starts to transmit "Request status of link" telegrams (retries are not shown in fig. 6.23).

The controlling station continues to send "Request status of link" telegrams (which time out) until the communication line is reconnected. The controlled station then responds with "Status of link", whereafter a "Reset of remote link" procedure follows, and the communication is re-established.

Note that the link telegrams that are used are fixed frame telegrams (ref. sec. 4.1) with Primary Message bit and Function Code as indicated.

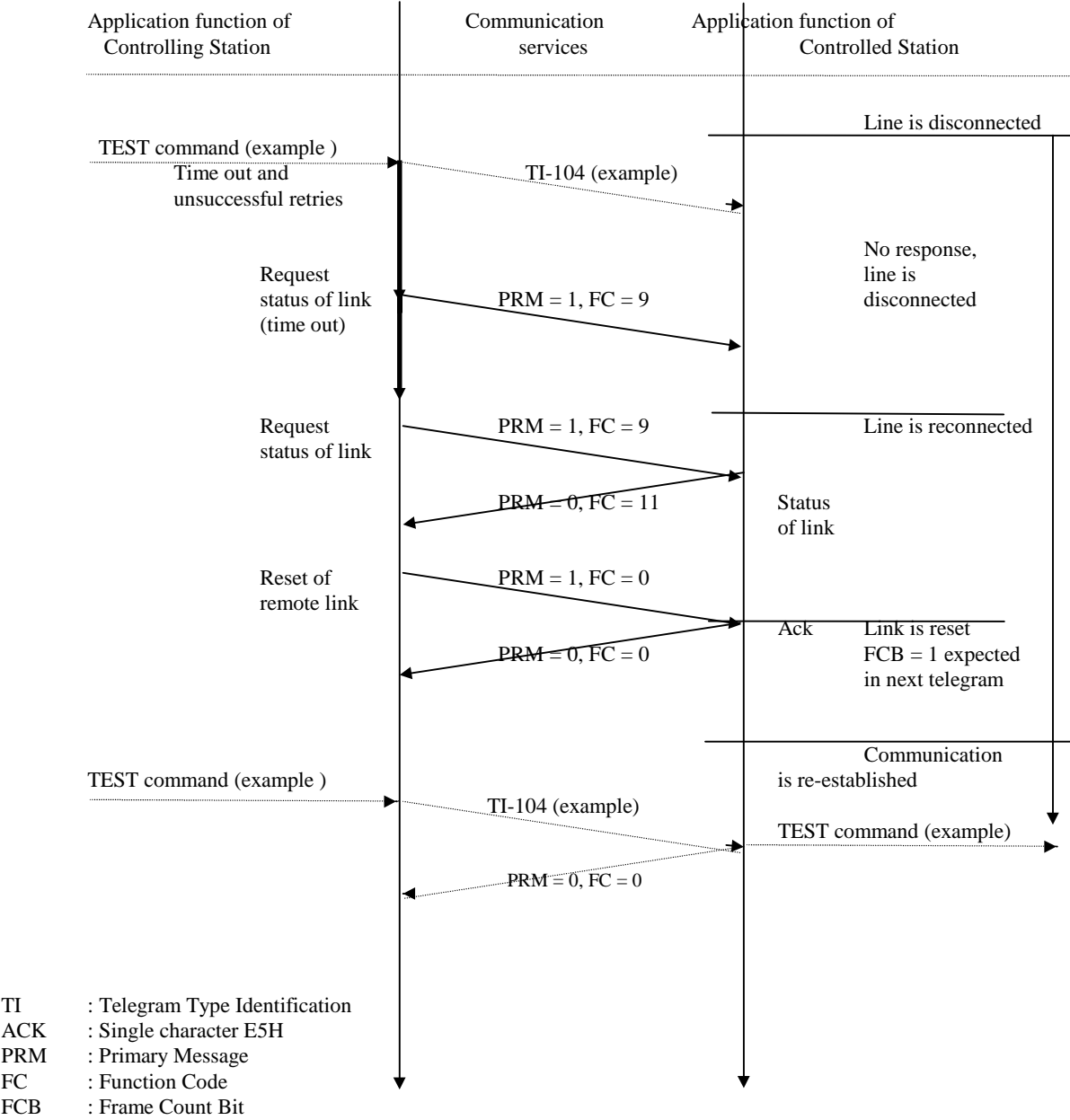


Fig 6.26 Communication recovery - unbalanced systems

6.2.2 Balanced transmission systems

Transmission of user data in both control direction and monitoring direction is always done by means of send/confirm link procedures balanced transmission systems. Balanced transmission systems are restricted to point to point configurations that are equipped with a duplex channel operation, and transmission of messages may take place in both directions simultaneously.

The figures 6.27 to 6.30 illustrate disturbed transmission procedures in balanced systems, using transfer of TEST commands in control direction and transfer of EVENTS in monitoring direction as examples. Additional description of these exception procedures is found in the subsequent sections.

6.2.2.1 Disturbed SEND frame

In fig. 6.27 the SEND frame carrying the event is disturbed when it reaches the controlling station, and hence no CONFIRM is received in the controlled station. The SEND frame is therefore repeated with the same frame count bit (FCB) after time-out.

In case of a disturbed SEND frame the receiving station waits until a specified line idle interval has elapsed before accepting a new frame. Because the TEST command ACK arrives after this interval has elapsed, the simultaneous transfer of the TEST command in control direction is carried out without any error. If the ACK had arrived before the idle time had elapsed it would have been ignored by the controlling station, and also the TEST command telegram would have been retransmitted (but discarded in the controlled station).

6.2.2.2 Disturbed CONFIRM frame

In fig. 6.28 a disturbed CONFIRM frame (ACK) belonging to a transferred EVENT frame is received in the controlled station. The EVENT frame is then retransferred with an unaltered frame count bit (FCB) after time-out.

The simultaneous transfer of the TEST command frame in control direction is not influenced by this erroneous EVENT transfer in the monitoring direction.

6.2.2.3 Disturbed channel in one direction

Fig. 6.29 shows an exception procedure where the channel in one direction (control direction in this example) is temporarily disturbed. Both a CONFIRM frame corresponding to an EVENT transfer and a subsequent TEST command SEND frame in the same direction are corrupted.

In this case both the EVENT frame in monitoring direction and the TEST command frame in control direction are retransmitted with unchanged frame count bit (FCB) after time out.

6.2.2.4 Data flow control

Data flow control is handled by the link layer. Either the controlling or the controlled station may indicate an overflow condition to the opposite station by setting the DFC bit in the control field.

Fig. 6.30 shows how data flow control in monitoring direction can be implemented. In case of a buffer overflow a fixed frame ACK with the data flow control bit (DFC) set in the control byte is returned. The controlled station then starts to transmit periodically the link telegram "Request status of link" until the controlling station indicates by the DFC bit set to 0 in the "Status of link" response that further messages are acceptable.

Note that that the transfer of the TEST command telegram (example) in the control direction is unaffected by the flow control procedure in the monitoring direction.

Data flow control in control direction can be implemented in a similar manner.

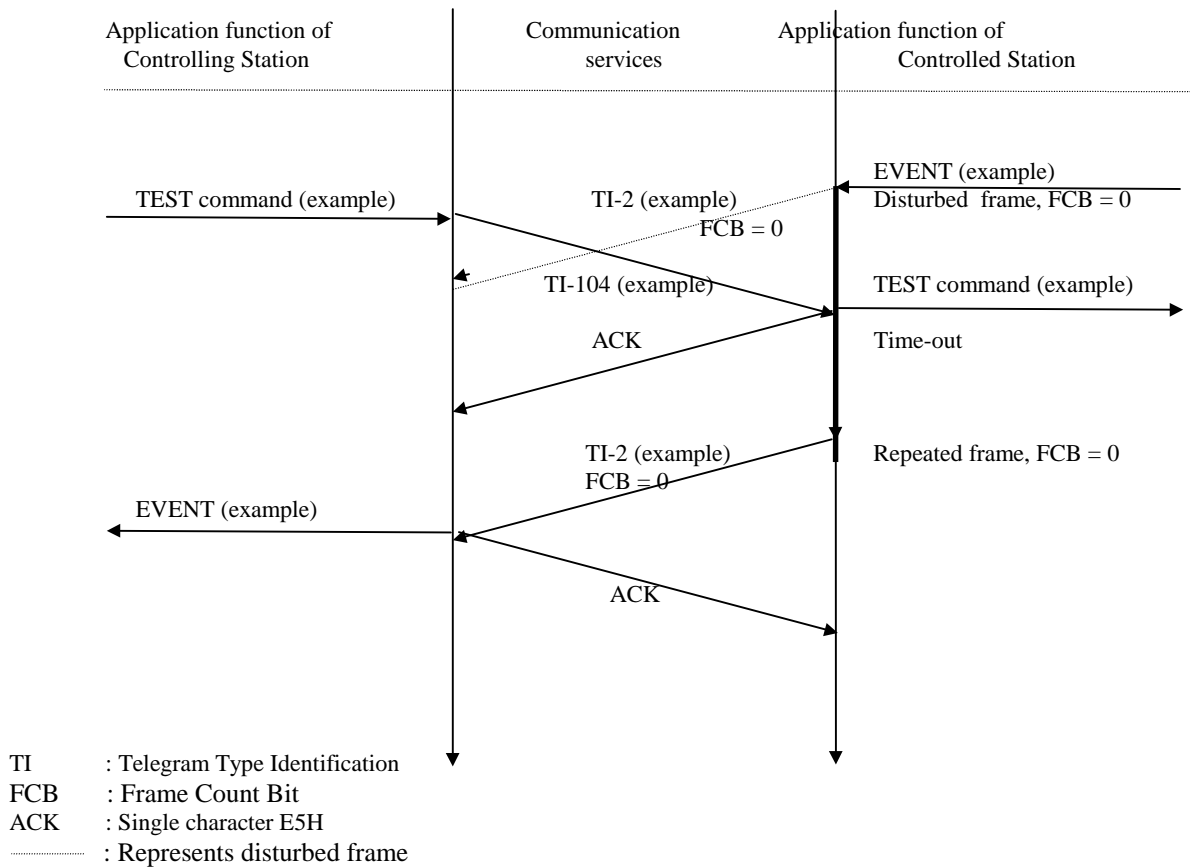


Fig 6.27 Disturbed SEND frame - balanced systems

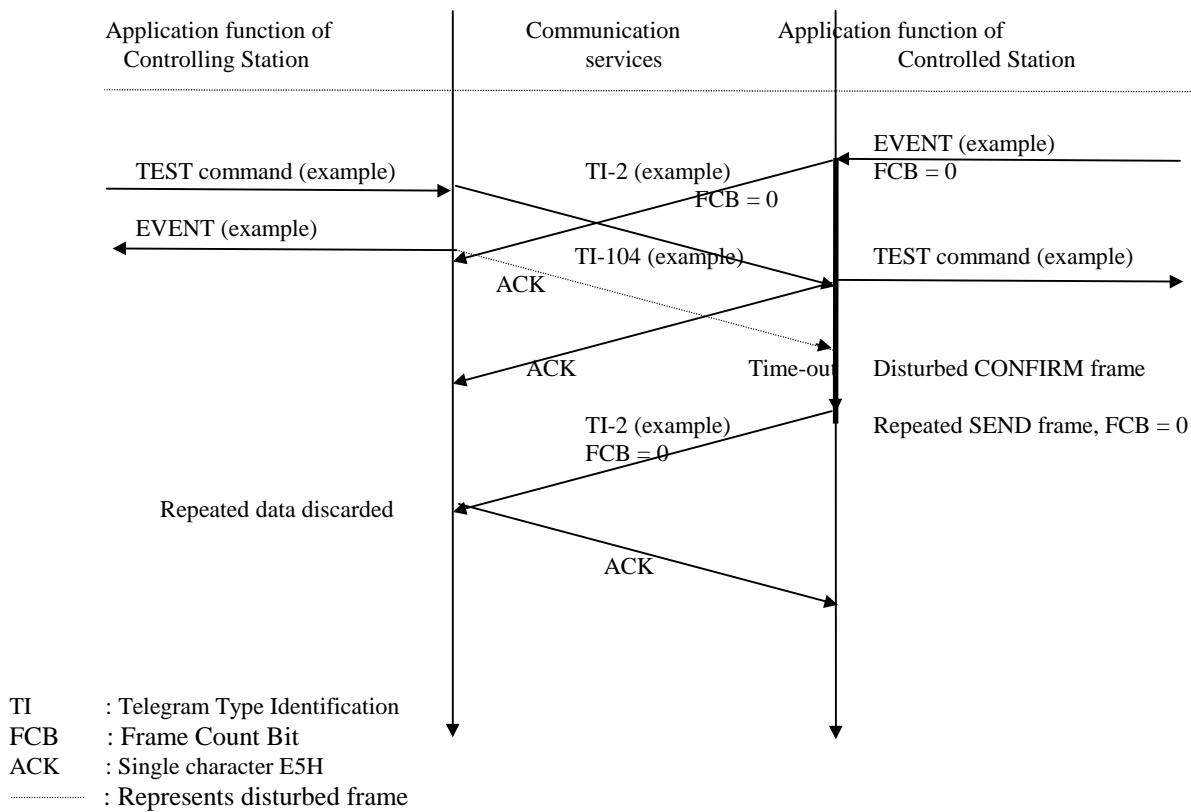


Fig 6.28 *Disturbed CONFIRM frame - balanced systems*

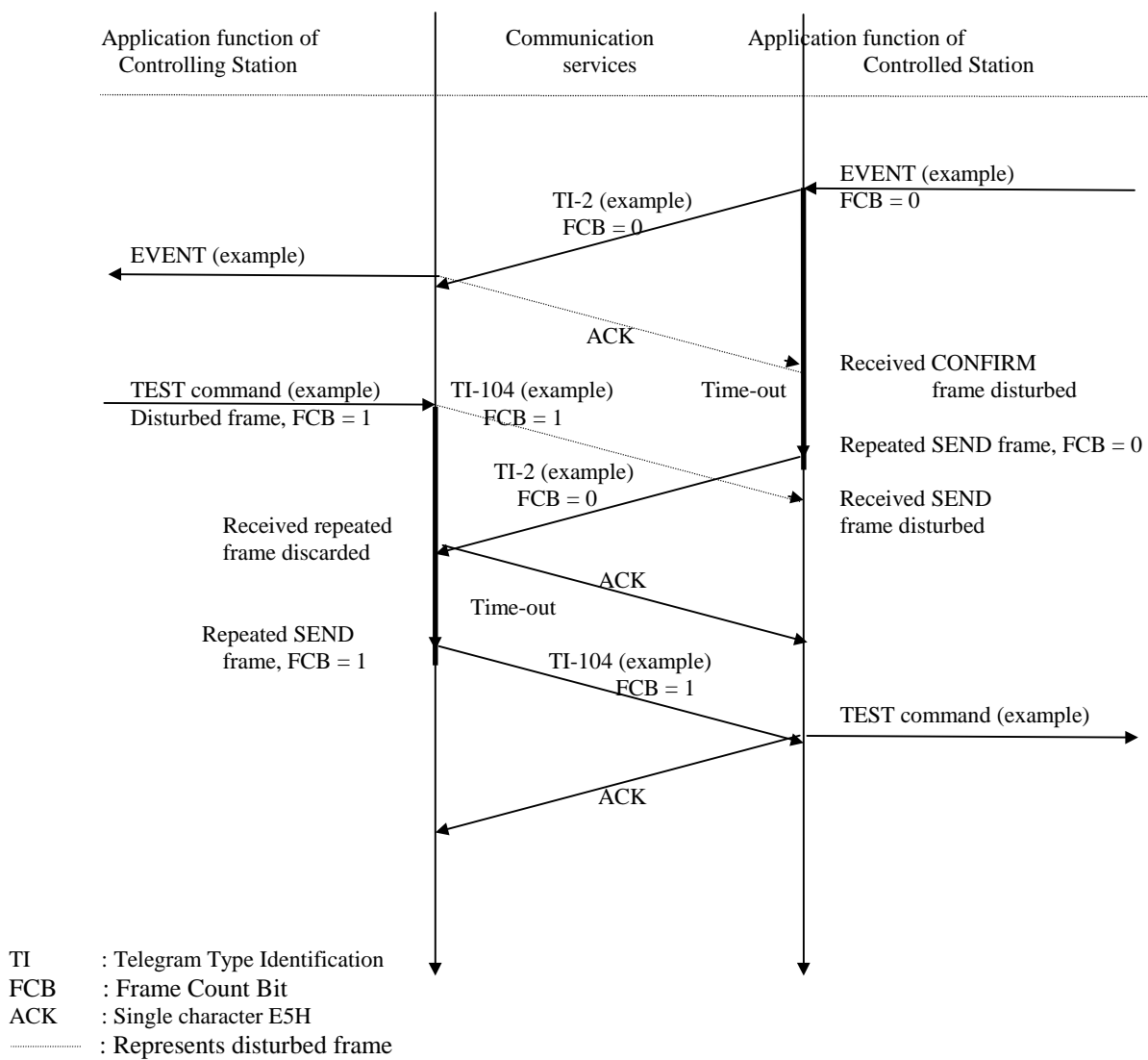


Fig 6.29 *Disturbed channel in one direction - balanced systems*

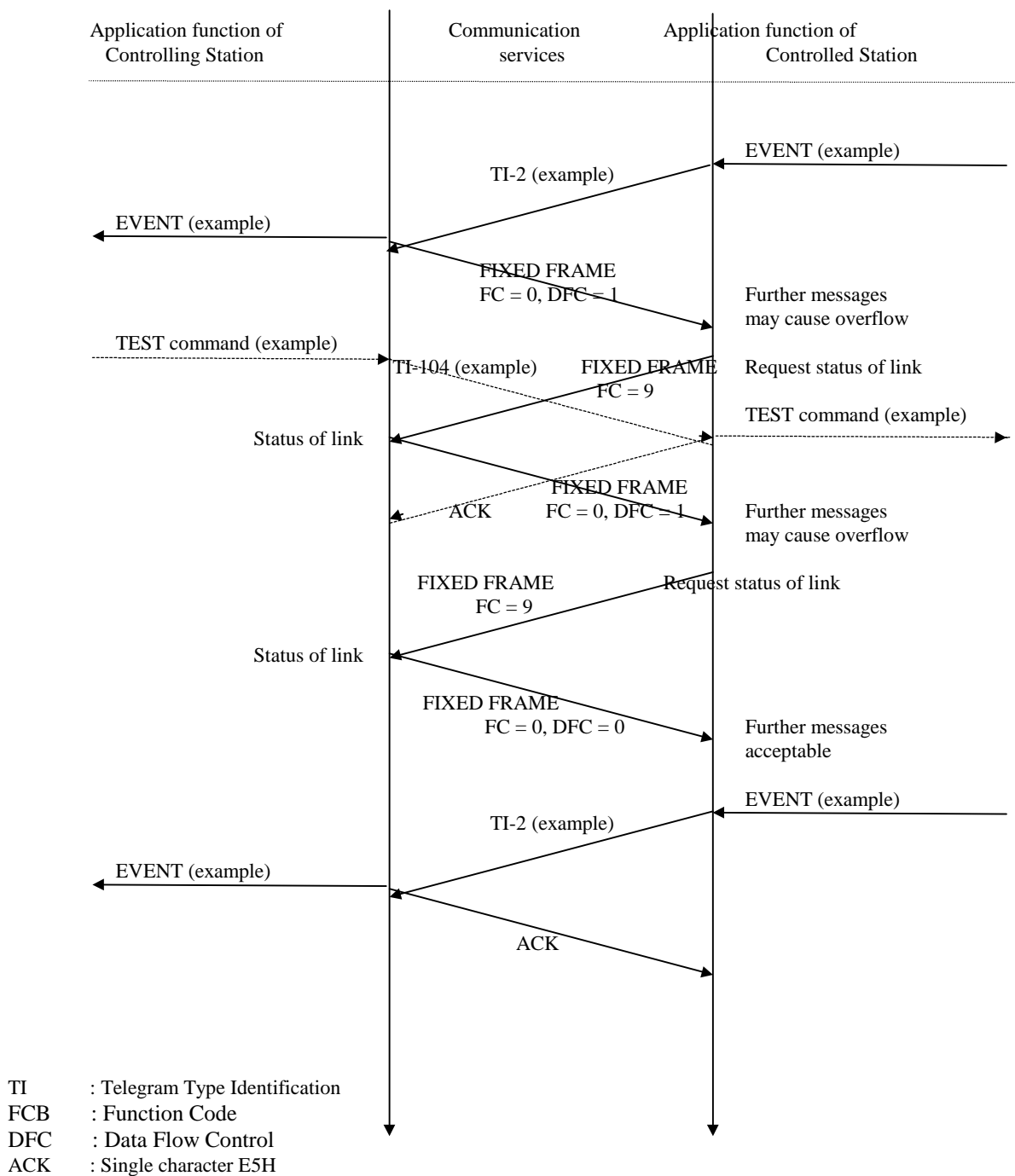


Fig 6.30 Data flow control - balanced systems

6.2.2.5 Communication recovery

If a telegram transfer in either control or monitoring direction (send/confirm procedures) cannot be accomplished within the configured maximum number of retries, the reason might be that either the opposite station or the communication line is down. The first case requires a station initialisation procedure as described in section 6.1.1.4 or 6.1.1.5, while this section describes the similar procedures to recover from a communication line fault.

1. Communication recovery in control direction

The recovery procedure in this case is shown in fig. 6.31. The disconnected line causes the TEST command send/confirm procedure (example) to time out due to missing ACKs. This send/confirm procedure is retried a configurable number of times before the controlling station starts to transmit "Request status of link" telegrams (retries are not shown in fig. 6.31).

The controlling station continues to send "Request status of link" telegrams (which time out) until the communication line is reconnected. The controlled station then responds with "Status of link", whereafter the controlling station transmits a "Reset of remote link" command to reset the link of the controlled station.

When the controlled station has transmitted an "Ack" to confirm that its link has been reset, it initiates a "Reset of remote link" request to reset the link of the controlling station. This request is answered by an "Ack" from the controlling station, whereafter the whole recovery procedure is terminated by a "Request status of link / Status of link" sequence initiated by the controlling station.

2. Communication recovery in monitoring direction

The recovery procedure in this case is shown in fig. 6.32. The event transmission send/confirm procedure (example) initiated by the controlled station times out due to a missing ACK, and the configured number of retries (not shown in fig. 6.32) are executed without any response. The controlled station therefore starts to poll the link of the controlling station by repeatedly transmitting "Request status of link".

When the line is reconnected, the controlled station initiates a reset of the link of the controlling station (via a "Request status of link / Reset of remote link" sequence), which thereafter initiates a reset of the link of the controlled station. The whole communication recovery procedure is terminated when the controlled station has confirmed the reset of its link by an "Ack".

Note that communication recovery in both monitoring and control direction may start and go on simultaneously.

The link telegrams that are used are fixed frame telegrams (ref. sec. 4.1) with Primary Message bit (PRM) and Function Code (FC) as indicated.

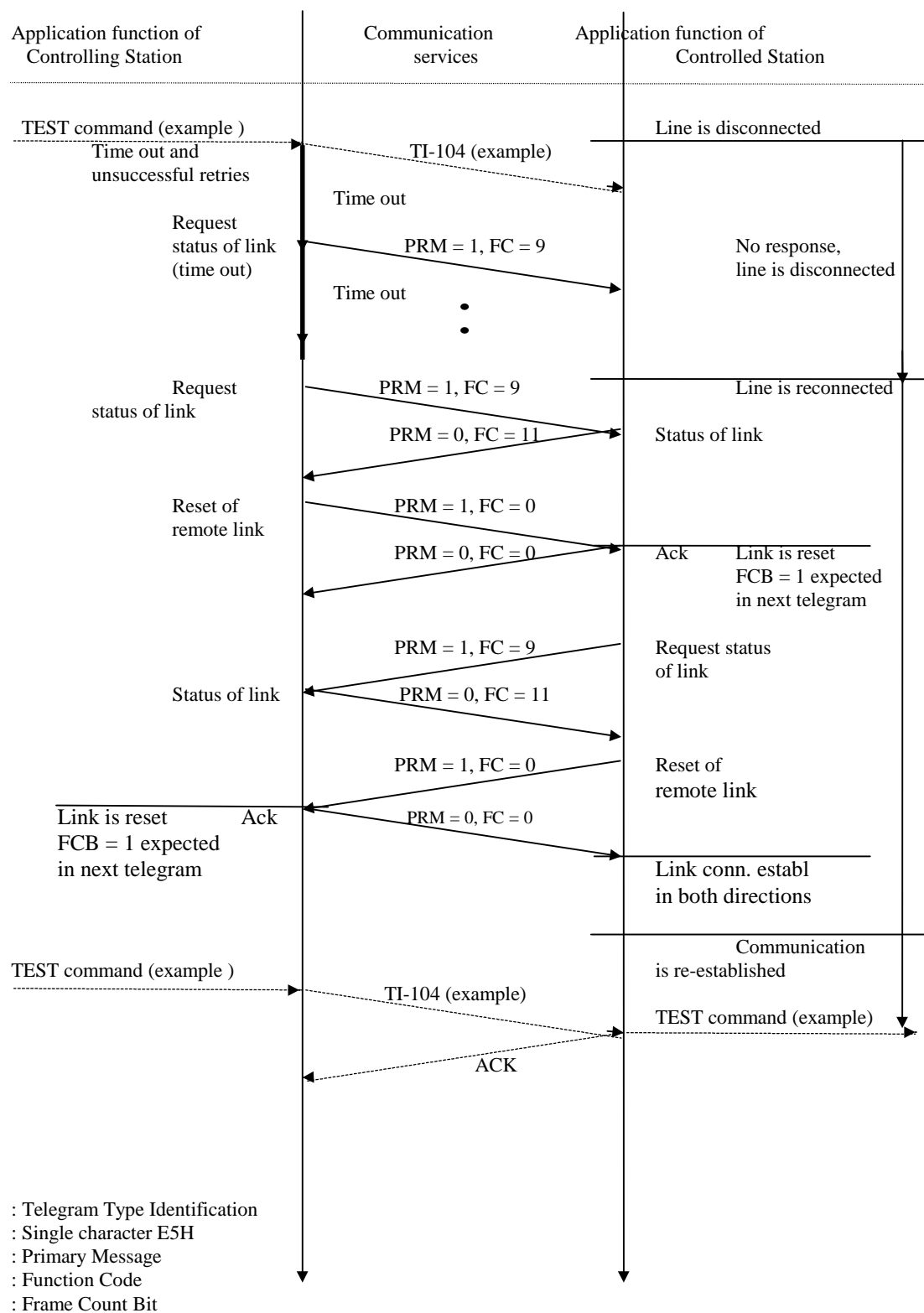


Fig 6.31 *Communication recovery in control direction - balanced systems*

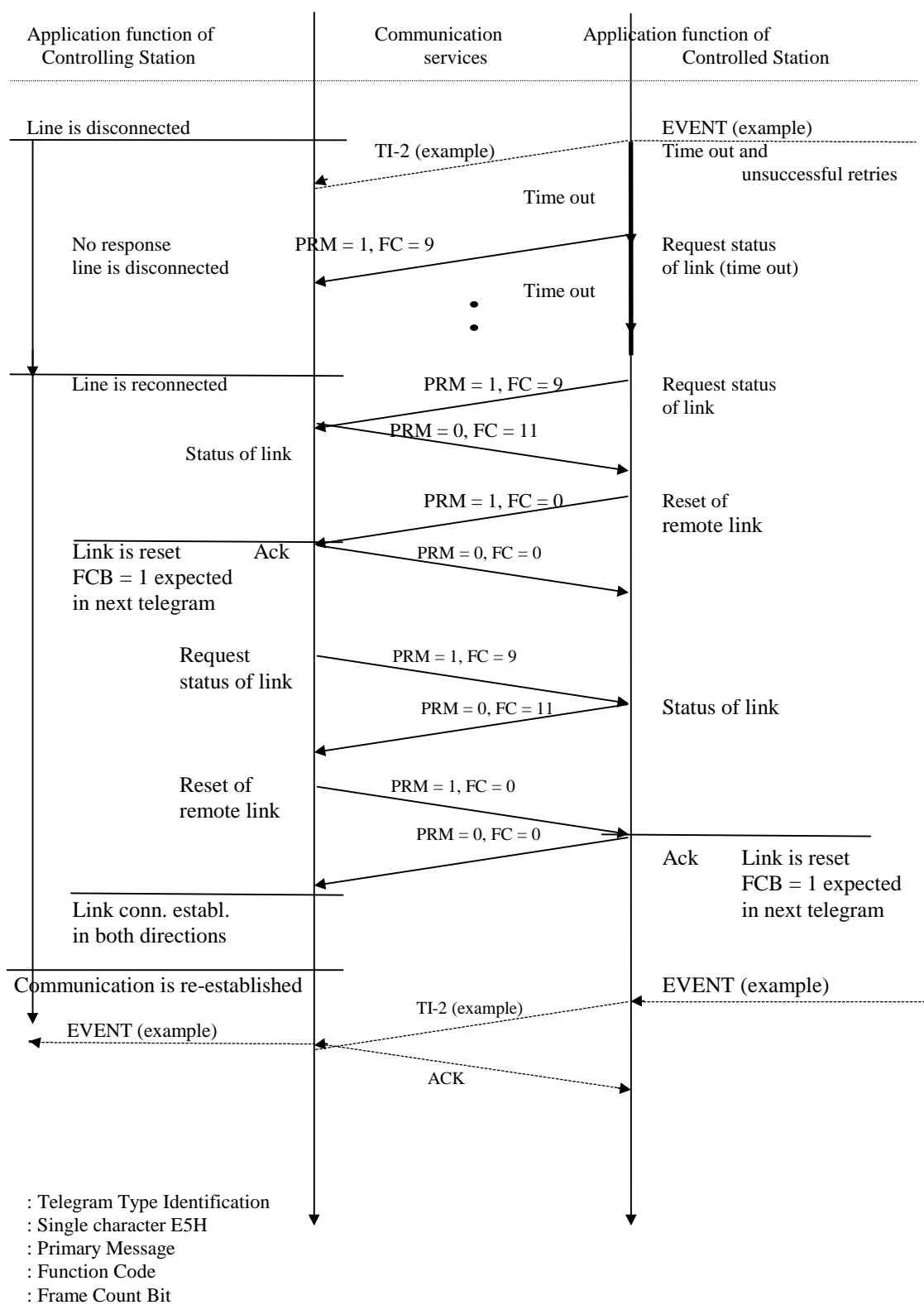


Fig 6.32 Communication recovery in monitoring direction - balanced systems

7 Functions

This chapter contains information about functionality which is not necessarily covered by the standard. However, the functions described in this chapter are functions needed for the Norwegian marked, and thus they should be implemented as described in this chapter.

7.1 Event handling

7.1.1 Transfer of data from Controlled Station to Controlling Station

In the Norwegian user convention Indications and Measured values and Pulse Counters are transferred from Controlled Station to Controlling Station on event basis. Indications after a bit-change, Measured values after passing of dead-band and Pulse Counters after a local freezing. These are the basic functions, but cyclic transfer of Scan Groups can be implemented on project basis. Events will then have higher priority than cyclic transfer and General Interrogation. Events can interrupt an ongoing cyclic transfer or General Interrogation. The Controlled Station algorithm must guarantee that the end-state of all data points after a general Interrogation is correct.

7.1.2 Event Buffers

All event handling in an Controlled Station will be based on event queues, one queue per priority level and a separate one for Pulse Counters. When overflow of a queue occurs one event must be deleted, either the oldest or the newest. Both methods should be implemented and selectable be local parameter. The default will probably be "delete newest" for Measured values and Indications and "delete oldest" for Pulse Counters.

When a buffer overflow occurs an internal Indication (Single Point Indication) shall be sent to the Master Station which decides what to do with the situation, typically a General Interrogation. Recommended Information Object Address (IOA) for this indication is 1.

The description of the event buffers must be understood logically. The actual data structure with corresponding software can be implemented in many ways.

7.1.3 Indications

After a change of state of an Indication the event is transferred **once** with or without time-stamp. The default function will be without time-stamp as a response to a and General Interrogation request and with time-stamp after a change of state event. For this user convention the formats for with full time will be utilised. However transferring without time-stamp in all situations is also a valid function. An Indications address can be represented with multiple entries in a queue.

7.1.4 Measured values

Measurend values can be sent to Controlling Station with or without time-stamp, most often without time-stamp. As a response to general interrogation ASDUs without time stamp are used, and ASDUs with consecutive information object addresses (Sequence of information elements, SQ=1) should be used if possible.

In projects without time-stamp the following function is to prefer. One measured value address shall only have one entry in the queue even if more events are generated before it is transferred to the Controlling Station. Transfer of the latest possible value is always desirable.

In projects where measured values are transferred with local time-stamp the measured values can follow the same functions as Indications with time-stamp with reduced number of entries.

7.1.5 Pulse Counters

Pulse Counters should have a separate queue so that indications and measurand values can not cause overflow for Pulse Counters in case of communication break. Since Pulse Counters is often used for settlement of accounts it should be possible to guarantee storing of Pulse Counters for a certain time period. The default function is "delete oldest" when an overflow occurs. The standard event criterion is freezing of values after elapsing of a local timer. Other criteria are possible and does not affect the further event handling and transferring to Controlling Station.

7.1.6 Priorities

An Controlled Station should support a number priorities at least Station with a certain amount of data points. The highest or more priorities can be mapped to class 1 (polling telegram for unbalanced mode) and the rest to class 2. Alternatively all priorities can be mapped to class 2 since this is most efficient.

In an event driven protocol like IEC870-5-101 the Controlled Station decides the sequence of data to be sent to the Master Station. The algorithm must guarantee that high priority events does not totally block events from lower priorities.

7.2 Redundant lines

A general requirement in Norway is that the redundant lines may operate at very different baud rates. The requirements for this function are influenced by this fact.

7.2.1 Unbalanced mode

7.2.1.1 General requirements

- After start-up of the Controlling Station, the Controlling Station starts the links with the link-telegram "Request Status of Link" on both links. Controlling Station decides which line to use as primary line fulfil the start-up procedure on this line.
- After restart of the Controlled Station it waits for initiative from the Controlling Station. When the Controlling Station is ready it will follow the procedure in the previous point. The Controlled Station understands the line on which it receives a "Reset of remote link" as the primary line.
- For supervising the backup line the Controlling Station sends "Request Status of Link" link-telegram cyclically on the backup line.
- When the Controlling Station loses contact on the primary line or if the Controlling Station wants to change line for other reasons, it sends a "Reset of Remote Link" and then starts polling on the other line and this line will now by definition become primary line.
- The Controlled Station must guarantee that events are not lost during a switching of line. This means that an event must be explicitly acknowledged by the Controlling Station before it is deleted in the Controlled Station. In unbalanced mode an event is acknowledged by the Controlling station when the Controlled station receives a new message (request) with an altered FCB bit. It is not necessary to perform a full General Interrogation after switching lines or after a communication break, but the Controlling Station can decide to do so.

7.2.1.2 Initialisation

- After startup of the Controlling station, the Controlling Station sends a "Request Status of Link" on both channels. The Controlled Station will reply with a "Status of Link" message to each of the "Request Status of Link" messages.
- The Controlling Station will then determine which channel to use as the primary channel and send a "Reset of Remote Link" on the primary channel. The Controlling Station will continue to send a "Request Status of Link" message on the backup channel cyclically. The Controlled Station will send a "Fixed frame confirmation (ACK)" message in response to the "Reset of Remote Link" message on the primary channel.
- The Controlling Station will then send a "Poll Request" on the primary channel and the polling sequence has begun.
- The Controlling Station will continue to send "Request Status of Link" messages on the backup channel and the Controlled Station will reply to each with a "Status of Link" message.
- The polling sequence will continue until there is an interruption of a channel.

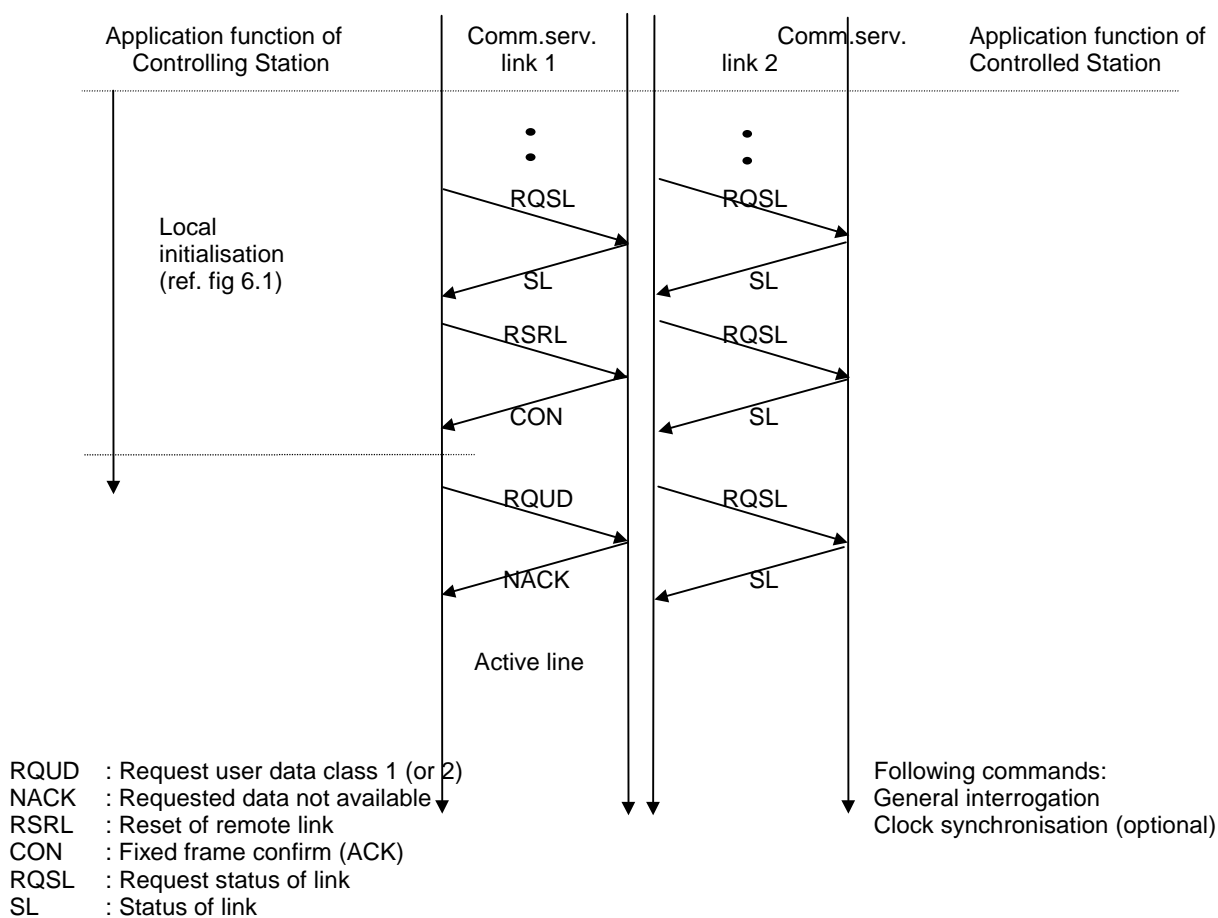


Fig 7.1 Initialisation of controlling station with redundant lines - unbalanced systems

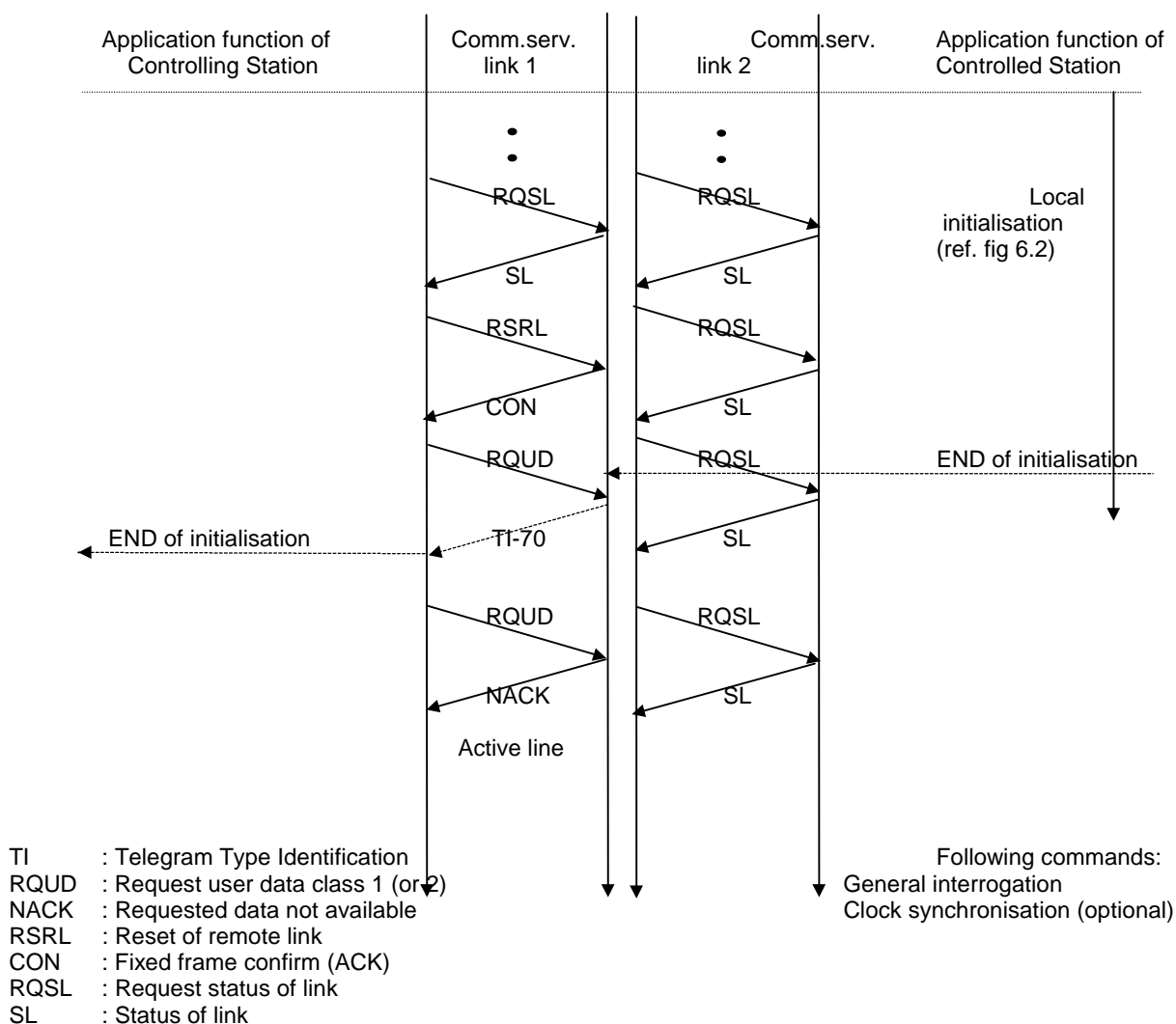


Fig 7.2 Initialisation of controlled station with redundant lines - unbalanced systems

7.2.1.3 Automatic line switch

- If the primary channel is interrupted then the Controlling Station will mark the primary channel down and send a "Reset of Remote Link" message to the Controlled station over the backup channel. The Controlling Station will not consider the data as "Not Renewed" at this point since the backup channel is available. The data will be marked as "Not Renewed" if the backup channel also does not get any response to its messages.
- The Controlled Station will respond to the "Reset of Remote Link" message with a Fixed frame confirm (ACK) message.
- The Controlling Station will then send a "Poll Request" and the polling sequence has been restarted on the new primary channel.
- Once the new primary channel has established the polling sequence the Controlling Station will begin sending a "Request Status of Link" message on the channel which lost communication with the Controlled Station .

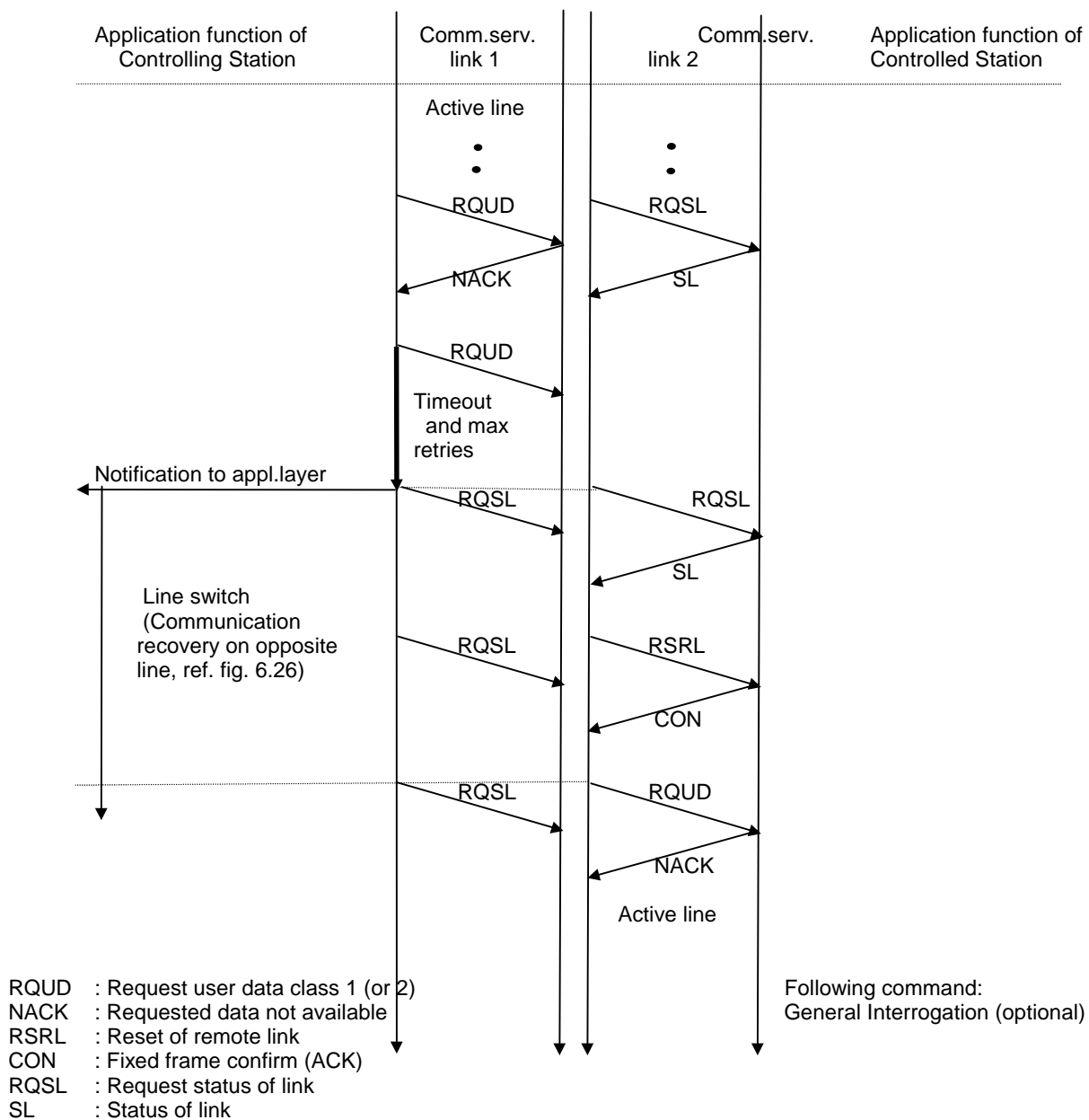


Fig 7.3 Redundant lines, automatic line switch - unbalanced systems

7.2.1.4 Application initiated line switch

- If the Controlling Station has a primary and a backup channel connected and wishes to switch the channels so that the current backup channel is primary, the Controlling Station will wait until there are no outstanding commands and then send a "Reset of Remote Link" message over the primary channel. The Controlling Station will not consider the data as "Not Renewed" at this point since the backup channel is available. The data will be marked as "Not Renewed" if the backup channel does not get any response to its messages.
- The Controlled Station will then send a Fixed frame confirm (ACK) in response to the "Reset of Remote Link" messages.
- The Controlling Station will then send a "Poll Request" and the polling sequence has been restarted on the new primary channel.
- The Controlling Station will continue to send a "Request Status of Link" on the backup channel cyclically.

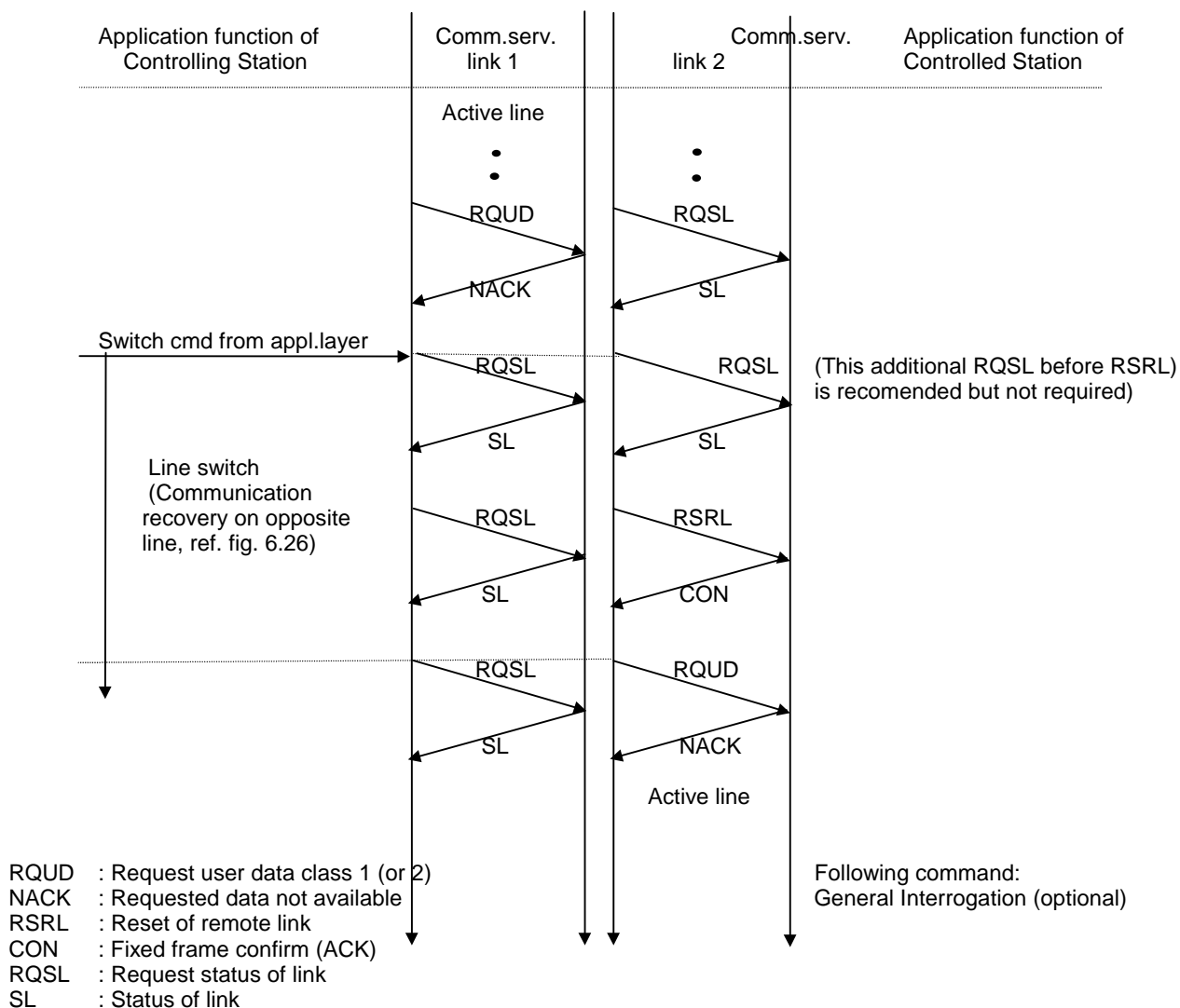


Fig 7.4 Redundant lines, application initiated line switch - unbalanced systems

7.2.2 Balanced mode

7.2.2.1 General requirements

Redundant communication implies the use of two separate communication lines. One line is defined to be the main communication line while the other line is a backup line.

The backup line will typically operate at a different (slower) communication speed than the main line. A possible solution is therefore to have two separate protocol links in each station (with identical link addresses) to handle the communication. The line (link) which is used for communication at any time is defined to be the active line (link).

Selection and switch of active line is the responsibility of the controlling station, and may be performed either automatically or manually, by e.g. the application layer or the user process. The controlled station always understands the line on which it received the last ASDU (application telegram) as the active line.

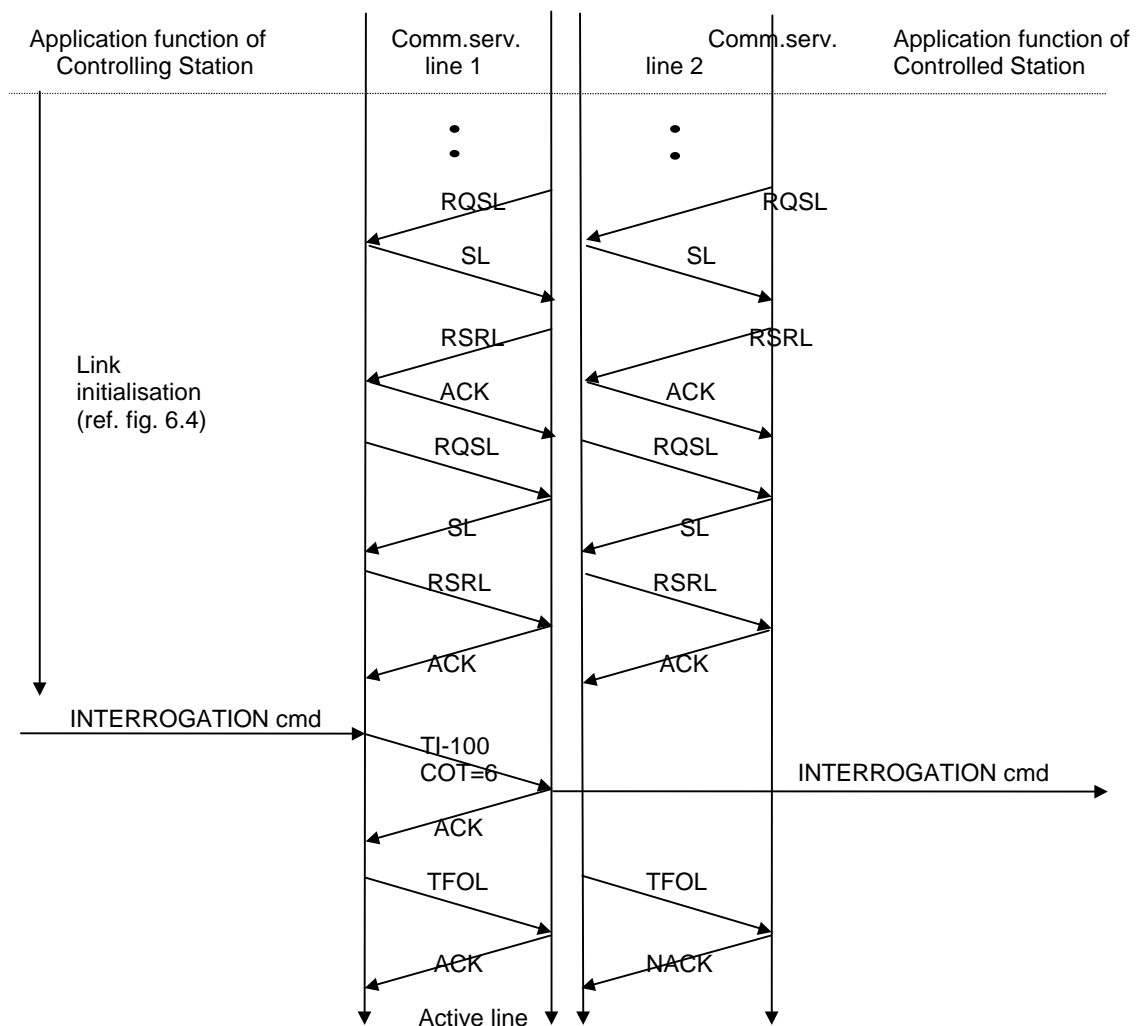
The link telegram "Test Function of Link" is transmitted periodically in control direction on both lines to supervise the status of the lines. An ACK will be received on the line which is defined to be the active line in the controlled station, and a NACK will be received on the passive line. If no response is received on a line, either the line or the controlled station is down. This link test procedure may also be performed periodically by the controlled station.

With respect to the figures 7.5 to 7.8 used to illustrate communication sequences it should be noted that the corresponding confirmation ASDUs from the controlled station to the command ASDUs from the controlling station are not shown in the figures.

7.2.2.2 Initialisation of controlling station

The sequential procedure for initialisation of the controlling station with redundant lines is shown in fig. 7.5.

After restart of the controlling station, link connection is (attempted) established in both directions on both lines according to the procedure described in section 6.1.1.4. Both links of the controlling station may by default be defined to be passive at the moment the link layer is available after a restart. An arbitrary ASDU, e.g. the mandatory INTERROGATION command, is therefore transmitted to define the active line (link).



TI : Telegram Type Identification
 ACK : Single character or fixed frame ACK
 COT : Cause of transmission
 RSRL : Reset of remote link
 RQSL : Request status of link
 SL : Status of link
 TFOL : Test function of link (FC=2)
 NACK : Message not accepted (FC=1)

Following command:
 Clock synchronisation (optional)

Fig. 7.5 Initialisation of controlling station with redundant lines - balanced systems

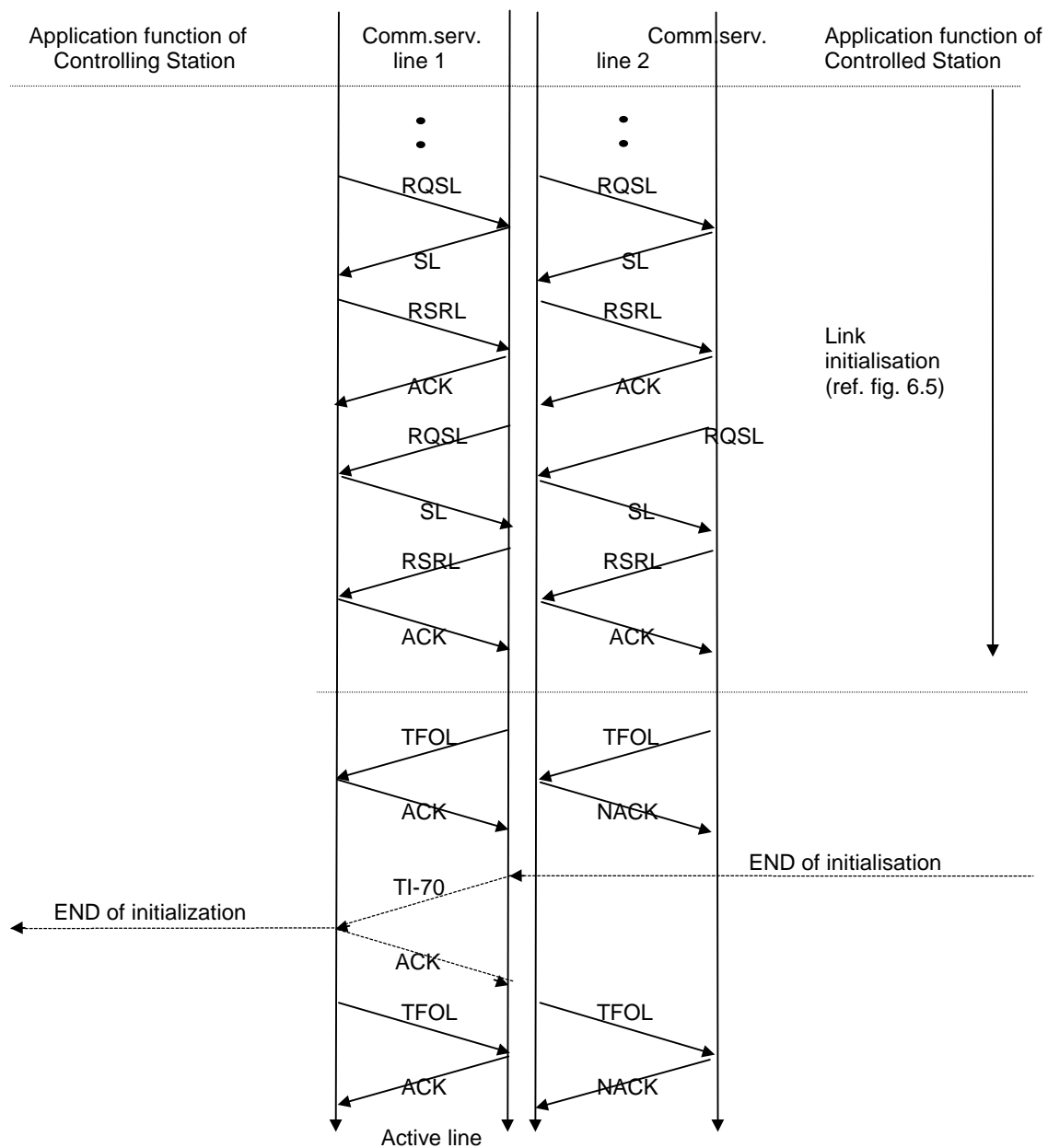
7.2.2.3 Initialisation of controlled station

The sequential procedure for initialisation of the controlled station with redundant lines is shown in fig. 7.6.

Link connection is (attempted) established in both directions on both lines according to the procedure described in section 6.1.1.5 (or 6.1.1.6 if remote initialisation). Both links of the controlled station are by default defined to be passive at the moment the link layer is available after a restart. The controlled station therefore starts to transmit the link telegram "Test Function of Link" cyclically on both lines to determine which line is the active line. The controlling station responds with ACK if a line is active and NACK if it is passive. "Test Function of Link" must hence be repeated until ACK is received on either line, or an arbitrary ASDU is received that defines the active line.

An END OF INITIALISATION message is then transmitted from the controlled station on the active line, and any subsequent user data will be transmitted on the same line.

In general "Test Function of Link" may be sent any time by the controlled station to verify which line is the active line.



TI : Telegram Type Identification
 ACK : Single character or fixed frame ACK
 COT : Cause of transmission
 RSRL : Reset of remote link
 RQSL : Request status of link
 SL : Status of link
 TFOL : Test function of link (FC=2)
 NACK : Message not accepted (FC=1)

Following commands:
 General interrogation
 Clock synchronisation (optional)

Fig 7.6 Initialisation of controlled station with redundant lines - balanced systems

7.2.2.4 User data from controlling station (commands)

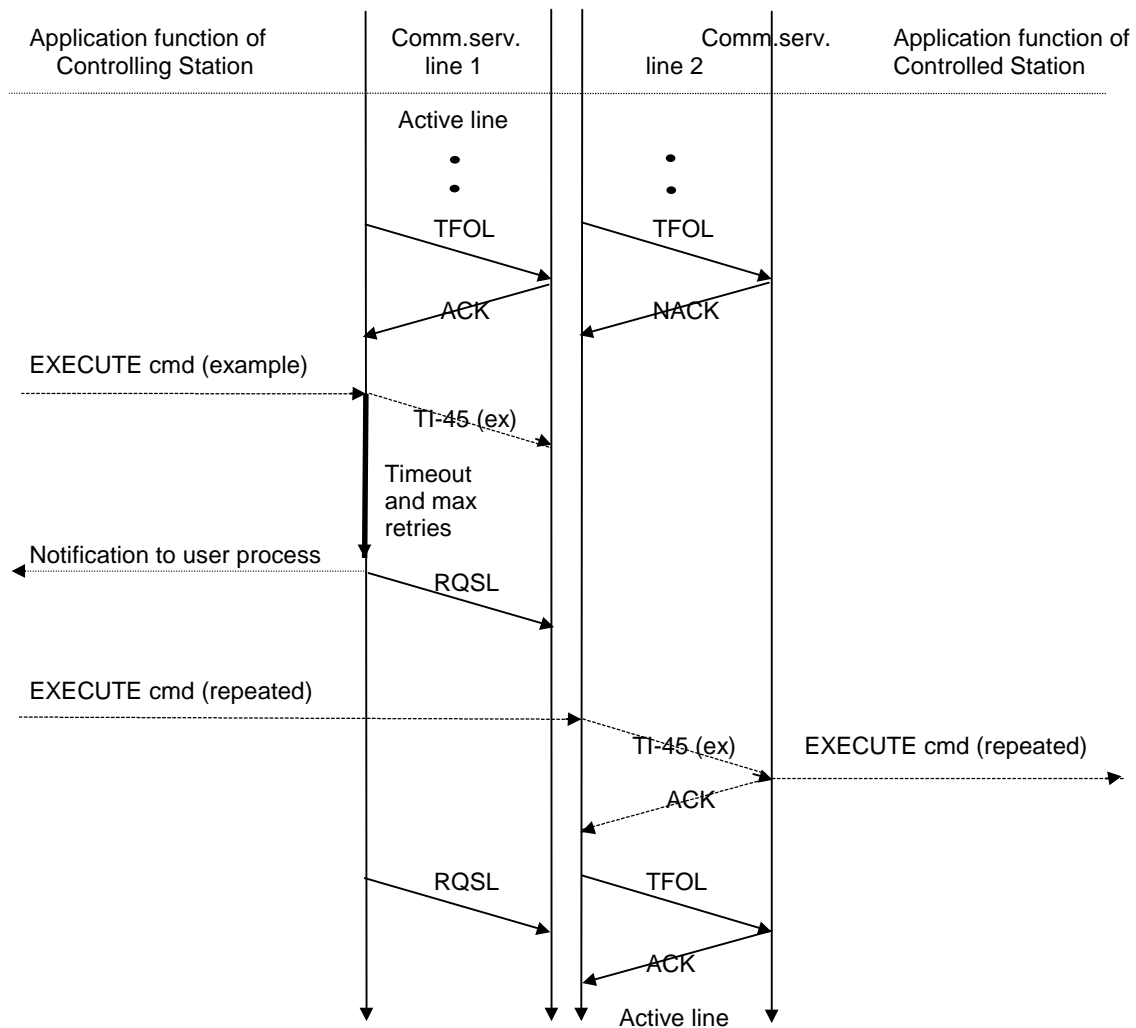
If communication fails on the active line when the controlling station attempts to transmit user data (e.g. a command transmission ASDU), a line switch will be performed. The sequential procedure in this case is shown in fig. 7.7.

When timeout after maximum transmission retries has elapsed, the ASDU is directed to the opposite line, either by retransmitting the ASDU on the opposite line or by terminating the ongoing application function and reinitiating it towards the opposite line (ref. fig. 7.7). The opposite line is then defined to be the new active line.

A line switch will also be performed whenever the periodic line check procedure on the active line (Test Function of Link) times out after maximum transmission retries, and hence reports a communication failure on the active line. An arbitrary ASDU, e.g. a TEST command or an INTERROGATION command, will then be transmitted on the opposite line to define it as the new active line.

A recommended interval for the periodic line check procedure is 10-20 seconds. To speed up the detection of failures on the active line, however, the check interval on this line should be reduced after e.g. 2 seconds of no traffic.

When the controlling station transmits "Test function of link" to check the lines, the controlled station may respond by a NACK on both lines to tell the controlling station that it does not know which line is the active line. In this case the controlling station may send an arbitrary ASDU (e.g. a TEST command) on the active line.



TI : Telegram Type Identification
 ACK : Single character or fixed frame ACK
 COT : Cause of transmission
 RQSL : Request status of link
 TFOL : Test function of link (FC=2)
 NACK : Message not accepted (FC=1)

Fig 7.7 Redundant lines, user data from controlling station - balanced systems

7.2.2.5 User data from controlled station

If communication fails on the active line when the controlled station attempts to transmit user data (e.g. an event ASDU), the controlled station must wait for the controlling station to detect the failure and perform a line switch before the ASDU may be retransmitted on the opposite line. A sequential procedure to illustrate this case is shown in fig. 7.8.

When timeout after maximum transmission retries has elapsed, the controlled station will start to transmit "Request Status of Link" periodically on the failed active line, according to standard procedure. Depending on the frequency of the periodic line check, however, the controlling station will eventually detect the failure and will switch lines by transmitting e.g. a TEST command or an INTERROGATION command on the opposite line. Upon reception of this command in the controlled station, the opposite line will be defined as the new active line. Any ASDU waiting for transfer will then be retransmitted on the new active line.

Whenever the active line fails during user data transfer, the controlled station will also start to transmit "Test Function of Link" cyclically on the opposite line. The controlling station may always use the reception of this telegram on any line to immediately force a line check on both lines, and hence perform a line switch as a result of this if necessary.

So long as the active line remains inoperative, the cyclic line check performed by the controlled station on the opposite line will continue until either an ACK is received or an ASDU is received to define the opposite line as the new active line. If however, communication on the failed active line recovers before any ASDU is received on the opposite line to switch lines, the controlled station will transmit "Test Function of Link" cyclically on both lines to verify which line is the active line. If then the recovered line is still the active line in the controlling station, the controlling station will respond with an ACK on this line, and any ASDU waiting for transfer will be retransmitted on this line without any line switch having been performed.

The controlling station will only accept user data on the active line as valid data. If an ASDU is received on a line that is passive, the controlling station will respond with a NACK. This does, however, not state anything about which line is active or passive.

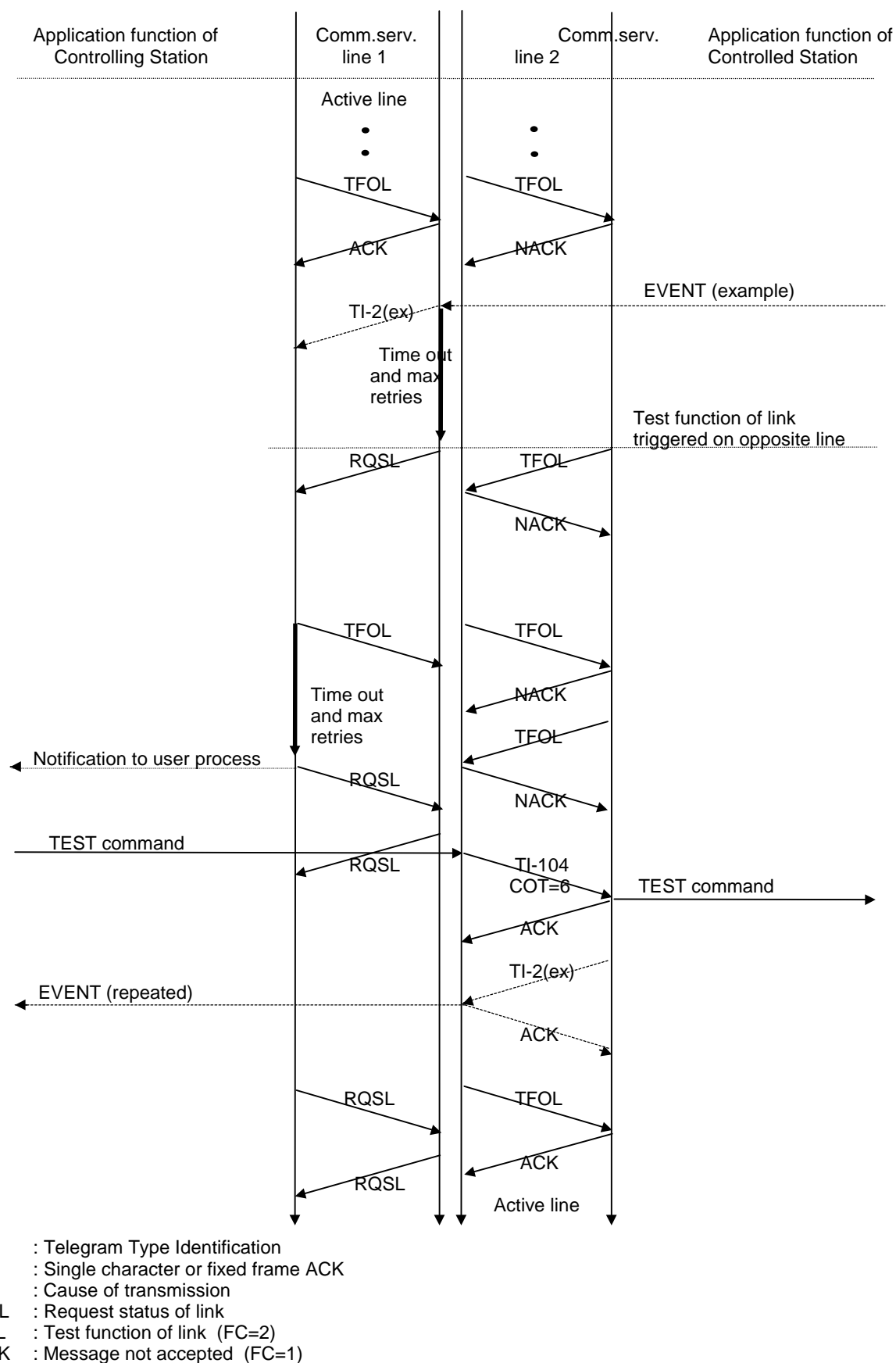


Fig 7.8 Redundant lines, user data from controlled station - balanced systems

7.3 Addressing

There are 3 levels of addresses in the IEC870-5-101 protocol. Valid ranges are defined in chapter 4.

7.3.1 Link Address

The link address is a number for a communication link which is used for the communication lines out from a Controlling Station. It is only used as an address in the communication network itself, and shall **not** be a part of total address of a data point. According to the standard this parameter can consist of 0,1 or 2 octets. 0 is valid only for balanced mode. According to the Norwegian user convention **1 octet** shall be used.

7.3.2 Common Address of ASDU

The Common Address of ASDU is common number used for all objects in one Controlled Station. One Controlled Station can be either an entire Station Control System or only a part of it. According to the standard this parameter can consist of 1 or 2 octets. According to the Norwegian user convention **1 octet** shall be used.

7.3.3 Information Object Address

The Information Object Address is a number given to each data point or object within one Controlled Station and is common for all data types. According to the standard this parameter can consist of 1,2 or 3 octets. According to the Norwegian user convention **2 octets** shall be used.

7.3.4 Addressing rules

All the addresses can be set to any valid number, but these rules must be noted:

- Link address is only used by the communication equipment.
- Under one link or line from a Controlling Station the total address built together by the Common Address of ASDU and Information Object Address shall be a unique identifier for all data points (objects).

7.3.5 Possible addressing conventions

A modern Station Control System often consists of a common communication equipment, several bay controllers and a number of Protection units. Each of them can consist of a number of objects. The IEC870-5-101 standard gives no rules for how addresses are given to all these objects as long as the above limitations are followed. Any structure using Common Address of ASDU and Information Object Address fields are allowed, but there are advantages to follow some conventions within a project to reduce engineering costs. These conventions must be agreed upon for each project because this user convention does not give any further rules. Here some possible structures are described.

- For traditional RTUs with I/O boards etc. one Common Address of ASDU number is used and all the objects within the RTU is given a unique Information Object Address. Each data type is given a range within the two octets.
- For a Station Control System the entire system is given one Common Address of ASDU. One of the two octets in the Information Object Address is used to identify each Bay Controller or Protection Unit. The other octet is used to identify each object within one unit.
- For a Station Control System each Bay Controller or Protection Unit is given a separate Common Address of ASDU. The objects within one unit is identified by the Information Object Address field.

7.4 Internal events

System events in the controlled station.

In the controlled station it could be integrated a lot of system events.

If the system events should be transferred to the controlling station it has to be done with standard ASDUs. It is not reserved special frames for internal events in the IEC 870-5-101 protocol.

The Norwegian user conventions does not specify any system events from controlled station.

Each project have to implement the system events witch is necessary for the correct functionality.

7.5 Parameter loading

Parameter loading is used to change predefined parameters in the controlled station.

The parameters can only be transmitted from the controlling station as a result of a operation from the operator.

In the controlled station the parameters is activated immediately after being checked for feasibility and accepted as having valid value.

In either case (positive or negative acceptance) the parameter value is returned to the controlled station to indicate that the (new or old) parameter is in operation.

The new parameter is stored in the controlled station. After initialisation of the controlled station, the last active value will be maintained.

7.6 Frame length

The frame length have to be a parameter in the controlled station.

The maximum frame length is 255 octets.

Each project have to implement the frame length witch is necessary for the correct functionality, and in due to the line quality between controlled and controlling station

7.7 Database handling

The database in the controlled station may contain addresses which is not defined in the project. If the implementation in the controlled station block information in such a way that information related to undefined addresses is sent, this should be regarded as an error. However, the controlling station should be able to handle the situation so that other messages are processed normally.

7.8 Scaling

7.8.1 Scaling of normalised measured values

Recommended scaling of normalised measured values (ASDU 9)

Range:	Normalised value to be transferred from controlled station:
Maximum value in engineering units (V_{Max})	+1
Minimum value in engineering units (V_{Min})	0 (unipolar values), -1 (bipolar values)

V_{Max} and V_{Min} for each measured value shall be exchanged to give correct scaling between controlled and controlling station regardless of the internal representation of the signal in controlled station.

7.8.2 Parameters for normalised measured values

Recommended interpretation of parameter values to be transferred from controlling station using ASDU 110:

Intended Threshold value:	Normalised value to be transferred from controlling station:
Value in engineering units ($0 < V < V_{Max}$)	0 .. +1 (both unipolar and bipolar values)

7.8.3 Scaling of normalised set point commands

Recommended scaling of normalised set point commands (ASDU 48)

Range:	Normalised value to be transferred from controlling station:
Maximum value in engineering units (V_{Max})	+1
Minimum value in engineering units (V_{Min})	0 (unipolar values), -1 (bipolar values)

V_{Max} and V_{Min} for each set point commands shall be exchanged to give correct scaling between controlling and controlled station regardless of the internal representation of the signal in controlled station.