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NUOTOLINIO VALDYMO ĮRENGINIŲ IR SISTEMŲ PERDAVIMO PROTOKOLŲ ĮDIEGIMAS AB RYTŲ SKIRSTOMUOSIUOSE TINKLUOSE PAGAL LST EN 60870-5-104:2002 (IEC 60870-5-104) STANDARTĄ

TECHNINIAI REIKALAVIMAI

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Protocol Implementation Document (PID)

for IEC 60870-5-104

Arnhem, 15 juli 2005

M. Adriaensen

KEMA Consulting

As ordered by Rytu Skirstomieji Tinklai AB

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Rytu Skirstomieji Tinklai AB
Protocol Implementation Document
for IEC 60870-5-104

Final version

Change log

Revision no.:	Date:	Chapter:	Comments:	Author:
0.1	8.07.2005	All	Initial version	Madr. KEMA
0.2	13.07.2005	All	Several changes after feedback from RST	Madr. KEMA
1.0	15.07.2005	All	Final version	Madr. KEMA

TABLE OF CONTENTS

1 INTRODUCTION

The interpretation of the IEC60870-5-104 protocol standard can vary from supplier to supplier. This document will describe the use of the IEC 60870-5-104 protocol within Rytu Skirstomieji Tinklai AB, Lithuania.

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 60870-5. Five documents specify the base IEC 60870-5.
These documents are:

IEC 60870-5-1 Transmission Frame Formats
IEC 60870-5-2 Data Link Transmission Services
IEC 60870-5-3 General Structure of Application Data
IEC 60870-5-4 Definition and coding of Information Elements
IEC 60870-5-5 Basic Application Functions

The IEC Technical Committee 57 have also generated a companion standard IEC 60870-5-101 and IEC 60870-5-101 ed.2. In addition to IEC 60870-5-101 a further companion standard IEC 60870-5-104 called “Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles” which is closely related to IEC 60870-5-101 was defined.
Both IEC 60870-5-101 and IEC 60870-5-104 are based of the five documents IEC 60870-5-1 till 5.

The Rytu Skirstomieji Tinklai AB Protocol Implementation Document for IEC60870-5-104 further called RST PID 104 is based on these standards. Besides these standards also detailed requirements and specifications of Rytu Skirstomieji Tinklai AB are incorporated in this PID.

In this document all the additions from the above mentioned standards are gathered together to form the Rytu Skirstomieji Tinklai AB Protocol Implementation Document for IEC104, further called RST PID104.

However the authors have written this document with great care, possible indistinctness, inaccuracy, etc can be crept into the document. It is the responsibility of the vendor to identify possible indistinctness, inaccuracy, etc in this document and the consistency between the RST PID104 and related IEC60870-5 standards. If indistinctness, inaccuracy, etc or inconsistency between the RST PID104 and the related IEC60870-5 standard are identified it is the responsibility of the vendor to contact the contact person within Rytu Skirstomieji Tinklai AB to discuss these issues.

2 PROTOCOL ARCHITECTURE

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.

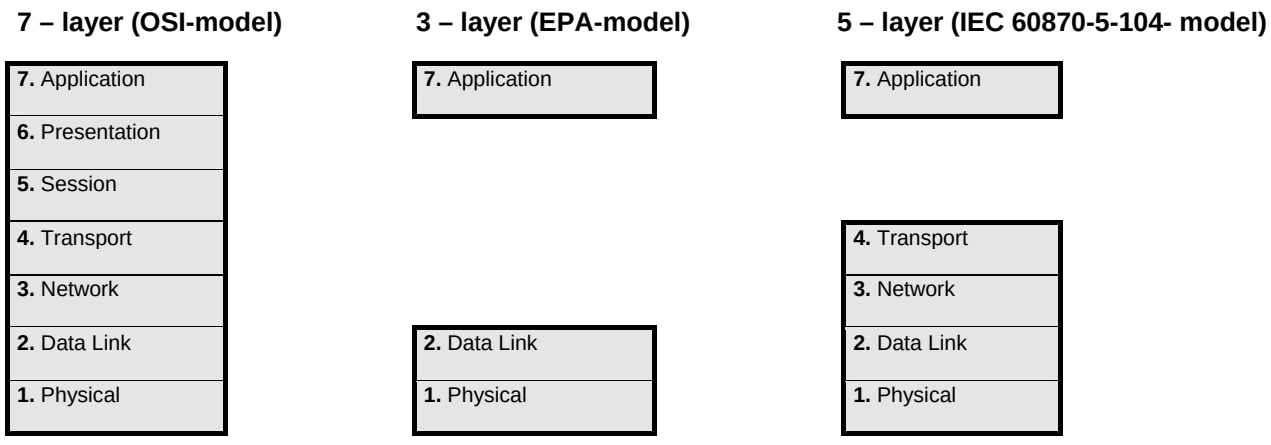
The open Systems Interconnect Reference Model
The Open Systems Interconnect (OSI) reference model is a layered set of protocols to facilitate open communications between computer networks. It was developed by the International Organisation for Standardisation (ISO) in conjunction with the Consultative 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 (OSI model)
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 (EPA-model)
The 3 - layer stack is also based on stable international standards. The 3 - layer stack provides a simpler mechanism for data communication.

The 5 – Layer Stack (IEC 60870-5-104 model)
The 5 – layer stack maps the Application Layer on a predefined Transport Profile which allowes the Application to communicate over networks.



2.3 Scope and Object of IEC 60870-5-104

2.3.1 Introduction

The companion standard, IEC 60870-5-104, is the networked version of companion standard IEC 60870-5-101.

IEC 60870-5-101 provides a communication profile for sending basic telecontrol messages between a central telecontrol station (**controlling station**) and telecontrol outstations (**controlled stations**), which uses permanent directly connected data circuits between the central station and individual outstations.

In some applications it may be required to send the same types of application messages between telecontrol stations using a data network containing relay stations which store and forward the messages and provide only a virtual circuit between the telecontrol stations. This type of network delays messages by varying amounts of time depending on the network traffic load.

In general the variable message delay times mean that it is not possible to use the link layer as defined in IEC 60870-5-101 between telecontrol stations. In some cases, however, it is possible to connect telecontrol stations having all three layers of the companion standard IEC 60870-5-101 to suitable data networks using Packet Assembler Disassembler (PAD) type stations to provide access for balanced communication.

In all other cases this companion standard which does not use the link functions of IEC 60870-5-101 may be used to provide balanced access via a suitable transport profile.

2.3.2 Scope

The defined telecontrol companion standard IEC 60870-5-104 utilizes standards of the series IEC 60870-5. The specifications of this standard present a combination of the application layer of IEC 60870-5-101 and the transport functions provided by a TCP/IP (Transmission Control Protocol/Internet Protocol). Within TCP/IP various network types can be utilized. Using the same definitions alternative ASDUs as specified in other IEC 60870-5 companion standards may be combined with TCP/IP, but this is not described further in this standard.

Security mechanisms others than mentioned in this document are out of the scope of this document.

2.4 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this section of IEC 60870-5. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this section of IEC 60870-5 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(371): 1984, International Electrotechnical Vocabulary (IEV)-
Chapter 371: Telecontrol

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

IEC 60870-1-3: 1997 Ed. 2, Telecontrol equipment and systems - Part 1:
General considerations - Section Three: Glossary

IEC 60870-1-4: 1994, Telecontrol equipment and systems - Part 1:
General considerations - Section 4: Basic aspects of telecontrol data transmission and organization of standards of IEC 60870-5 and IEC 60870-6

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

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

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

IEC 60870-5-101 ed.2: 2000, Telecontrol equipment and systems - Part 5:
Transmission protocols - Section 101: Companion standard for basic telecontrol Tasks

IEC 60870-5-104 2000, Telecontrol equipment and systems - Part 5:
Transmission protocols - Section 104: Network acces for IEC60870-5-101 using standard transport profiles

ISO 7498-1: 1994, Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model

ISO/IEC 8208: 1990, Information technology - Data communications - X.25 packet layer protocol for data terminal equipment

ITU - CCITT Geneva 1989, Data Communication Networks: Services and Facilities, Interfaces - Recommendations X.1-X.32
Blue Book, Volume VIII - Fascicle VIII.2

[RFC791] Internet Protocol
Request for Comments 791 (MILSTD 1777)
(September, 1981)

[RFC793] Transmission Control Protocol
Request for Comments 793 (MILSTD 1778)
(September, 1981)

[RFC1700] Assigned Numbers
Request for Comments 1700 (STD 2)
(October, 1994)

[RFC 2200] Internet Official Protocol Standard
Request for Comments 2200
(June, 1997)

2.5 Definitions

For the purpose of this PID, 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.

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

A station which is monitored or commanded by a master station (IEV 371-06-04).

Controlling Station (Master station)

A location at which telecontrol of outstations is performed (IEV 371-06-01).

3 General architecture

This document defines the use of an open TCP/IP-interface to a network, containing for example a LAN for telecontrol equipment, which transports IEC 60870-5-101/104 ASDUs. Routers which include the different WAN-types may be connected via a common TCP/IP-LAN-interface (see figure 1).

Motivations:

The use of separate routers offers advantages as follows.

- No need for network-specific software in end systems.
- No need for routing functionality in end systems.
- No need for network management in end systems.
- Facilitates obtaining end systems from manufacturers that specialize in telecontrol equipment.
- Facilitates obtaining individual separate routers, to suit a variety of networks from manufacturers specialising in this non-telecontrol specific field.
- A change of network type requires only a change of router type, without affecting the end systems.
- Particularly suitable for converting existing end systems that conform to IEC 60870-5-101.
- Suitable for present and future implementations.

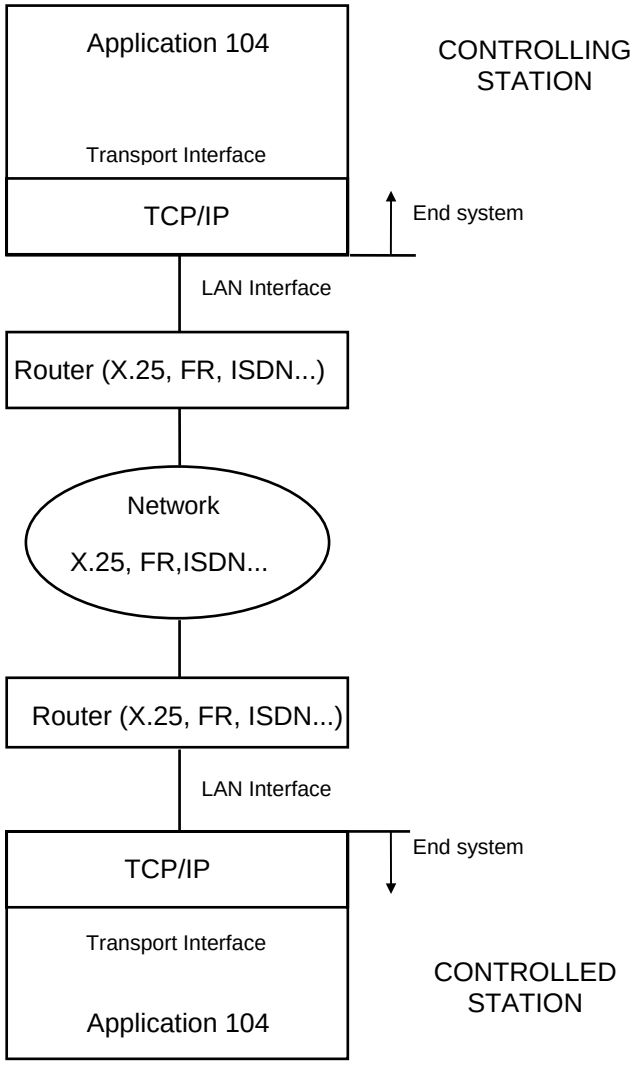


Figure 1 - General architecture (example)

4 Protocol structure

Figure 2 shows the protocol structure of the end system.

<table>
<tr><td colspan="2">Selection of Application Functions
of
IEC 60870-5-5 according to IEC 60870-5-101 and 104</td><td>Initialization</td><td>User process</td></tr>
<tr><td colspan="3">Selection of Application Service Data Units
of
IEC 60870-5-101 and 104</td><td rowspan="2">Application (layer 7)</td></tr>
<tr><td colspan="3">APCI Application Protocol Control Information
Transport Interface (User to TCP interface)</td></tr>
<tr><td colspan="3" rowspan="4">Selection of
TCP/IP Protocol suite (RFC 2200)</td><td>Transport (layer 4)</td></tr>
<tr><td>Network (layer 3)</td></tr>
<tr><td>Link (layer 2)</td></tr>
<tr><td>Physical (layer 1)</td></tr>
</table>

Note: Layers 5 and 6 are not used

Figure 2 - Selected standard provisions of the defined telecontrol companion standard 104

Figure 2a shows the recommended selection of the TCP/IP Protocol suite (RFC 2200) used in this standard. At the time of publication, the RFCs indicated were valid, but may be revised by equivalent, relevant RFCs. The relevant RFCs are available on the Internet address http://www.ietf.org.

The Ethernet 802.3 stack shown may be used by a telecontrol station end system or DTE to drive a separate router as shown in the example in figure 1. If a redundant configuration is not required, a point-to-point interface (e.g. X.21) to the separate router may be used instead of a LAN interface, thus retaining more of the original hardware when converting end systems originally conforming to IEC 60870-5-101.

Other compatible selections from RFC 2200 are also permitted.

This standard uses TCP/IP Transport Profile as defined in other referenced standards, without alteration.

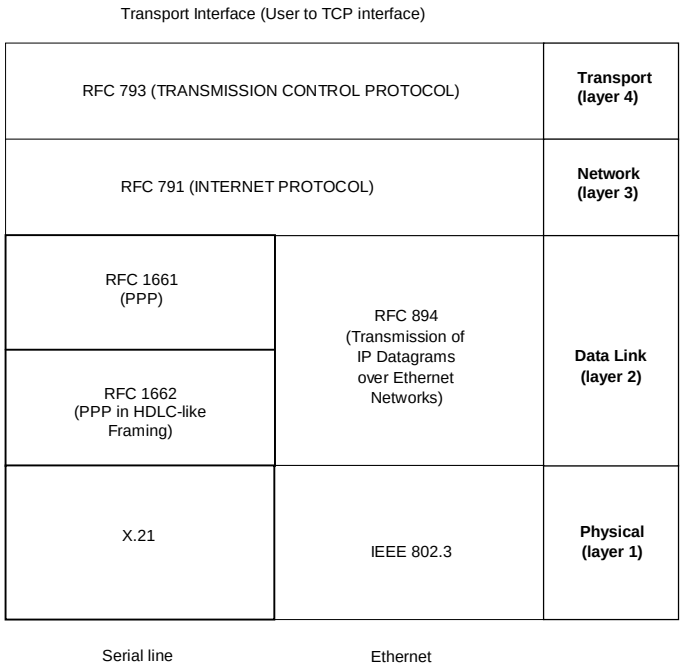


Figure 2a - Selected standard provisions of the TCP/IP Protocol suite RFC 2200 (Example)

In the RST PID104 the Ethernet 802.3 stack is recommended.

Other selections from RFC 2200 are also possible, but if another selection of RFC 2200 is choosen, the actual project has to take care of the additional specification and testing required.

4.1 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 870-5-104 protocol.

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:

- TYPE IDENTIFICATION
- VARIABLE STRUCTURE QUALIFIER
- CAUSE OF TRANSMISSION (ORIGINATOR ADDRESS IS NOT USED IN THE RST PID104 AND THEREFORE SET TO 0)
- COMMON ADDRESS OF ASDU
- INFORMATION OBJECT ADDRESS

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.

In the RST PID104 only the specific CAA station address will be used. Therefore the broadcast address (FFFF) is not used.

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

The format CP56Time2a for TIME TAGS is used exclusively in the RST PID104.

Day of week is not used in this PID 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 Definition of Application Protocol Control Information APCI

The transport interface (User to TCP interface) is a stream oriented interface which does not define any start or stop mechanism for the ASDUs of IEC 60870-5-101. For detecting the start and end of ASDUs, each APCI includes the following delimiting elements: a start character, the specification of the “Length of the ASDU“, plus the Control field (see figure 3). Either a complete APDU (or for control purposes, only the APCI fields) may be transferred (see figure 4).

Note: The abbreviations used above are taken from IEC 60870-5-3 clause 5 as follows.

APCI Application Protocol Control Information

ASDU Application Service Data Unit

APDU Application Protocol Data Unit

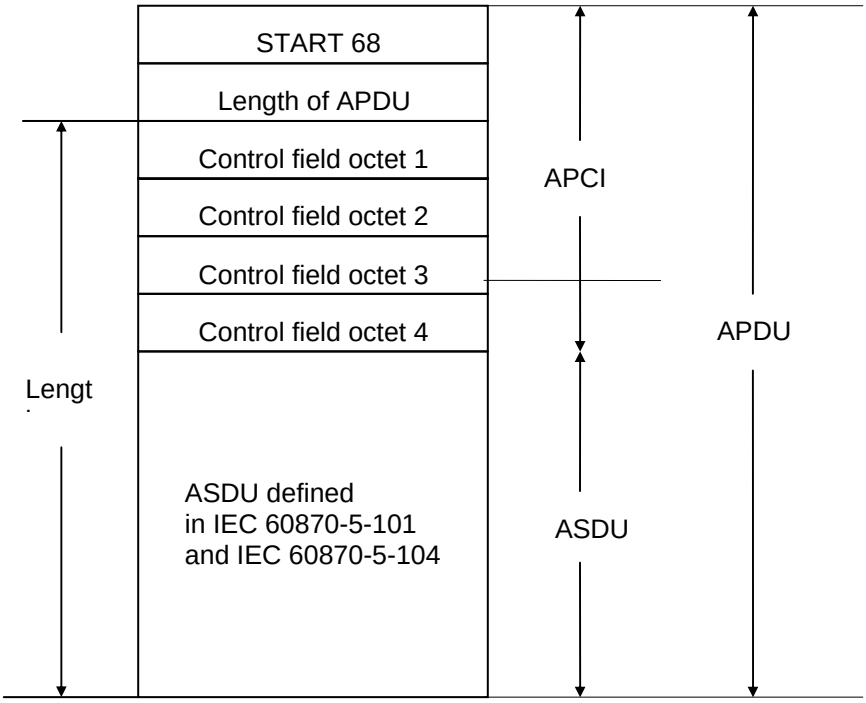


Figure 3 - Application Protocol Data Unit of the defined telecontrol companion standard 104

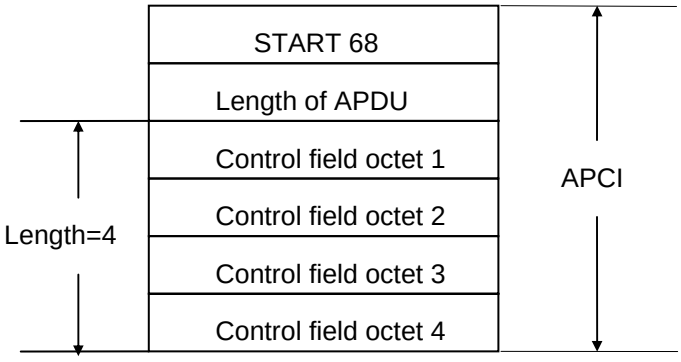


Figure 4 - Application Protocol Control Information of the defined telecontrol companion standard 104

START 68 defines the point of start within the data stream.

Length of APDU defines the length of the body of the APDU which consists of the four control field octets of the APCI plus the ASDU. The first counted octet is the first octet of the control field, the last counted octet is the last octet of the ASDU. The maximum length of the ASDU is limited to 249 because the maximum value of the field “Length of APDU“ is 253 ($APDU_{max}$=255 minus start and length octet) and the length of the control field is 4 octets.

The control field defines control information for the protection against loss and duplication of messages, start and stop of message transfers and the supervision of transport connections. The counter mechanism of the control field is defined according clauses 2.3.2.2.1 to 2.3.2.2.5 of the X.25 recommendations.

For the description and use of the APCI information see Chapter 5 of IEC 60870-5-104.

4.3 Selection of ASDUs defined in IEC 60870-5-101 and additional ASDUs

The following ASDUs defined in IEC 60870-5-101 ed.2 and ASDUs for process information in control direction with time tag (defined in IEC 60870-5-104) are valid:

Table 1 - Process information in monitor direction

TYPE IDENTIFICATION := UI8[1..8]<0..44>		
<0>	:= not defined	
<1>	:= single-point information	M_SP_NA_1
<3>	:= double-point information	M_DP_NA_1
<5>	:= step position information	M_ST_NA_1
<7>	:= bitstring of 32 bit	M_BO_NA_1
<9>	:= measured value, normalized value	M_ME_NA_1
<11>	:= measured value, scaled value	M_ME_NB_1
<13>	:= measured value, short floating point number	M_ME_NC_1
<15>	:= integrated totals	M_IT_NA_1
<20>	:= packed single-point information with status change detection	M_PS_NA_1
<21>	:= measured value, normalized value without quality descriptor	M_ME_ND_1
<22..29>	:= reserved for further compatible definitions	
<30>	:= single-point information with time tag CP56Time2a	M_SP_TB_1
<31>	:= double-point information with time tag CP56Time2a	M_DP_TB_1
<32>	:= step position information with time tag CP56Time2a	M_ST_TB_1
<33>	:= bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
<34>	:= measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
<35>	:= measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
<36>	:= measured value, short floating point number with time tag CP56Time2a	M_ME_TF_1
<37>	:= integrated totals with time tag CP56Time2a	M_IT_TB_1
<38>	:= event of protection equipment with time tag CP56Time2a	M_EP_TD_1
<39>	:= packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
<40>	:= packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1
<41..44>	:= reserved for further compatible definitions	

Table 2 - Process information in control direction

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

CON	<45>	:=	single command	C_SC_NA_1
CON	<46>	:=	double command	C_DC_NA_1
CON	<47>	:=	regulating step command	C_RC_NA_1
CON	<48>	:=	set point command, normalized value	C_SE_NA_1
CON	<49>	:=	set point command, scaled value	C_SE_NB_1
CON	<50>	:=	set point command, short floating point number	C_SE_NC_1
CON	<51>	:=	bitstring of 32 bit	C_BO_NA_1
	<52..57>	:=	reserved for further compatible definitions	

ASDUs for process information in control direction with time tag:

CON	<58>	:=	single command with time tag CP56Time2a	C_SC_TA_1 **)
CON	<59>	:=	double command with time tag CP56Time2a	C_DC_TA_1 **)
CON	<60>	:=	regulating step command with time tag CP56Time2a	C_RC_TA_1 **)
CON	<61>	:=	set point command, normalized value with time tag CP56Time2a	C_SE_TA_1 **)
CON	<62>	:=	set point command, scaled value with time tag CP56Time2a	C_SE_TB_1 **)
CON	<63>	:=	set point command, short floating point number with time tag CP56Time2a	C_SE_TC_1 **)
CON	<64>	:=	bitstring of 32 bit with time tag CP56Time2a	C_BO_TA_1 **)
	<65..69>	:=	reserved for further compatible definitions	

Process information in control direction may be sent with or without a time tag, but must not be mixed when sending to a given station.

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

**) … ASDUs defined in IEC 60870-5-104

ASDUs selected in the RYTU SKIRSTOMIEJI TINKLAI AB PID 104 are described in Chapter 5.

Table 3 - System information in monitor direction

TYPE IDENTIFICATION := UI8[1..8]<70..99>

	<70>	:= end of initialization	M_EI_NA_1
	<71..99>	:= reserved for further compatible definitions	

Table 4 - System information in control direction

TYPE IDENTIFICATION := UI8[1..8]<100..109>

CON	<100>	:= interrogation command	C_IC_NA_1
CON	<101>	:= counter interrogation command	C_CI_NA_1
	<102>	:= read command	C_RD_NA_1
CON	<103>	:= Clock synchronization command (optional,see clause 6.6)	C_CS_NA_1
CON	<105>	:= reset process command	C_RP_NA_1
CON	<107>	:= test command with time tag CP56time2a	C_TS_TA_1 **)
	<108..109>	:= reserved for further compatible definitions	

Table 5 - Parameter in control direction

TYPE IDENTIFICATION := UI8[1..8]<110..119>

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

Table 6 - File transfer

TYPE IDENTIFICATION := UI8[1..8]<120..127>

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

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

**) … ASDUs defined in IEC 60870-5-104

Table 9 - Semantics of CAUSE OF TRANSMISSION

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

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

Cause of transmission possibilities for each ASDU used in the RYTU SKIRSTOMIEJI TINKLAI AB PID104 is described in chapter 5.

5 Application layer telegram formats

5.1 Interoperability list

The marked functions and ASDUs in the interoperability list on the following pages represent the current maximum requirements for an IEC 60870-5-104 system according to the RYTU SKIRSTOMIEJI TINKLAI AB PID 104. Marks are to be removed or changed for unused or changed selections in specific projects.

Unmarked white boxes represent parameters that are currently not required. However, selections of such parameters can be agreed upon in specific projects.

Interoperability

This PID presents sets of parameters and alternatives from which subsets must be selected to implement particular telecontrol systems. Certain parameter values, such as the choice of “structured“ or “unstructured“ fields of the INFORMATION OBJECT ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications.This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

The interoperability list is defined as in IEC 60870-5-101 and extended with parameters used in this standard. The text descriptions of parameters which are not applicable to this PID are strike-through (corresponding check box is marked black).

Note:

- In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardized (default)

☒ **R** Function or ASDU is used in reverse mode

☒ **B** Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific clause or parameter.

A black check box indicates that the option cannot be selected in this companion standard.

System or device

(system-specific parameter, indicate definition of a system or a device by marking one of the following with ‘**X**’)

☒ System definition (Definition for Master and Slave)

☐ Controlling station definition (Master)

☐ Controlled station definition (Slave)

Network configuration

(network-specific parameter, all configurations that are used are to be marked ‘**X**’)

■ ~~Point-to-point~~ ■ ~~Multipoint-partyline~~

■ ~~Multiple-point-to-point~~ ■ ~~Multipoint-star~~

Physical layer

(network-specific parameter, all interfaces and data rates that are used are to be marked '**X**')

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200bit/s	Balanced interchange Circuit X.24/X.27	
~~100 bit/s~~	~~2 400 bit/s~~	~~2 400 bit/s~~	~~56 000 bit/s~~
~~200 bit/s~~	~~4 800 bit/s~~	~~4 800 bit/s~~	~~64 000 bit/s~~
~~300 bit/s~~	~~9 600 bit/s~~	~~9 600 bit/s~~	
~~600 bit/s~~		~~19 200 bit/s~~	
~~1 200 bit/s~~		~~38 400 bit/s~~	

Transmission speed (monitor direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200bit/s	Balanced interchange Circuit X.24/X.27	
~~100 bit/s~~	~~2 400 bit/s~~	~~2 400 bit/s~~	~~56 000 bit/s~~
~~200 bit/s~~	~~4 800 bit/s~~	~~4 800 bit/s~~	~~64 000 bit/s~~
~~300 bit/s~~	~~9 600 bit/s~~	~~9 600 bit/s~~	
~~600 bit/s~~		~~19 200 bit/s~~	
~~1 200 bit/s~~		~~38 400 bit/s~~	

Link layer

(network-specific parameter, all options that are used are to be marked '**X**'. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the Type ID and COT of all messages assigned to class 2.)

~~Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.~~

Link transmission procedure

- ~~Balanced transmission~~
- ~~Unbalanced transmission~~

Frame length

- ~~Maximum length L (number of octets)~~

Address field of the link

- ~~not present (balanced transmission only)~~
- ~~One octet~~
- ~~Two octets~~
- ~~structured~~
- ~~unstructured~~

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

■ ~~The standard assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission
9, 11, 13, 21	<1>

■ ~~A special assignment of ASDUs to class 2 messages is used as follows:~~

Type identification	Cause of transmission

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

Application layer

Transmission mode for application data

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

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked '**X**')

■ ~~One octet~~ [X] Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked '**X**')

■ ~~One octet~~ [ ] structured
■ ~~Two octets~~ [X] unstructured
[X] Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked '**X**')

■ ~~One octet~~ [X] Two octets (with originator address)
Originator address is set to zero if not used

Length of APDU

(system-specific parameter, specify the maximum length of the APDU per system) Length of the APDU must be configurable with a maximum length of 253 (default). The maximum length may be reduced per system.

253 Maximum length of APDU per system

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions). In this project Reversed direction is not used, however the interfaces must be able to communicate in Reversed direction in the future.

X	<1>:=Single-point information	M_SP_NA_1
■	~~<2>:=Single-point information with time tag~~	~~M_SP_TA_1~~
X	<3>:=Double-point information	M_DP_NA_1
■	~~<4>:=Double-point information with time tag~~	~~M_DP_TA_1~~
X	<5>:=Step position information	M_ST_NA_1
■	~~<6>:=Step position information with time tag~~	~~M_ST_TA_1~~
	<7>:=Bitstring of 32 bit	M_BO_NA_1
■	~~<8>:=Bitstring of 32 bit with time tag~~	~~M_BO_TA_1~~
X	<9>:=Measured value, normalized value	M_ME_NA_1
■	~~<10> := Measured value, normalized value with time tag~~	~~M_ME_TA_1~~
X	<11> := Measured value, scaled value	M_ME_NB_1
■	~~<12> := Measured value, scaled value with time tag~~	~~M_ME_TB_1~~
X	<13> := Measured value, short floating point value	M_ME_NC_1
■	~~<14> := Measured value, short floating point value with time tag~~	~~M_ME_TC_1~~
	<15> := Integrated totals	M_IT_NA_1
■	~~<16> := Integrated totals with time tag~~	~~M_IT_TA_1~~
■	~~<17> := Event of protection equipment with time tag~~	~~M_EP_TA_1~~
■	~~<18> := Packed start events of protection equipment with time tag~~	~~M_EP_TB_1~~
■	~~<19> := Packed output circuit information of protection equipment with time tag~~	~~M_EP_TC_1~~
	<20> := Packed single-point information with status change detection	M_PS_NA_1
	<21> := Measured value, normalized value without quality descriptor	M_ME_ND_1
X	<30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
X	<31> := Double-point information with time tag CP56Time2a	M_DP_TB_1
X	<32> := Step position information with time tag CP56Time2a	M_ST_TB_1
	<33> := Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
X	<34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
X	<35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
X	<36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
	<37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
	<38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
	<39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
	<40> := Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Either the ASDUs of the set <2> - <13> (short time tag) or of the set <30> - <40> (long time tag) are used.

Process information in control direction

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X]	<45> :=	Single command	C_SC_NA_1
[X]	<46> :=	Double command	C_DC_NA_1
[X]	<47> :=	Regulating step command	C_RC_NA_1
[ ]	<48> :=	Set point command, normalized value	C_SE_NA_1
[ ]	<49> :=	Set point command, scaled value	C_SE_NB_1
[ ]	<50> :=	Set point command, short floating point value	C_SE_NC_1
[ ]	<51> :=	Bitstring of 32 bit	C_BO_NA_1
[X]	<58> :=	Single command with time tag CP56Time 2a	C_SC_TA_1
[X]	<59> :=	Double command with time tag CP56Time 2a	C_DC_TA_1
[X]	<60> :=	Regulating step command with time tag CP56Time 2a	C_RC_TA_1
[ ]	<61> :=	Set point command, normalized value with time tag CP56Time 2a	C_SE_TA_1
[ ]	<62> :=	Set point command, scaled value with time tag CP56Time 2a	C_SE_TB_1
[ ]	<63> :=	Set point command, short floating point value with time tag CP56Time 2a	C_SE_TC_1
[ ]	<64> :=	Bitstring of 32 bit with time tag CP56Time 2a	C_BO_TA_1

Either the ASDUs of the set <45> – <51> or of the set <58> – <64> are used.

System information in monitor direction

(station-specific parameter, mark with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, and "**B**" if used in both directions)

[X]	<70> :=	End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X]	<100>:=	Interrogation command	C_IC_NA_1
[ ]	<101>:=	Counter interrogation command	C_CI_NA_1
[X]	<102>:=	Read command	C_RD_NA_1
[X]	<103>:=	Clock synchronization command	C_CS_NA_1
[ ]	~~<104>:=~~	~~Test command~~	~~C_TS_NA_1~~
[X]	<105>:=	Reset process command	C_RP_NA_1
[ ]	~~<106>:=~~	~~Delay acquisition command~~	~~C_CD_NA_1~~
[ ]	<107>:=	Test command with time tag CP56time2a	C_TS_TA_1

Parameter in control direction

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐	<110>:=	Parameter of measured value, normalized value	P_ME_NA_1
☐	<111>:=	Parameter of measured value, scaled value	P_ME_NB_1
☐	<112>:=	Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113>:=	Parameter activation	P_AC_NA_1

File Transfer

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

X	<120>:=	File ready	F_FR_NA_1
X	<121>:=	Section ready	F_SR_NA_1
X	<122>:=	Call directory, select file, call file, call section	F_SC_NA_1
X	<123>:=	Last section, last segment	F_LS_NA_1
X	<124>:=	Ack file, ack section	F_AF_NA_1
X	<125>:=	Segment	F_SG_NA_1
X	<126>:=	Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1

Type Identifier and Cause of Transmission Assignments

(station-specific parameters)

Shaded boxes are not required.
Black boxes are not permitted in this companion standard
Blank = Function or ASDU is not used.
Mark Type Identification/Cause of transmission combinations:
'**X**' if only used in the standard direction
'**R**' if only used in the reverse direction
'**B**' if used in both directions

Type Identification		**Cause of transmission**																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1					X									X					
~~<2>~~	~~M_SP_TA_1~~																			
<3>	M_DP_NA_1					X									X					
~~<4>~~	~~M_DP_TA_1~~																			
<5>	M_ST_NA_1					X									X					
~~<6>~~	~~M_ST_TA_1~~																			
<7>	M_BO_NA_1																			
~~<8>~~	~~M_BO_TA_1~~																			
<9>	M_ME_NA_1	X		X		X									X					
~~<10>~~	~~M_ME_TA_1~~																			
<11>	M_ME_NB_1	X		X		X									X					
~~<12>~~	~~M_ME_TB_1~~																			
<13>	M_ME_NC_1	X		X		X									X					
~~<14>~~	~~M_ME_TC_1~~																			
<15>	M_IT_NA_1																			
~~<16>~~	~~M_IT_TA_1~~																			
~~<17>~~	~~M_EP_TA_1~~																			
~~<18>~~	~~M_EP_TB_1~~																			
~~<19>~~	~~M_EP_TC_1~~																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X								X	X							
<31>	M_DP_TB_1			X								X	X							
<32>	M_ST_TB_1			X								X	X							
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1			X [1]																
<35>	M_ME_TE_1			X [1]																
<36>	M_ME_TF_1			X[1]																
<37>	M_IT_TB_1																			
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			

[1] For each project it is the responsibility of the vendor to verify with RYTU SKIRSTOMIEJI TINKLAI AB if spontaneous measurements (events) are transmitted with or without time tag.

Type Identification		**Cause of transmission**																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X	X
<46>	C_DC_NA_1						X	X	X	X	X						X	X	X	X
<47>	C_RC_NA_1						X	X	X	X	X						X	X	X	X
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1																			
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<58>	C_SC_TA_1						X	X	X	X	X						X	X	X	X
<59>	C_DC_TA_1						X	X	X	X	X						X	X	X	X
<60>	C_RC_TA_1						X	X	X	X	X						X	X	X	X
<61>	C_SE_TA_1																			
<62>	C_SE_TB_1																			
<63>	C_SE_TC_1																			
<64>	C_BO_TA_1																			
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						X	X			X						X	X	X	X
<101>	C_CI_NA_1																			
<102>	C_RD_NA_1					X											X	X	X	X
<103>	C_CS_NA_1						X	X									X	X	X	X
~~<104>~~	~~C_TS_NA_1~~																			
<105>	C_RP_NA_1*)						X	X									X	X	X	X
~~<106>~~	~~C_CD_NA_1~~																			
<107>	C_TS_TA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1													X						
<121>	F_SR_NA_1													X						
<122>	F_SC_NA_1					X								X						
<123>	F_LS_NA_1													X						
<124>	F_AF_NA_1													X						
<125>	F_SG_NA_1													X						
<126>	F_DR_TA_1*)			X		X														

*) blank or X only

Station initialization

(station-specific parameter, mark '**X**' if function is used)

[X] Remote initialization

Cyclic data transmission

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X] Cyclic data transmission

Read procedure

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X] Read procedure

Spontaneous transmission

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X] Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type '**X**' where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

- [ ] Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1
- [ ] Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1
- [ ] Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1
- [ ] Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)
- [ ] Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1
- [ ] Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1
- [ ] Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

Station interrogation

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- [X] global
- [X] group 1
- [X] 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

Information Object Addresses assigned to each group must be shown in a separate table

Clock synchronization

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- [X] Clock synchronization (optional)

Command transmission

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- [X] Direct command transmission
- [ ] Direct set point command transmission
- [X] Select and execute command
- [ ] Select and execute set point command
- [X] C_SE ACTTERM used

- [X] No additional definition
- [X] Short pulse duration (duration determined by a system parameter in the outstation)
- [X] Long pulse duration (duration determined by a system parameter in the outstation)
- [X] Persistent output

- [X] Supervision of maximum delay in command direction of commands and set point commands

configurable Maximum allowable delay of commands and set point commands with a maximum of 1 minute

Transmission of integrated totals

(station- or object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- ☐ Mode A: Local freeze with spontaneous transmission
- ☐ Mode B: Local freeze with counter interrogation
- ☐ Mode C: Freeze and transmit by counter interrogation commands
- ☐ Mode D: Freeze by counter interrogation command, frozen values reported spontaneously

- ☐ Counter read
- ☐ Counter freeze without reset
- ☐ Counter freeze with reset
- ☐ Counter reset

- ☐ General request counter
- ☐ Request counter group 1
- ☐ Request counter group 2
- ☐ Request counter group 3
- ☐ Request counter group 4

Parameter loading

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

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

Parameter activation

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

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

Test procedure

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- ☐ Test procedure

File transfer

(station-specific parameter, mark '**X**' if function is used)

File transfer in monitor direction

[X] Transparent file

[X] Transmission of disturbance data of protection equipment

[X] Transmission of sequences of events

[X] Transmission of sequences of recorded analogue values

File transfer in control direction

[X] Transparent file

Background scan

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[ ] Background scan

Acquisition of transmission delay

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[■] ~~Acquisition of transmission delay~~

Definition of time outs

Parameter	Default value	Remarks	Selected value
t_0	30s	Time out of connection establishment	
t_1	15s	Time out of send or test APDUs	
t_2	10s	Time out for acknowledges in case of no data messages $t_2 < t_1$	
t_3	20s	Time out for sending test frames in case of a long idle state	

Maximum range of values for all time outs: 1 to 255 s, accuracy 1 s

Maximum number of outstanding I format APDUs k and latest acknowledge

Parameter	Default value	Remarks	Selected value
K	12 APDUs	Maximum difference receive sequence number to send state variable	
W	8 APDUs	Latest acknowledge after receiving w I-format APDUs	

Maximum range of values k: 1 to 32767 (2^{15}-1) APDUs, accuracy 1 APDU

Maximum range of values w: 1 to 32767 APDUs, accuracy 1 APDU (Recommendation: w should not exceed 2/3 of k).

Portnumber

Parameter	Value	Remarks
Portnumber	2404	In all cases

RFC 2200 suite

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of this standard.

☒ Ethernet 802.3

☐ Serial X.21 interface

☐ Other selection from RFC 2200:

List of valid documents from RFC 2200

1. ……..
2. ……..
3. ……..
4. ……..
5. ……..
6. ……..
7. etc.

5.2 Definition and presentation of the specific ASDUs

In the following all ASDUs for use within RYTU Skirstomieji Tinklai AB are defined.

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

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

<5> := request or requested
<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>
<0> := valid
<1> := invalid

Quality descriptor

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 Double-point information without time tag

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

<5> := request or requested
<20> := interrogated by general interrogation

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

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

Quality descriptor

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 Step position information

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

<5> := request or requested
<20> := interrogated by general interrogation

VTI := CP8{Value,Transient}
Value := I7[1..7]<-64..+63>
Negative numbers are presented in two's complement

Transient := BS1[8]
<0> := equipment is not in transient state
<1> := equipment is in transient state

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

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 Measured value, normalised value

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

<1> := periodic, cyclic
<3> := spontaneous
<5> := request or requested
<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.

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

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 Measured value, scaled value

TYPE IDENT 11: M_ME_NB_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

<1> := periodic, cyclic
<3> := spontaneous
<5> := request or requested
<20> := interrogated by general interrogation

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

The resolution of measured values is not defined. If the resolution of the measured value is coarser than the unit of the LSB, then the least significant bits are set to zero.
Range and position of decimal points are fixed parameters

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

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 Measured value, short floating point value

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

<1> := periodic, cyclic
<3> := spontaneous
<5> := request or requested
<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 =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

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 Single-point information with time tag CP56Time2a

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

<3> := spontaneous
<11> := return information caused by a remotecommand
<12> := return information caused by a local command

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>
<0> := valid
<1> := invalid

Quality descriptor

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 Double-point information with time tag CP56Time2a

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

<3> := spontaneous
<11> := return information caused by a remotecommand
<12> := return information caused by a local command

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

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

Quality descriptor

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 Step position information with time tag CP56Time2a

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

<3> := spontaneous
<11> := return information caused by a remotecommand
<12> := return information caused by a local command

VTI := CP8{Value,Transient}
Value := I7[1..7]<-64..+63>
Negative numbers are presented in two's complement.

Transient := BS1[8]
<0> := equipment is not in transient state
<1> := equipment is in transient state

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

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.

5.2.1.10 Measured value, normalised value with time tag CP56Time2a

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

<3> := spontaneous

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.

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

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.

5.2.1.11 Measured value, scaled value with time tag CP56Time2a

TYPE IDENT 35: M_ME_TE_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

<3> := spontaneous

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

The resolution of measured values is not defined. If the resolution of the measured value is coarser than the unit of the LSB, then the least significant bits are set to zero.
Range and position of decimal point are fixed parameters.

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

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 Measured value, short floating point value with time tag CP56Time2a

TYPE IDENT 36:= M_ME_TF_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

<3> := spontaneous

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	

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

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.

5.2.2 ASDUs for process information in control direction

5.2.2.1 Single command

TYPE IDENT 45:= C_SC_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

in control direction:
<6> := activation
<8> := deactivation
in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

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}

QOC := CP6{QU, S/E}
QU := UI5[3..7]<0..31>
<0> := no additional definition *
<1> := short pulse duration (f.e. 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

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

in control direction:
<6> := activation
<8> := deactivation
in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

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}

QOC := CP6{QU, S/E}
QU := UI5[3..7]<0..31>
<0> := no additional definition *
<1> := short pulse duration (f.e. 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

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

in control direction:
<6> := activation
<8> := deactivation
in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

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}

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 Single command with time tag CP56Time2a

TYPE IDENT 58 := C_SC_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

in control direction:
<6> := activation
<8> := deactivation
in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

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}

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

5.2.2.5 Double command with time tag CP56Time2a

TYPE IDENT 59:= C_DC_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

in control direction:
<6> := activation
<8> := deactivation
in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

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}

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

5.2.2.6 Regulating step command with time tag CP56Time2a

TYPE IDENT 60 := C_RC_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

in control direction:
<6> := activation
<8> := deactivation
in monitor direction:
<7> := activation confirmation
<9> := deactivation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

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}

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

5.2.3 ASDUs for system information in monitor direction

5.2.3.1 End of initialisation

TYPE IDENT 70 := M_EI_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

<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

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

in control direction:
<6> := activation
in monitor direction:
<7> := activation confirmation
<10> := activation termination
<44> := unknown type identification
<45> := unknown cause of transmission
<46> := unknown common address of ASDU
<47> := unknown information object address

QOI := UI8[1..8]<0..255>
<20> := Station interrogation (global)

5.2.4.2 Reset process command

TYPE IDENT 105 := C_RP_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

in control direction:
<6> := activation

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

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

6 Communication procedures

Table 6.1 shows a list of all basic communication procedures (basic application functions) that are offered in IEC 60870-5-5. The subset of these procedures that are applicable to the IEC 870-5-104 standard and to the RST PID 104 are listed in bold types.

Table 6.1 Basic Application Functions specified in IEC 60870-5-5

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

The relevant application functions are further described in the subsequent sections. The figures 6.1 to 6.4 show initialisation procedures specific to IEC 60870-5-104. The sequence diagrams in the figures 6.5 to 6.11 correspond to the diagrams in 60870-5-5, except that options are confirmed or removed according to the 60870-5-104 standard and according to selections agreed upon in this PID.

The applicable ASDU type identifications (TI) are shown in the diagrams, in addition to the corresponding causes of transmission (COT).

Note that only the telegrams that apply to the described sequence are shown in the diagrams. Additional telegrams (e.g. event telegrams) may be transmitted in between the sequence telegrams.

6.1 Station initialisation

Release of connections can be initiated by either the controlling or the controlled station. Connection establishment is performed by

- the controlling station in case of a controlled station as a partner
- a fixed selection (parameter) in case of two equivalent controlling stations or partners

Figure 6.1 shows that an established connection may be closed by the controlling station giving an active close call to its TCP, followed by the controlled station giving a passive close to its TCP. The figure then shows the establishment of a new connection by the controlling station giving an active open call to its TCP after the controlled station has previously given a passive open call to its TCP. Finally the figure shows the alternative active close of the connection by the controlled station.

Figure 6.2 shows that during the initialisation of the controlling station, a connection is established with each controlled station in turn. Starting with station 1 the controlling station gives an active open call to its TCP which results in connection establishment if the TCP of station 1 has the listen status (status not shown in the figure). This is then repeated for the remaining controlled stations.

Figure 6.3 shows the controlling station repeatedly attempting to establish a connection with a controlled station. These attempts fail until the controlled station has performed a local initialisation and given a passive open call to its TCP which has then acquired the listen status (status not shown in the figure).

Figure 6.4 shows the controlling station establishing a connection by giving an active open call to its TCP. The controlling station then sends Reset_Process to the connected controlled station, which confirms back the Reset_Process and gives an active close call to its TCP. The connection then closes after the controlling station has given a passive close call to its TCP. Then the controlling station tries to connect the controlled station by giving cyclic active opens to its TCP. When the controlled station is again available, after its remote initialisation, it returns a CLT=SYN, ACK. This results in the establishment of a new connection if the controlling station acknowledges the CLT=SYN, ACK.

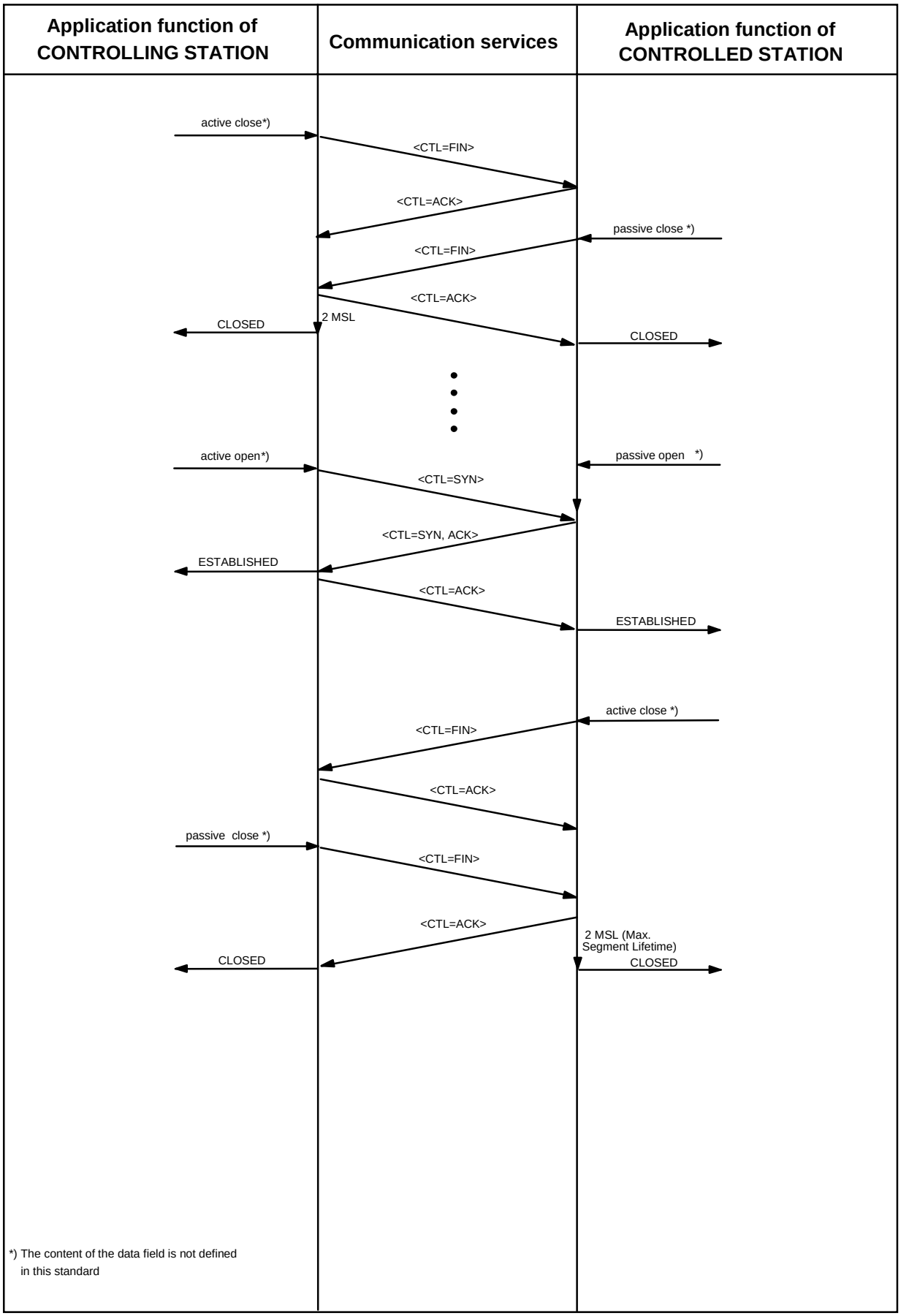


Figure 6.1: TCP Connection establishment and close

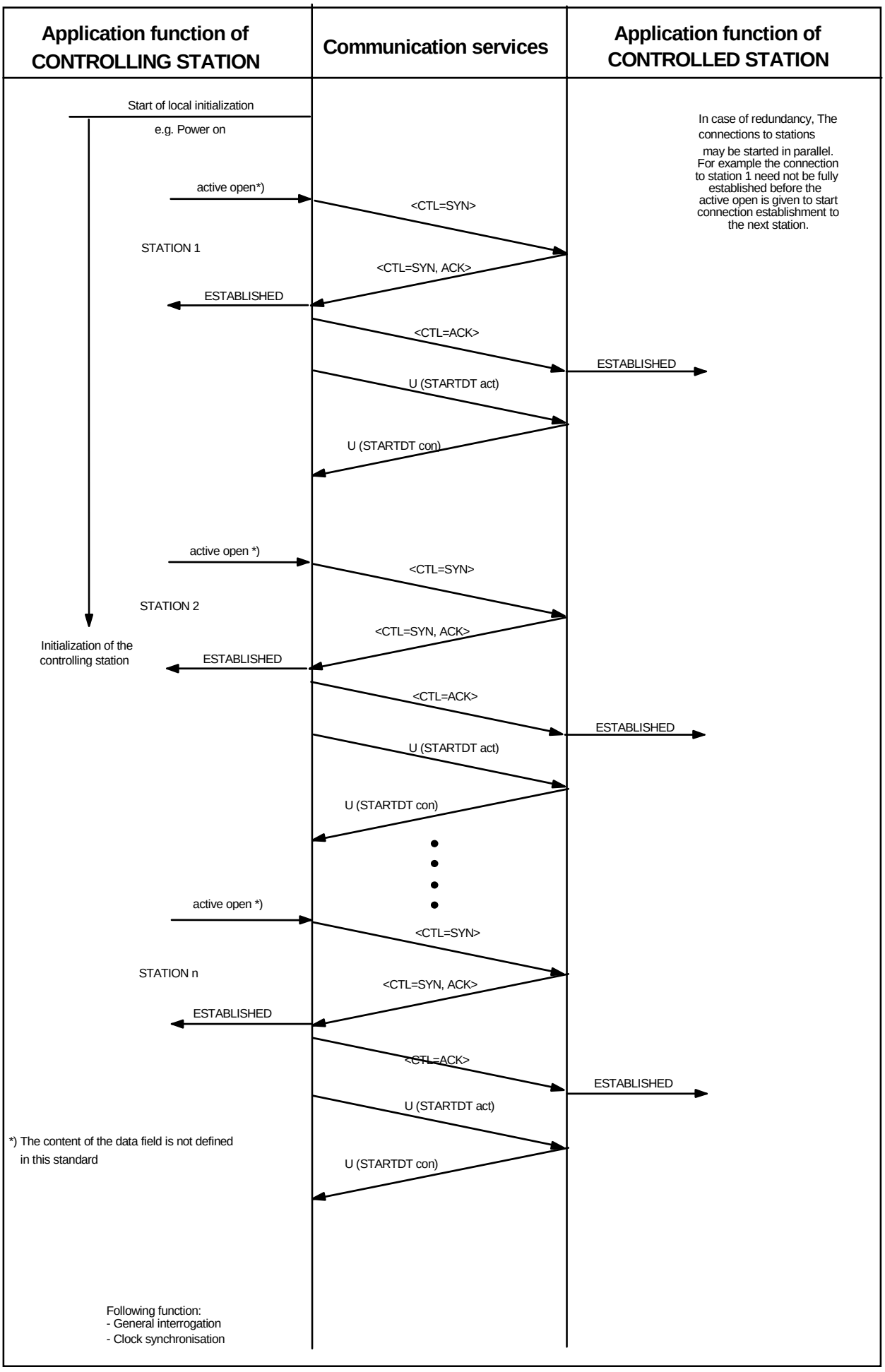


Figure 6.2: Initialization of the controlling station

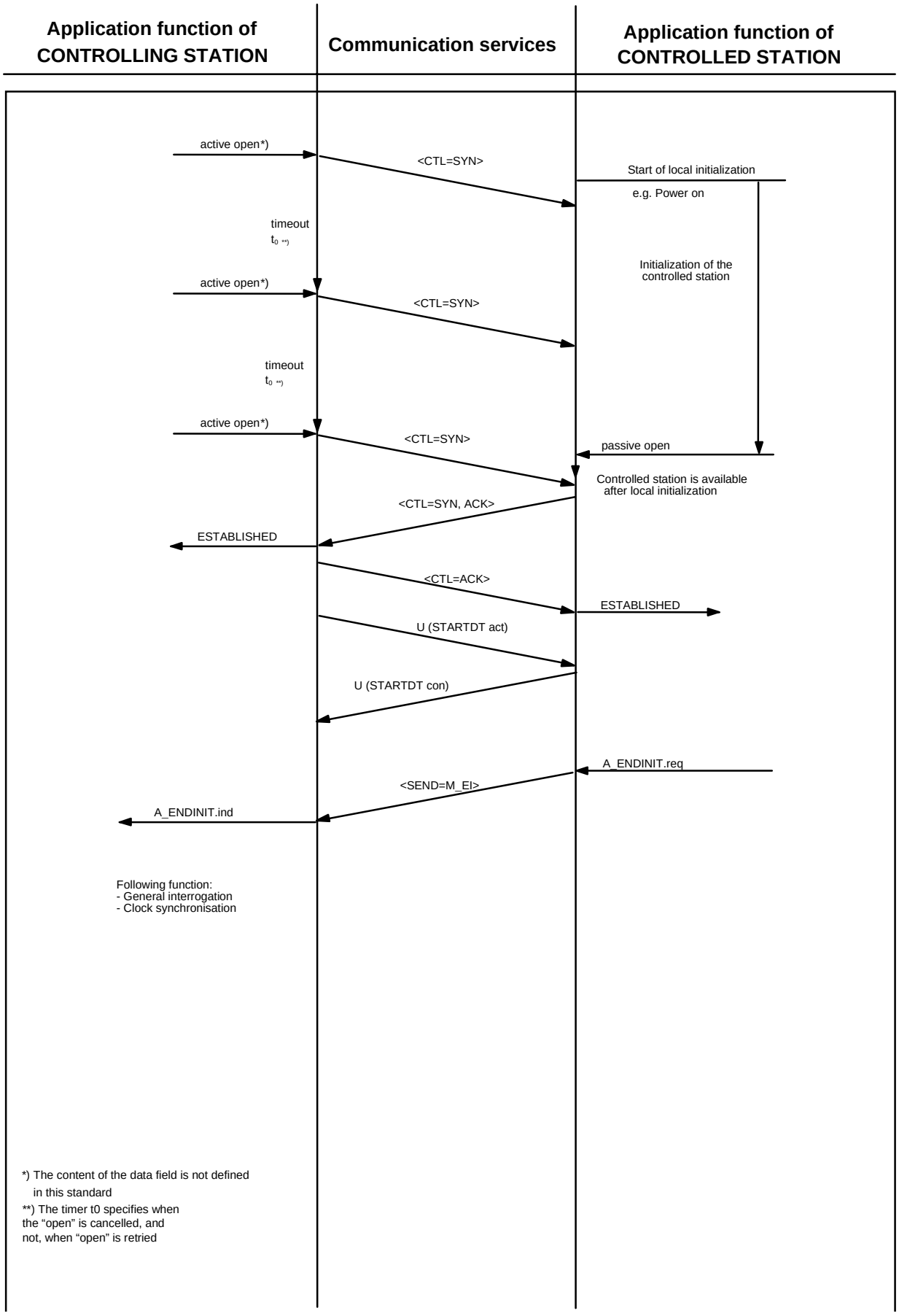


Figure 6.3: Local initialization of the controlled station

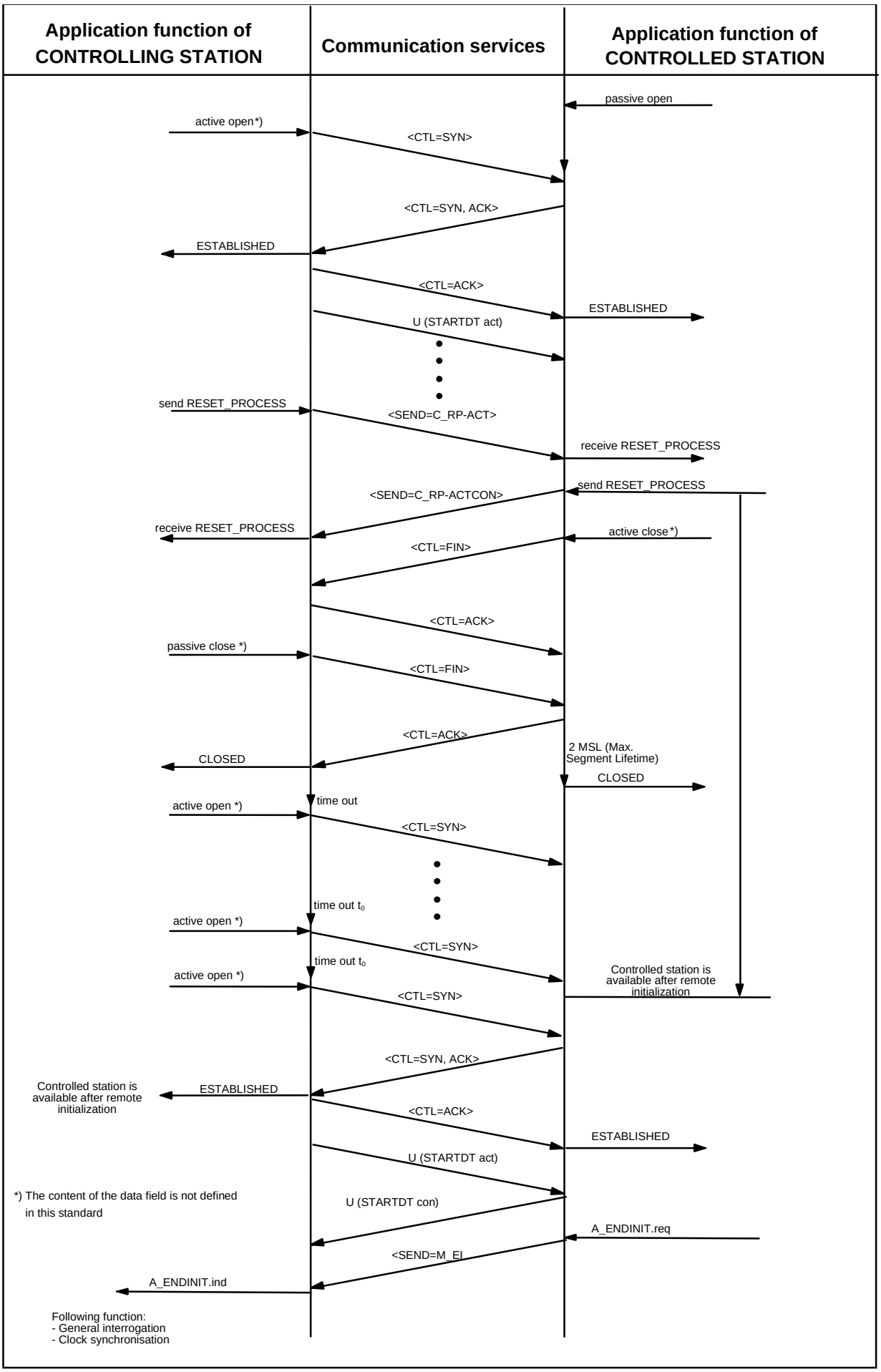


Figure 6.4: Remote initialization of the controlled station

6.2 Cyclic data transmission

Complete function, defined in IEC60870-5-5, paragraph 6.3 is used.

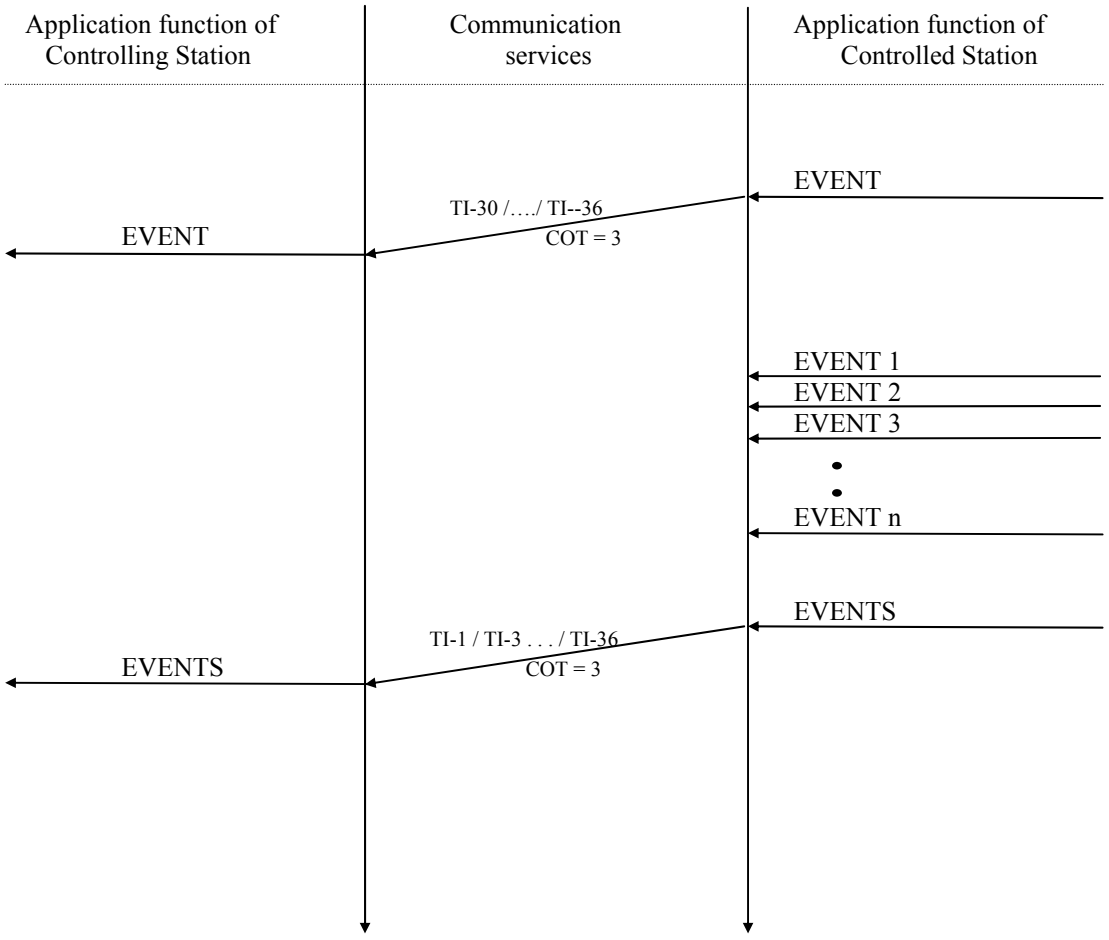
6.3 Acquisition of events

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.

Fig. 6.5 shows the sequential procedure for event acquisition. 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.

The maximum number of events in an event ASDU is determined by the configured maximum frame length of the system.

The buffer size must be configured in a way that the amount of events configured in a station multiplied with a factor 5 and a minimum of 1000 events can be stored in case that no connection is available.



TI : Telegram Type Identification
COT : Cause Of Transmission

Figure 6.5: Acquisition of events

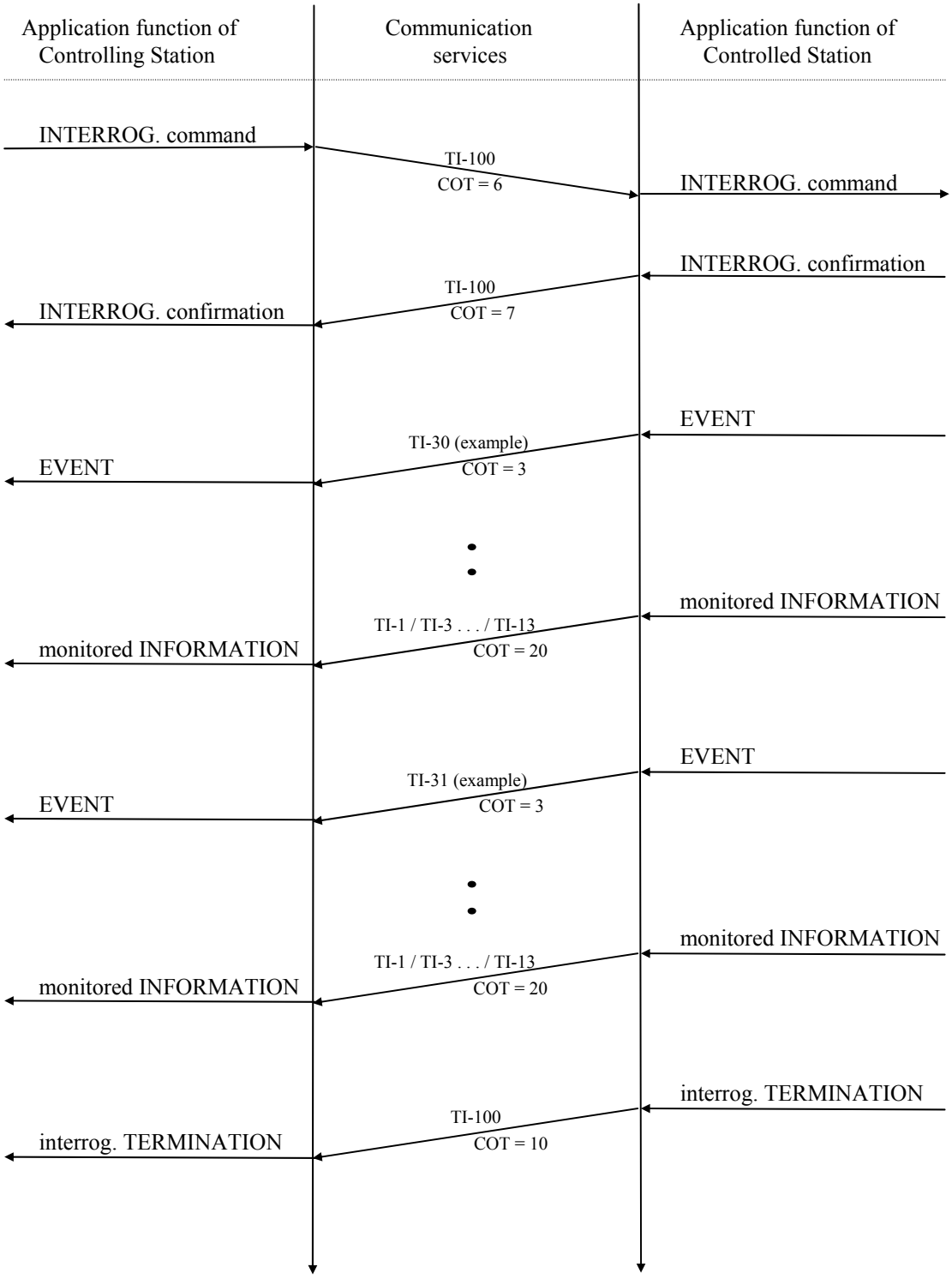
6.4 General interrogation

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 that may eventually occur in the controlled station.

Fig. 6.6 shows the sequential procedure. 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. Receiving an ASDU 70 (Initialized) from the controlled station can trigger this INTERROGATION command 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.



TI : Telegram Type Identification
COT : Cause Of Transmission

Figure 6.6: Interrogation procedure (events may arrive in between responses)

6.5 Clock synchronisation

The clock synchronisation command is used to synchronise the time in the controlled station with the time in the controlling station. Because a flexible time delay in the network, RST can decide per location to choose for clock synchronisation via the clock synchronisation command (ASDU 103) or via an external clock (f.e. GPS).

The clock synchronisation command function will be send when an IEC104 connection is established and the Start procedure is finished. Besides it should also be configurable up to 1 day (f.e. in steps of one hour) to send the clock synchronisation command function.

6.6 Command transmission

6.6.1 General

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 (IOA) in the controlled station (by system configuration parameters in the controlling station).

6.6.2 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. 6.8. 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 (return information caused by a command) when reached.

The RYTU SKIRSTOMIEJI TINKLAI AB PID 104 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.

6.6.3 Direct commands

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. 6.8.

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.

The application in the controlling station must check that the command has been properly executed.

6.6.4 Delayed commands

The time tag of a command is always to be checked by the receiving station to determine if the command is excessively delayed. In case of a delayed command no command confirmation is to be returned by the protocol, and the command is not executed.

NOTE: Preferable an indication is send to the control center to indicate that a delayed command is received in the controlled station. In the controlling center then (f.e.) a counter is recording the number of times delayed commands have been received.

6.6.5 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, double command, etc) has been given by the user process, no new select and execute or direct command 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
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.

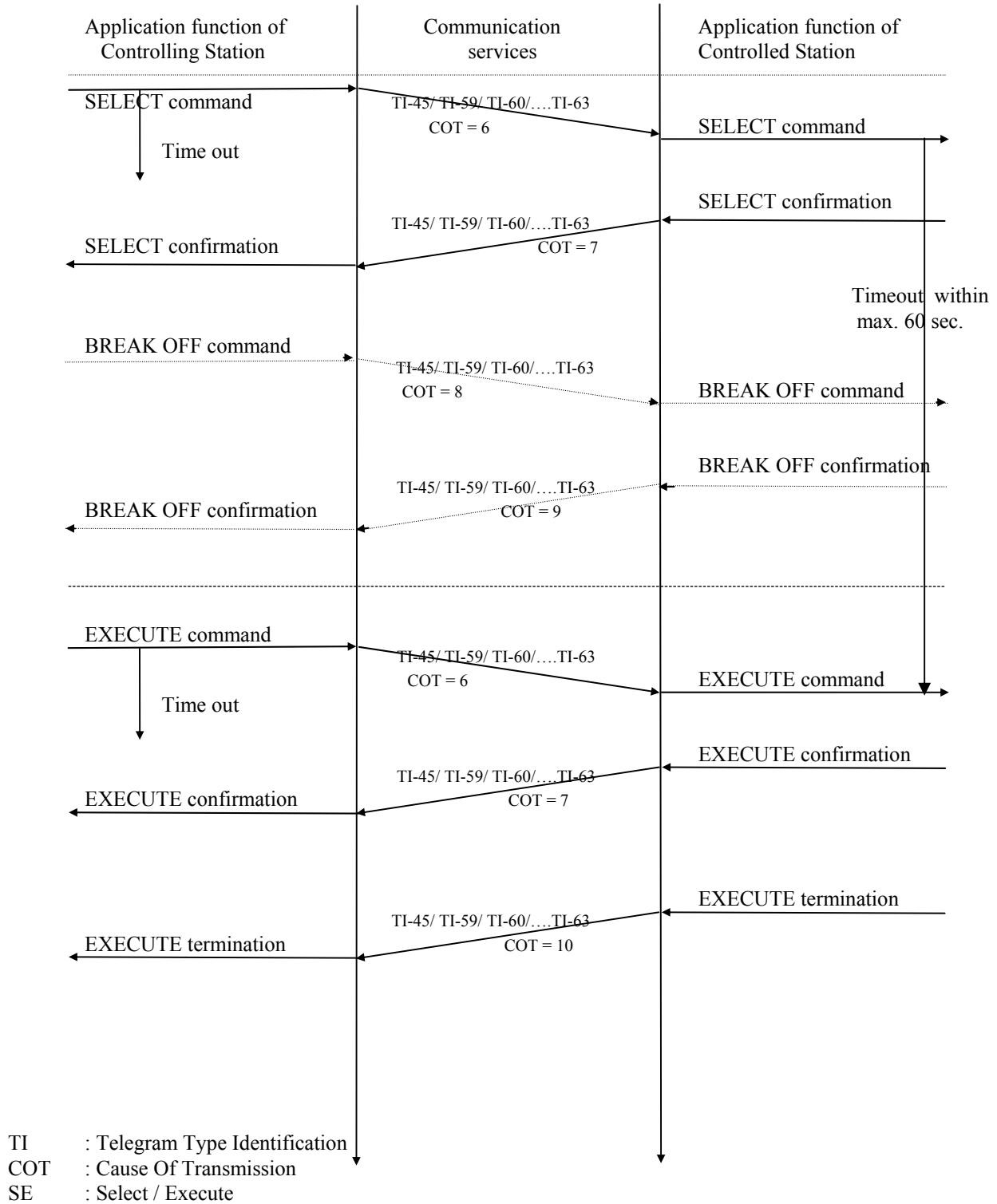


Figure 6.8: Command transmission procedure

6.7 File transfer

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

File transfer with IEC104 will be used in both monitor and control direction for all in paragraph 5.1 selected options.

7 Functions

This chapter contains additional information about functionality that is not necessarily covered by the standard. However, the functions described in this chapter are functions needed for within RYTU SKIRSTOMIEJI TINKLAI AB, and thus they should be implemented as described in this chapter.

7.1 General

It may never appear that the protocol implementation goes in a stop/halt/abort state as a result of a not correct received or erroneous data-frame/quality flag etc. The implementation should log the event with additional relevant data in the system event list for maintenance engineers.

7.1.1 Load balancing

In the RST PID104 redundancy on IEC104 level is required. However, administrators need to know which front-end is active and is managing the active IEC104 connections and which of them is the “hot standby front end. Because of this, planned maintenance can be performed on the standby front end. Therefore it is not allowed that both front-ends are managing active lines at the same moment to (f.e.) perform load balancing.

7.1.2 Performance

Under normal conditions a general interogation of a substation with 2000 information object addresses must be terminated within 1 minute.

7.1.3 Transfer of data from Controlled Station to Controlling Station

In the RST PID 104 Indications, Measurands and Pulse Counters are transferred from Controlled Station to Controlling Station on event basis. Events, caused by a trip or a (remote) command, will have higher priority than General Interrogation. Events can interrupt an ongoing General Interrogation. The Controlled Station algorithm must guarantee that the end-state of all data points after a general Interrogation is correct.

7.1.4 Event Buffers

The buffer size must be configured in a way that the amount of events configured in a station multiplied with a factor 5 and a minimum of 1000 events can be stored in case that no connection is available.

7.1.5 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 General Interrogation request and with time-stamp after a change of state event.

7.1.6 Measurands

Measurands can be sent to the Controlling Station with or without time-stamp. For each project it is the responsibility of the vendor to verify with RYTU SKIRSTOMIEJI TINKLAI AB if measurements with COT = spontaneous (events) are transmitted with or without time tag.

7.2 Redundant connections

7.2.1 General requirements

Redundancy in an IEC 60870-5-104 system can be achieved by providing the possibility to establish more than one logical connection between two stations. A logical connection is defined by a unique combination of two IP-addresses and two port-numbers, one IP-address/port-number pair in each station.

Connection establishment is performed by the controlling station in case of a controlled station as a partner, or by a fixed selection (parameter) in case of two equivalent controlling stations or partners, as stated in sec. 6.1. The station that performs the connection is anyhow referred to as the controlling station (station 1 and 2) in the subsequent description, while the partner station is referred to as the controlled station (station B).

The following general rules apply to this specification of redundant connections:

1. The controlling and controlled station must be able to handle a minimum of two logical connections
2. Only one logical connection is active sending/receiving user data at a time
3. The controlling station decides which one of the connections to be active
4. The logical connections represent one redundancy group
5. All logical connections of a redundancy group must be supervised by the controlling station
6. In case of a switch over no data (commands, events, etc.) may be lost.

The logical connection which is enabled for user data transfer at any time is defined to be the active connection, while the others are standby connections. The controlled station (station B) always understands the connection on which it last received a STARTDT function as the active connection.

As stated in rule 3, selection and switch of connection is always the responsibility of the controlling station, and may be performed either automatically or manually, by e.g. the application layer (transport interface), or the user process. Automatic switch of connection is performed by transmitting a STARTDT function on the standby connection that is selected to take over.

Manual switchover between two alive and operative connections is performed by first issuing a STOPDT function on the currently active connection and then a STARTDT function on the selected new active connection.

Automatic switchover between two alive and operative connections is performed by issuing a STARTDT function on the new active connection.

The controlling station must regularly check the status of all established connections to detect any communication problems as soon as possible. This is done by using the Unnumbered control function TESTFR, which is sent periodically after a period of no traffic on the connection. This connection check procedure may also be performed by the controlled station.

7.2.2 System topology examples

Fig. 1 in chapter 3 shows the simplest possible IEC 60870-5-104 communication system, with a single connection between the stations without any redundant connections. Figures 7.1 and 7.2 however, show a topology that demonstrates how redundancy will be accomplished.

In fig. 7.1 illustrates a system where a controlling station communicates with a controlled station. Two LAN interfaces and two separate LANs are available on either side (with corresponding interface cards). By connecting both routers on the controlling side to both LANs, a minimum of two connections can be established to the controlled station. All connections belong to the same redundancy group.

In fig. 7.2 illustrates a system where a controlling station communicates with a controlled station. By connecting a RTU on lacation that consists of two LAN interfaces a minimum of two connections can be established to the controlled station. All connections belong to the same redundancy group.

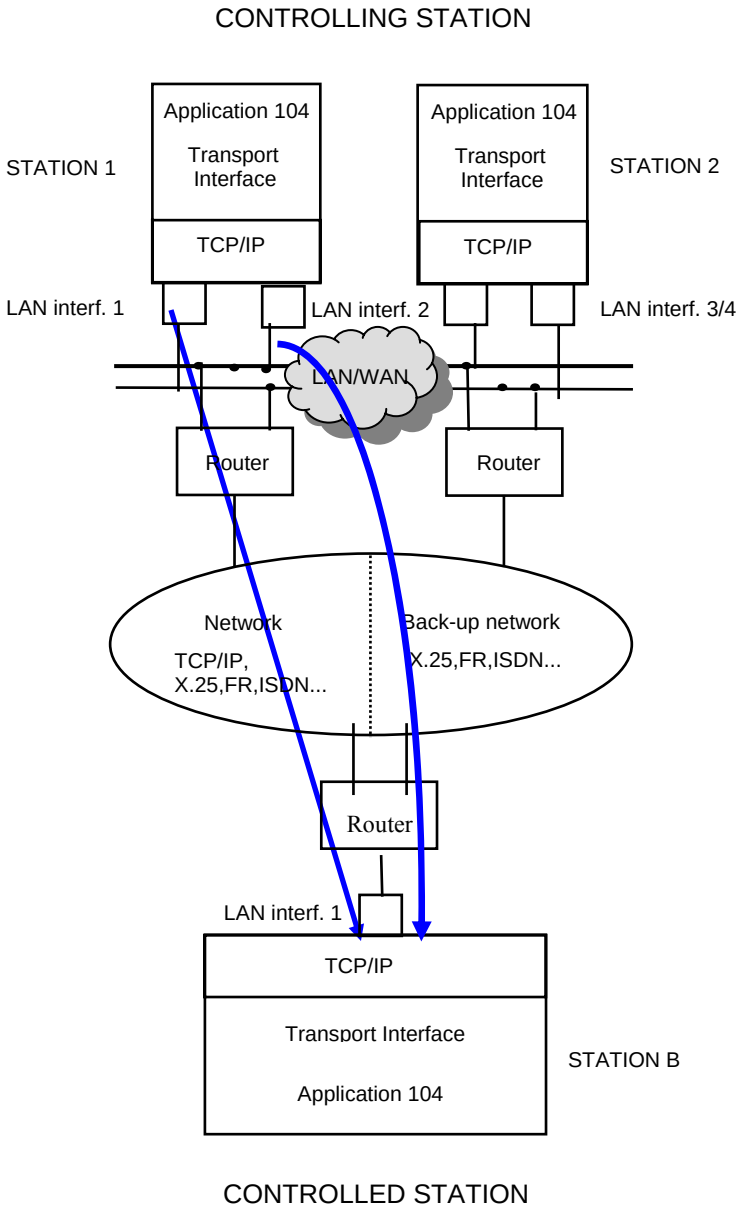


Figure 7.1: Redundant system with a minimum of two possible connections from two interfaces at the front end

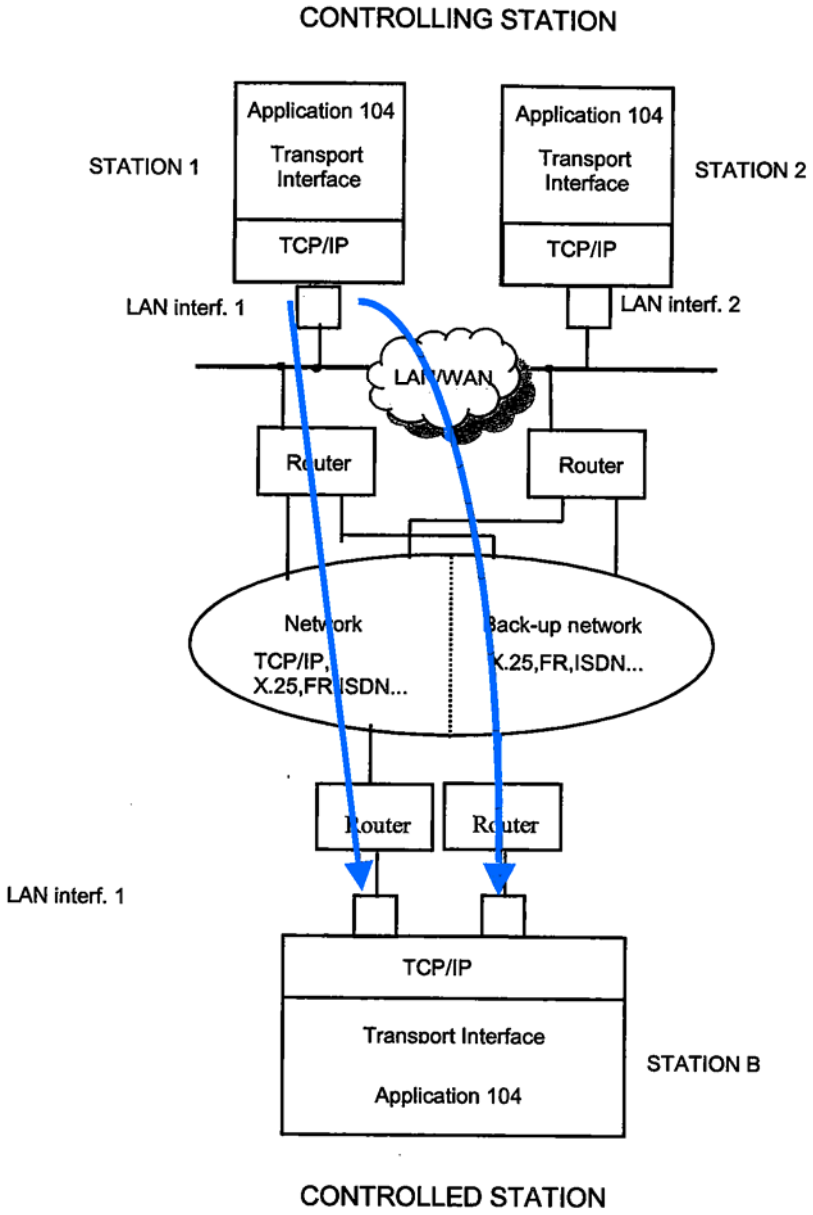


Figure 7.2: Redundant system with a minimum of two possible connections from one front-end interface to one RTU with two interfaces

Communication procedures

7.2.2.1 Initialisation of controlling station

The sequential procedure for initialisation of the controlling station with a minimum of two redundant connections is shown in fig. 7.3.

After restart of station A, the logical connections to station B are brought up according to the initialisation procedure shown in fig. 6.2. After connection establishment STOPDT is always default, and one of the connections (e.g. connection 1) is therefore made active by issuing a STARTDT control frame on this connection. Any user data between the stations will hereafter be transferred on this connection.

When the initialisation procedure is completed, the periodic connection check procedure starts on all connections.

For reasonably fast communication error detection the check period should not be configured with the default value as recommended by the IEC commission (default 20 sec.).

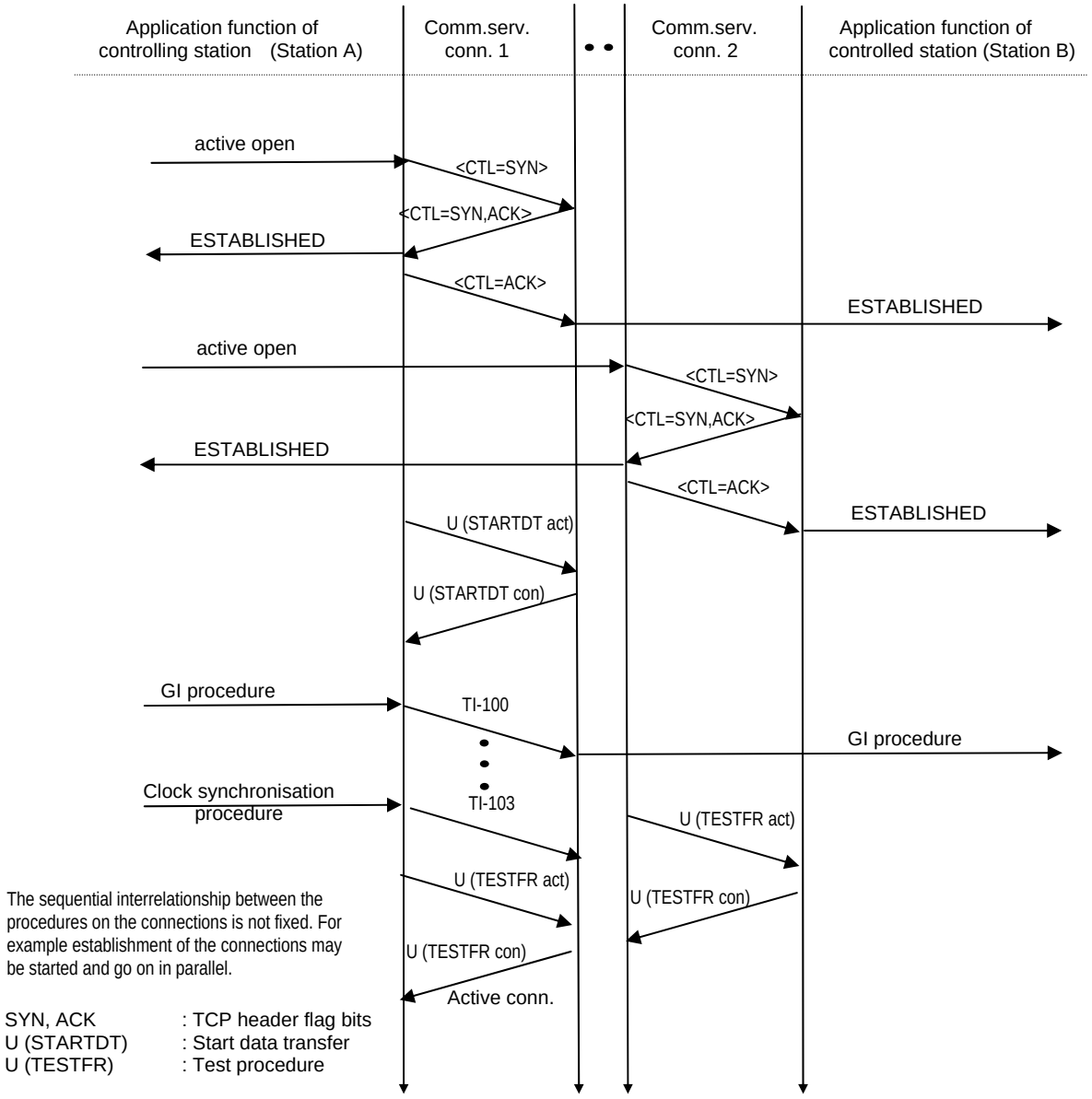


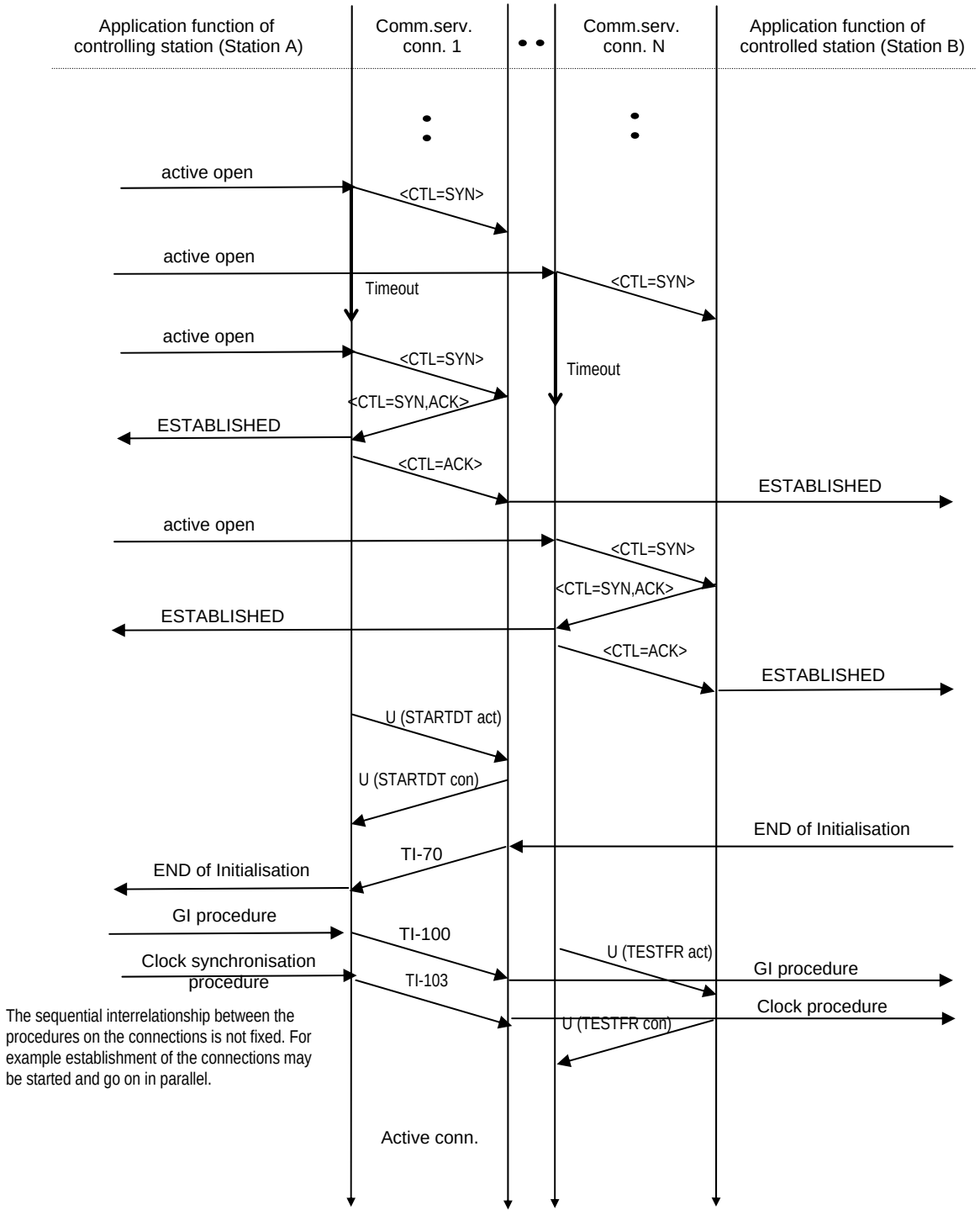
Figure 7.3: Initialisation of controlling station with redundant connections

7.2.2.2 Initialisation of controlled station

The sequential procedure for initialisation of the controlled station with two redundant connections is shown in fig. 7.4.

While the controlled station is down, timeout occurs when the controlling station attempts to establish the connections. After restart of the controlled station the connections are established according to fig. 6.3, but no user data is transmitted from the controlled station until it has received a STARTDT control function on either of the connections (e.g. connection 1) to make it active.

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



TI : Telegram Type Identification
SYN, ACK : TCP header flag bits
U (STARTDT) : Start data transfer
U (TESTFR) : Test procedure

Figure 7.4: Initialisation of controlled station with redundant connections

7.2.2.3 User data from controlling station

If communication fails on the active connection (e.g. connection 1) when the controlling station attempts to transmit user data (e.g. a command transmission ASDU), a connection switch will be performed. The sequential procedure in this case is shown in fig. 7.5.

When transmission timeout has elapsed, the standby connections (connection 2) is made active using the STARTDT function. The ASDU is then directed to the new active connection either by re-transmitting the ASDU on this connection or by terminating the ongoing application function and reinitiating it towards the new connection. The failed connection is closed by the controlling station according to the procedure in fig. 6.1, and reopening is regularly retried until the error has been corrected and the connection is re-established.

Any subsequent user data from the controlled station (e.g. events) are now transmitted on the new active connection.

A connection switch may also be performed whenever the periodic connection check procedure on the active connection fails and hence reports a communication error on this connection.

A general interrogation and a clock synchronisation procedure are required after a connection switch has been performed.

The controlled station must only acknowledge user data received on the connection on which it last received a STARTDT function (the active connection).

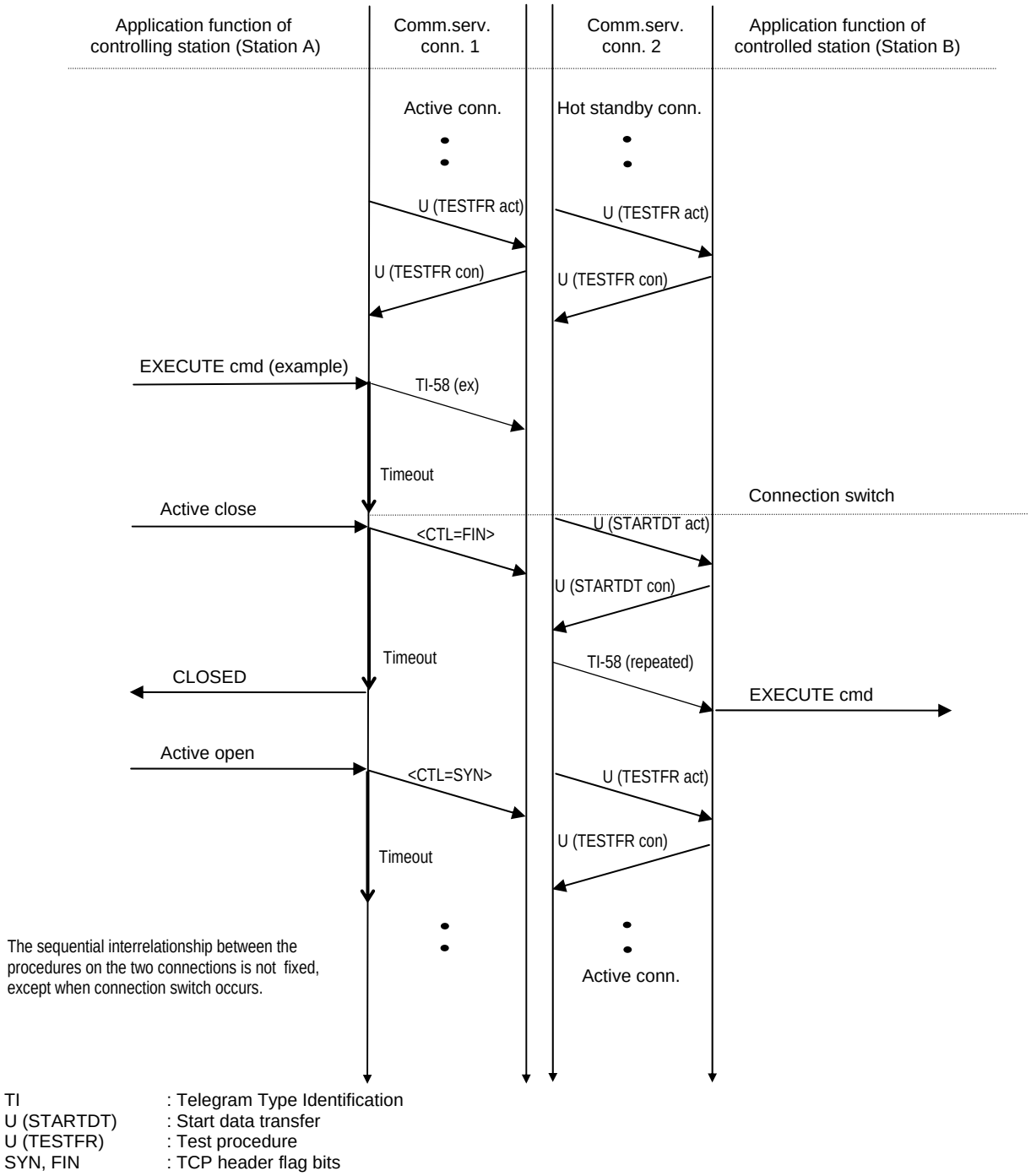


Figure 7.5: Redundant connections - user data from controlling station

7.2.2.4 User data from controlled station

If communication fails on the active connection when the controlled station (station B) attempts to transmit user data (e.g. an event ASDU), the controlled station must wait for the controlling station (station A) to detect the failure and perform a connection switch before the ASDU can be retransmitted on one of the standby connections. A sequential procedure to illustrate this case is shown in fig. 7.6.

After acknowledgement timeout on the active connection (e.g. connection 1) the controlled station performs an active close according to fig. 6.1. A STARTDT function will then eventually be received on one of the standby connections (connection n) as a result of a timeout in the controlling station to the TESTFR function on the currently active but failed connection. The selected standby connection now becomes the new active connection, and the pending event is retransmitted on this connection.

The failed connection is also closed by the controlling station on its side (according to fig. 6.1), and reopening is then regularly retried until the error has been corrected and the connection is re-established.

The controlling station must not acknowledge user data received on a connection which is in the STOPDT state (not active).

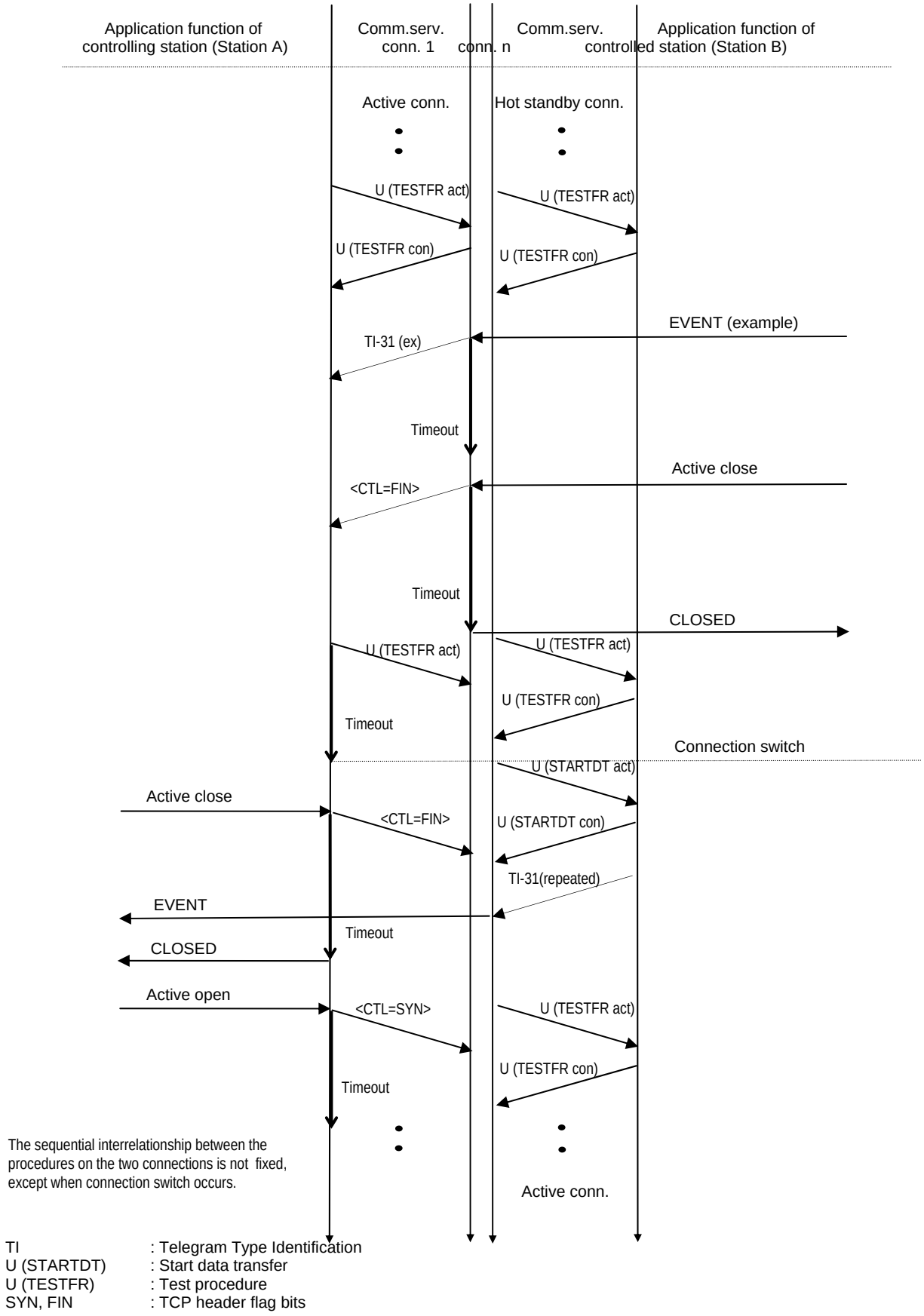


Figure 7.6: Redundant connections - user data from controlled station

7.3 Addressing

7.3.1 Portnumber

Every TCP address consists of an IP address and a port number. Every equipment connected to the TCP-LAN has its individual IP address, while the standard port number for IEC 60870-5-104 is defined to be **2404**, confirmed by IANA.

The server (listener, controlled station) uses the port number **2404** in all cases, both for the listening port and the established connections. The client (connector, controlling station) is free to use ephemeral port numbers, e.g. as allocated by the client's TCP/IP implementation.

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 **2 octet** must be used. Valid ranges are defined in chapter 4. The RST PID104 specifies that the broadcast address for the Common address of ASDU (FFFF) is not 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 **3 octets** must be used. Valid ranges are defined in chapter 4.

7.3.4 Addressing rules

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

- Under one logical link 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).

7.4 Internal events

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 870-5-104 protocol.

The RST PID 104 does not specify any system events from controlled station.

7.5 Quality bits

The protocol implementations must always support all quality bits. Vendors of stations that issue monitoring data should implement the quality bits in the application to a largest possible extent, in accordance with the definitions. Vendors of stations that receive monitoring data should submit to the project how the quality bits are utilised (e.g. logged or flagged) in the application.

7.6 Gateways

When gateways are used, quality bits and addressing have to be implemented to a largest possible extend.

7.7 Time tags

Within RYTU SKIRSTOMIEJI TINKLAI AB the time to be exchanged is UTC+2 time. This means that all time tagged data that is transferred over “the line” contains UTC+2 time. For this reason the summertime bit within the CP56Time2a timetag will not be used and therefore the time in the time tag is always wintertime.

Both local and central HMI applications can translate (if desirable in the project) the UTC+2 time to the local time and display this local time on the HMI to the operators.

It is the responsibility of the vendor that there will be no mismatch in the time tags when displaying time tagged data, exchange time tagged data and storing this time tagged data.

7.8 Security

The controlled station should only accept the establishment of a TCP/IP connection that is known in the controlled station. Therefore it must be possible to configure a list of IP addresses from Master stations (SCADA Front-Ends) that are allowed to establish a connection to.

8 “High level” test criteria

The test criteria will describe the tests to be performed to prove that the protocol implementation delivered by the vendor is according to the IEC standards and the RST PID 104.

The test criteria will consist of a:

- Conformance test
- FAT test
- SAT test

8.1 Conformance testing

Conformance testing, is the process of verifying that an implementation performs in accordance with the applicable dcuments as the IEC standard, PID, etc. A manufacturer may claim: “*my equipment conforms to standard ISO/IEC xxx-x* ”. Conformance testing enables such a claim to be investigated and assessed by an objective and independent third party test institute, to establish its validity. The conformance test may result in certification by means of an Attestation of Conformity, for the tested implementation version in that equipment.

8.2 Factory Acceptance Test

It is in the power of RST to decide if and how the FAT will be organized and which functionality will be tested.

8.3 Side Acceptance test

It is in the power of RST to decide if and how the SAT will be organized and which functionality will be tested.

8.4 Test requirements

Conformance testing enables thus the claim of a vendor being conform according the referenced documents, which need to be investigated and assessed by an objective and independent institute to establish its validity.

- An objective and (supplier) independent third party test institute must perform the conformance test. The test institue will be organized according the international standard ISO.IEC17025. Besides this standard the test organisation and test procedures must follow a quality system according ISO9001/9002. If requested RYTU SKIRSTOMIEJI TINKLAI AB can supply contact information of at least one independent test institute.
- The conformance test must be performed for all to be delivered types of controlling and controlled station protocol implementations.
- The conformance test will be performed against a conformance test plan that, before the conformance test will be performed, need to be approved by RYTU SKIRSTOMIEJI TINKLAI AB.
- If necessary a retest must be done. When the test results are according the requirements the test institute will issue an Attestation of Conformance.
- An Attestation of Conformance remains valid as long as the vendor guarantees that no changes in communication hard- and software have been made that can influence the certified protocol implementation. If changes have been made, a retest is mandatory to update the Attestation of Conformity and to assure conformance.

A paper version of the Attestation of Conformance must be handed over to RYTU SKIRSTOMIEJI TINKLAI AB. The supplier shall also provide the belonging test reports, model numbers, software and firmware references, etc. as necessary, to clearly identify the functionality covered by the protocol implementation. All this documents, information etc. must be handed over prior to the FAT.