SVENSKA KRAFTNÄT
SWEDISH NATIONAL GRID

K1

UNIT, BUSINESS AREA
NTT, Substation Automation Technology

OUR REFERENCE
TR02-04-04E

DATE
2022-10-25

CONSULTATIONS
IAK

TECHNICAL GUIDELINE

REVISION
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APPROVED
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Protocol Implementation Document IEC 60870-5-104 Ed.2

Revision

Notes	Change notes	Date
1	First issue	2018-08-22
2	Changes in telegram types	2022-10-25

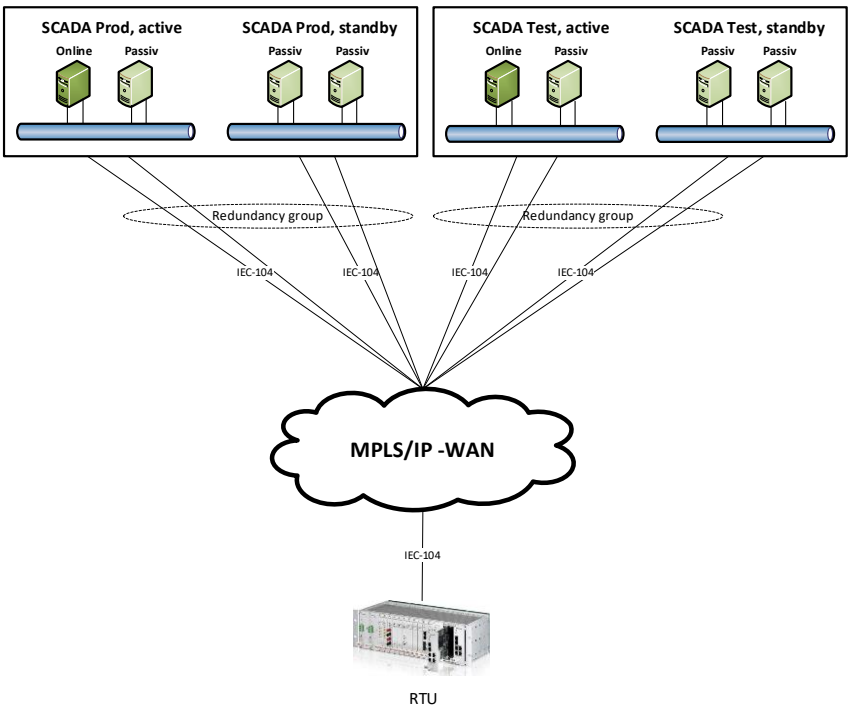
Content

1 Scope and object

The defined telecontrol companion standard IEC104 utilizes standards of the IEC 60870-5 series. The specifications of this standard present a combination of the application layer of IEC 60870-5-101 Ed. 2.0 (IEC101) and the transport functions provided by the TCP/IP (Transmission Control Protocol/Internet Protocol).

Security mechanisms are out of the scope of this document, except for the ones specifically mentioned in paragraph 7.7 in this document.

The purpose of the document is to provide a clear and unambiguous specification of the implementation of the IEC104 standard used within Svenska kraftnät substations and control centers. The document consists of an Interoperability list, defining the subset of IEC104 used within Svenska kraftnät, and detailed descriptions of additional implementation specific requirements.



The 104 data is used to exchange at least the following information:

- Control Switch positions on overhead and underground lines
- Alarm management
- Aquisition of measurements

2 Normative references and protocol definitions

2.1 Normative references

IEC 60870-5-104:2006 - Ed. 2.0, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 104: Network access for IEC 60870-5-101 using standard transport profiles, first edition.

IEC 62351-3:2014 - Power systems management and associated information exchange - Data and communications security - Part 3: Communication network and system security - Profiles including TCP/IP (IEC/IS 62351-3:2014)

RFC 5246:2008 - The Transport Layer Security (TLS) Protocol Version 1.2

IEC 60870-5-101:2003 - Ed. 2.0, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 101: Companion standard for basic telecontrol tasks, second edition.

IEC 61850-80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC104

In case any contradiction regarding the contents and requirements in the above mentioned documents and this document appears, the content of these documents are leading in descending order starting with the first.

Observe that the documents mentioned above might refer to other standards and documents.

2.2 Definitions

For the purpose of this document, the following instantiation of IEC101 definitions apply.

Controlling Station: In general, it is the Svenska kraftnät central control system. Effectively it is a front end processor (FEP) that performs IEC104 client (master) with respect to the Svenska kraftnät substations.

Controlled Station: Substation gateway or RTU that performs IEC104 server (slave) with respect to Svenska kraftnät central system.

Control Direction: The direction of transmission from Controlling Station to Controlled Station (for Normal Direction implementations as in this document).

Monitor Direction: The direction from Controlled Station to Controlling Station (for Normal Direction implementations as in this document).

2.3 Acronyms

APDU = Application Protocol Data Unit

ASDU = Application Service Data Unit (= Application level messages)

CAA = Common Address of ASDU

CDC = Common Data Class (IEC 61850)

COT = Cause Of Transmission

FEP = Front End Processor

IEC101 = IEC 60870-5-101:2003 - Ed. 2.0

IEC104 = IEC 60870-5-104:2006 - Ed. 2.0

IE = Information Element

IOA = Information Object Address

NTP = Network Time Protocol

RTU = Remote Terminal Unit

Svk = Svenska kraftnät

TI = Type Identification

UTC = Universal Coordinated Time

VSQ = Variable Structure Qualifier

3 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 Svenska kraftnät Protocol implementation document (this document).

3.1 Conformance Test

Conformance testing enables 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 institute must be organized according the international standard ISO.IEC17025. Besides this standard the test organization and test procedures must follow a quality system

according ISO9001/9002. If requested Svenska kraftnät 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, needs to be approved by Svenska kraftnät

> When all tests described in the test plan are successfully performed 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.

The supplier shall provide an attestation of conformance according to the applicable documents as in paragraph 2.1 from a third party test house for the installed software version and hardware.

The supplier shall also provide the corresponding 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.

3.2 Proof of Concept

It is up to Svenska kraftnät to decide how and if/when the Proof of Concept will be organized and what the scope of that test will be.

3.3 Factory Acceptance Test

It is up to Svenska kraftnät to decide how and when the FAT will be organized and what the scope of the FAT will be.

3.4 Site Acceptance Test

It is up to Svenska kraftnät to decide how and when the SAT will be organized and what the scope of the SAT will be.

4 General architecture

The general communication architecture used is described in clause 3 of IEC104.

Further Information regarding the physical communication architecture used within Svenska kraftnät is described in accompanying procurement documents since these vary depending on the installation and the geographical location.

5 Protocol structure

The protocol stack and specified selections of protocols are described in clause 4 of IEC104. Svenska kraftnät uses the Ethernet 802.3 stack, unless otherwise specified in procurement documents.

5.1 General structure of application data

IEC 60870-5-3 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 IEC104 and IEC101 protocol IEC104 in Clause 9 Interoperability restricts number of options for some ASDU fields. Here is a recapitulation of ASDU structure as defined in IEC104.

- TI - one octet
- VSQ - one octet
- COT - two octets
- CAA - two octets The CAA typically is the station address, which may be structured in accordance to IEC 61850-80-1
- IOA - three octets, structured
- Time tag: The format CP56Time2a for TIME TAGS is used exclusively in IEC104. Day of week is not used in this companion standard and set to 0.

NOTE: The CASDU together with the IOA distinguishes the complete set of IEs within the system. The CASDU/ IOA combination shall be unambiguous for the system. The TI is not a part of an address.

6 Selection of ASDU

The ASDU:s which is used in this user convention is listed in clause 6 of IEC104. The list contains ASDU:s defined in IEC101 and additional ASDU:s defined in IEC104.

ASDU:s selected for this user convention is listed in clause 9. Descriptions on the selected ASDU:s can be found in 7.3 of IEC101 and clause 8 of IEC104.

7 Specification of application functions

This clause provides details and reference information on the basic application functions supported according the Interoperability list in clause 9.

The information here is also complemented with design requirements described in the following section.

7.1 Station initialization

The application function “Station initialization” shall be supported and implemented according IEC104 section 7.1.

In accordance with the standard, the Controlled station shall send an ENDOFINIT when, and only when, a connection has been established following a local initialization of the RTU, not after a TCP connections establishment and close, or Initialization of the controlling station.

7.2 Cyclic data transmission

Cyclic data transmission shall be supported. On a project specific base, it might be not required.

7.3 Acquisition of events

The application function Acquisition of events as specified in IEC104 section 7.4 shall be supported, with the following additional requirements.

Multiple events may be transferred in the same event ASDU (i.e. SQ=1 shall be supported too). The configured maximum frame length of the system determines the maximum number of events in an event ASDU.

7.4 Transmission of data from Controlled Station to Controlling Station

In the Svenska kraftnät user convention, Alarms, Indications and Measurements are transferred from Controlled Station to Controlling Station on event basis (for measurements cyclically too) - Indications and Alarms after a bit-change, Measurements after passing of dead-band.

If there are more than one ASDU ready for sending, then the order / priority for their transmission shall be determined according to IEC101 Table 16. Events are further prioritized internally in Controlled Station as described in 6.5.4.

Events, ASDU:s sent by controlled station with COT=3 will consequently have higher priority than General Interrogation. This means that Events can interrupt General Interrogation, and then Controlled Station algorithm must guarantee that the end-state of all data points after a general Interrogation is correct.

7.4.1 Event Queues

All event handling in a Controlled Station shall be based on an event queue.

When an overflow of a queue occurs, the oldest event shall be deleted.

A queue of minimum 100 entries shall be implemented.

For Alarms and Indications (Single Points and Double Points), every change shall be stored in the queue. For measurements objects: each measurement shall only have one entry (the most up to date) in the queue even if more messages are generated while buffering.

When a buffer overflow occurs an internal Alarm (Single Point Indication) shall be sent to the Controlling Station which then decides what to do with the situation, typically a General Interrogation. IOA for this indication is 117.

7.4.2 Alarms and indications

After a change of state of an Alarm or Indication the event is transferred once with or without timestamp. The function will be without timestamp only as a response to a General Interrogation request and with timestamp otherwise.

Above mentioned is valid for all Alarms and Indications.

7.4.3 Aggregate messages

The Controlled station needs to be able to aggregate different input signals into one single protocol message, following the aggregation logic requested by Svenska kraftnät. This is at least, but it is not limited to: two Alarms aggregated in a single 104 message, which value is ON if at least one Alarm is ON (OR philosophy; other logics might be requested in the specific project).

This can result in the aggregate message to update from OFF to ON, but also from ON with a timestamp t1, to ON with a timestamp t2.

This is why on the Controlling station side, the system shall be able to signal the operator not only when the value of the message changes, but when the timestamp of the messages or the quality bits change as well.

Svenska kraftnät Scada needs to know which type is used.

7.4.4 Measurements

Measurements can be sent to the Controlling Station with timestamp (as spontaneous) or without timestamp (as cyclic, GI).

As a response to general interrogation ASDU s without timestamp are used, and ASDU s with consecutive information object addresses (Sequence of information elements, SQ=1) should be used if more efficient.

7.4.5 Queue Priorities

The Controlled Station decides the sequence of data to be sent to the Controlling Station. The algorithm must guarantee that high priority events do not totally block events from lower priorities.

At a minimum, following three levels of priority for events should be supported:

1. High: Alarms, Warnings
2. Medium: Indications
3. Low: Measurements

7.5 General interrogation

The application function General interrogation as specified in IEC104 section 7.5 shall be supported.

A broadcast Global interrogation with address 65535 shall return data for all CAA.

7.6 Clock synchronization

Clock synchronization shall be accomplished by means of NTP.

7.7 Command transmission

7.7.1 General

The application function Command transmission as specified in IEC104 section 7.7 shall be supported.

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

7.7.2 Select and execute command

An EXECUTE termination message is issued from the controlled station when the command application procedure is completed successfully. The addressed equipment should change its state, and the new state is indicated to the controlling station by a spontaneous data message (i.e. ASDU is sent with COT = 3, 11 or 12) when reached.

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 timeout interval shall be from 1 to 30 seconds, set to 20 seconds.

7.7.3 Direct command

A direct execute command shall be responded with a ACTCONneg by the controlled station if it is sent to an IOA configured as select and execute command. Each IOA must be configurable as a direct or select and execute command in case both command transmission methods are supported.

A respond ACTCONpos on a command ACT implies the following: the IOA is correct and configured as a controllable IOA, and the interlocking allows the command to be executed.

7.7.4 Delayed and pre-arrived commands

The time tag of a command is always to be checked by the receiving station to determine if the command is excessively delayed or if the time tag of the command is before the present time in the controlled station. In case of a delayed (or premature) command, no command confirmation is to be returned by the protocol, and the command is not to be executed.

The length of the accepted delay is 30 s by default but varies from station to station as a result of the mixed communication infrastructure deployed within Svenska kraftnät because of which it will be necessary to be able vary the delay time, and shall be configurable between 1 and 60 s.

NOTE: It is recommended for maintenance reasons to keep a counter for recording the number of time delayed commands have been received.

7.7.5 Suppression of intermediate position

In case of a command where the return information is a Step Position indication the T-bit will be set when the equipment starts to move. This information must be suppressed in a similar way, and shall be sent only if the corresponding timeout interval of 10 s elapses. The “command operation complete” event will then indicate intermediate position (transient state) by means of the T-bit.

7.7.6 SELECT / BREAK OFF / EXECUTE confirmation

When a select and execute command (single, double command, or regulating step command) has been given by the user process of a Controlled Station, no new command of this group is treated by the protocol until the ongoing select and execute command has reached any of the following states:

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

4. The select and execute command has been deactivated (BREAK OFF command given)

The aim is to have only one selected point in a controlled station at a time, for safety reasons. However, set point commands and bit string commands must be allowed in between single, double and regulating step commands.

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

7.8 Parameter loading

Parameter loading is used to change predefined parameters, e.g. dead band values that define when analogue measurements are to be transmitted.

Reference is made to IEC104 section 7.9.

In case a negative value is sent in the parameter load command the value shall not be accepted and the present value shall be transmitted in the ACTCONneg.

Management interface are used for all configuration.

7.9 File transfer

File transfers shall be accomplished by means of other networking protocols. IEC104 shall not be used for file transfer.

8 Additional implementation requirements

8.1 Addressing

8.1.1 Common Address of ASDU

One Controlled Station can be either an entire Station Control System or only a part of it. The option of having a number of RTUs addressed within one CAA-address is to be considered as mandatory.

It shall also be possible to incorporate a number of CAA:s within a single device/RTU. When doing a broadcast General Interrogation (GI with CAA: 65535) on the RTU it should then return the information available for all CAA:s within the RTU.

Consequently, it shall be possible to access multiple CAA:s through one IP-address.

Not supported in Scada and not used in present configuration.

8.1.2 Addressing rules

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

> Station address, as a part of CAA shall be unique within the system.

> Combination of CAA and IOA shall be unique identifier for its respective data point within the system.

8.1.3 Addressing convention

A modern Station Control System often consists of one common communication equipment, several bay controllers and a number of protection units. Each of them can consist of a number of objects. The IEC870-5-104 standard gives no rules for how addresses are assigned to individual objects. Any structure using CAA and IOA fields is valid by the standard, but there are advantages to follow some conventions within a project in order to reduce engineering costs.

One Common Address of ASDU number per RTU is used and all the objects within the RTU are given a unique Information Object Address. Each data type is given a range within the three octets.

The address range for the IEC104 protocol database shall be organized as described in Table 1.

Table 1

Address	Description
1-100	Internal RTU indications (System Events)
101–110	Internal RTU commands
111–999	Internal RTU indications (System Events)
1001-5000	Single indications
5001-10000	Double indications
10001-12000	Analog measurements
12001-13000	Digital measurements
15001-16000	Commands (CMD) Single commands
16001-17000	Commands (CMD) Double commands
17001-18000	Commands Analog Setpoints (including bitstring commands)
18001-19000	Regulation step commands
19001-20000	Step position information

21000-22000	Bitstring of 32 bit

8.2 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 ASDU:s. There are not reserved special frames for internal events in the IEC104 protocol. They shall be allocated in Internal Variables address space as defined in adressing convention.

Each project has to implement the system events which are necessary for the correct functionality.

8.3 Database handling

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

8.4 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 in accordance with the definitions below. Vendors of stations that receive monitoring data should submit to the project how the quality bits are utilized (e.g. logged or flagged) in the application.

In general quality should be added as close to the source of the value chain as possible. To do so, it is important that the source, i.e. the equipment connected to the process, is handling the quality correctly. Equipment later in the value chain, i.e. other controlled stations, controlling stations and/or mediators should not decrease the quality of an object but, if possible, should add quality to the objects.

> Quality bits need to be handled individually. It shall thus be possible to set quality bits individual from each other.

> The value of each object shall be set individually and in accordance with the associated quality bits.

> Status change of a quality bit shall result in spontaneous transmission with timestamp according to the time of occurrence.

> If one quality bit is set and a new higher ranked quality condition occurs, then the device shall recalculate and update with the correct quality bits.

The ranking of quality bits is as follows: OV (lowest), NT, SB, BL and IV (highest).

> When an IV bit is to be set for an object, then the value of the object shall be the most recent value that was successfully updated.

8.5 Command qualifier

Systems shall support command qualifier QU=0.

8.6 Time Reference

UTC + 1 shall always be used for implementations according this Interoperability specification. Consequently the summer time bit shall always be set to zero (SU=0).

The application in the receiving station must be able to handle time tagged commands correctly (perform a correct command delay check and monitor the return information correctly).

8.7 Security

A controlled station shall only accept attempts to set up a connection, and establish such a connection, from a client's IP addresses that are configured in the controlled station as selected IP addresses.

Other Security requirements are described in TR02-04-03.

9 Redundant connections

The controlling station must be able to handle at least four logical connections within one redundancy group.

The IEC timeouts should be configurable per redundancy group.

The controlled station must be able to handle at least eight redundancy groups (eight different Control Centers).

10 Interoperability list

This companion standard 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 IEC101 and extended with parameters used in this standard. The text descriptions of parameters which are not applicable to this companion standard 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 supported

☒ Function or ASDU is used as standardized (default)

☒ Function or ASDU is used in reverse mode

☒ 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. For this mapping document the selection(s) as made in this document are mapped in this document.

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

10.1 System or device

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

☒ System definition

☐ Controlling station definition (Master)

☐ Controlled station definition (Slave)

10.2 Network configuration

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

■ ~~Point-to-point~~

■ ~~Multiple point-to-point~~

■ ~~Multipoint-party~~ line

■ ~~Multipoint-star~~

10.3 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 >1200 bit/s	Balanced interchange Circuit X.24/X.27
~~100 bit/s~~	~~2400 bit/s~~	~~2400 bit/s~~
~~200 bit/s~~	~~4800 bit/s~~	~~4800 bit/s~~
~~300 bit/s~~	~~9600 bit/s~~	~~9600 bit/s~~
~~600 bit/s~~		~~19200 bit/s~~
~~1200 bit/s~~		~~38400 bit/s~~
		~~56000 bit/s~~
		~~64000 bit/s~~

Transmission speed (monitor direction)

Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 Recommended if >1200 bit/s	Balanced interchange circuit X.24/X.27
~~100 bit/s~~	~~2400 bit/s~~	~~2400 bit/s~~
~~200 bit/s~~	~~4800 bit/s~~	~~4800 bit/s~~
~~300 bit/s~~	~~9600 bit/s~~	~~9600 bit/s~~
~~600 bit/s~~		~~19200 bit/s~~
~~1200 bit/s~~		~~38400 bit/s~~
		~~56000 bit/s~~
		~~64000 bit/s~~

10.4 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 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 cause 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>**

■ The 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).~~

10.5 Application Layer

10.5.1 Transmission mode for application data

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

10.5.2 Common address of ASDU

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

■ ~~One octet~~ [X] Two octets

10.5.3 Information object address

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

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

10.5.4 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.

10.5.5 Length of APDU

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)

[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_SP_TA_1~~
[X]	<5>	:= Step position information	M_ST_NA_1
■	<6>	~~:= Step position information with time tag~~	~~M_ST_TA_1~~
[X]	<7>	:= Bit string of 32 bit	M_BO_NA_1
■	<8>	~~:= Bit string 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~~
[ ]	<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 with time tag	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
X	<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
☐	<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_ME_TF_1
☐	<38>	:= Event of protection equipment with time tag CP56Time2a	M_ME_TF_1
☐	<39>	:= Packed start events of protection equipment with time tag CP56Time2a	M_ME_TF_1

	<40>	:= Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

In this companion standard only the use of the set 30-40 for ASDUs with time tag is permitted.

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
X	<48>	:= Set point command, normalized value	C_SE_NA_1
X	<49>	:= Set point command, scaled value	C_SE_NB_1
X	<50>	:= Set point command, short floating point value	C_SC_NC_1
X	<51>	:= Bitstring of 32 bit	C_BO_NA_1
X	<58>	:= Single command with time tag CP56Time2a	C_SC_TA_1
X	<59>	:= Double command with time tag CP56Time2a	C_DC_TA_1
X	<60>	:= Regulating step command with time tag CP56Time2a	C_RC_TA_1
X	<61>	:= Set point command, normalized value with time tag CP56Time2a	C_SE_TA_1
X	<62>	:= Set point command, scaled value with time tag CP56Time2a	C_SE_TB_1
X	<63>	:= Set point command, short floating point value with time tag CP56Time2a	C_SE_TC_1
X	<64>	:= Bitstring of 32 bit with time tag CP56Time2a	C_BO_TA_1

Either the ASDUs of the set <45> – <51> or of the set <58> – <64> are used, this is decided in the implementation phase.

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_IC_NA_1
X	<103>	:= Clock synchronization command (option, see 7.6)	C_IC_NA_1
	~~<104>~~	~~:= Test command~~	~~C_TS_NB_1~~
	<105>	:= Reset process command	C_RP_NC_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 standard direction, '**R**' if only used in reverse direction, and '**B'** if used in both directions. '**S**' if only used in selected cases)

☐	<120>	:= File ready	F_FR_NA_1
☐	<121>	:= Section ready	F_SR_NA_1
☐	<122>	:= Call directory, select file, call file, call section	F_SC_NA_1
☐	<123>	:= Last section, last segment	F_LS_NA_1
☐	<124>	:= Ack file, ack section	F_AF_NA_1
☐	<125>	:= Segment	F_SG_NA_1
☐	<126>	:= Directory {Blank or X, only available in monitor (standard) direction}	F_DR_TA_1
☐	<127>	:= QueryLog – Request archive file	F_SC_NB_1

Type identifier and cause of transmission assignments
(Station-specific parameter)

Shaded boxes are not required
Black boxes are not permitted in this companion standard
Blank = Function or ASDU 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	X		x					
~~<2>~~	~~M_SP_TA_1~~																			
<3>	M_DP_NA_1					X						X	X		x					
~~<4>~~	~~M_DP_TA_1~~																			
<5>	M_ST_NA_1					X						X	X		x					
~~<6>~~	~~M_ST_TA_1~~																			
<7>	M_BO_NA_1					X									x					
~~<8>~~	~~M_BO_TA_1~~																			
<9>	M_ME_NA_1																			
~~<10>~~	~~M_ME_TA_1~~																			
<11>	M_ME_NB_1																			
~~<12>~~	~~M_ME_TB_1~~																			
<13>	M_ME_NC_1	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			X																
<34>	M_ME_TD_1			X																
<35>	M_ME_TE_1																			
<36>	M_ME_TF_1			X																
<37>	M_IT_TB_1			X																
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<40>	M_EP_TF_1																			
<45>	C_CS_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						X	X			X						X	X	X	X
<49>	C_SE_NB_1						X	X			X						X	X	X	X
<50>	C_SE_NC_1						X	X			X						X	X	X	X
<51>	C_BO_NA_1						X	X			X						X	X	X	X
<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						X	X	X	X	X						X	X	X	X
<62>	C_SE_TB_1						X	X	X	X	X						X	X	X	X
<63>	C_SE_TC_1						X	X	X	X	X						X	X	X	X
<64>	C_BO_TA_1						X	X			X						X	X	X	X
<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						X	X									X	X	X	X
<113>	P_AC_NA_1						X	X									X	X	X	X
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1*)																			

*) Blank or X only

10.6 Basic application functions

10.6.1 Station initialization

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

[**X**] Remote initialization

10.6.2 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

10.6.3 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

10.6.4 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

10.6.5 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 specific project)

☐	Measured value, normalized	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

10.6.6 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)

☒ global

☐ group 1 ☐ group 7 ☐ group 13

☐ group 2 ☐ group 8 ☐ group 14

☐ group 3 ☐ group 9 ☐ group 15

☐ group 4 ☐ group 10 ☐ group 16

☐ group 5 ☐ group 11

☐ group 6 ☐ group 12

Information object addresses assigned to each group must be shown in a separate table.

10.6.7 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)

☒	Clock synchronization (optional)
☐	Day of week used
☐	RES1, GEN (time tag substituted/ not substituted) used
☐	SU-bit (summertime) used

10.6.8 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

X	Direct set point command transmission.
X	Select and execute command
X	Select and execute set point command
X	C_SE_ACTTERM used
X	No additional definition
	Short pulse duration (duration determined by a system parameter in the outstation)
	Long pulse duration (duration determined by a system parameter in the outstation)
	Persistent output
	Supervision of maximum delay in command direction of commands and set point commands

Maximum allowable delay of commands and set point commands: See chapter 7.7.4

10.6.9 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

Addresses per group have to be defined

10.6.10 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

10.6.11 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

10.6.12 Test 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)

☐ Test procedure

10.6.13 File transfer

(Station-specific parameter, mark '**X**' if function is used, mark '**S**' if function is used in selected cases)

☐ Transparent file

☐ Transmission of disturbance data protection equipment

☐ Transmission of sequence of events

☐ Transmission of sequence of recorded analog values

File transfer in control direction

☐ Transparent file

10.6.14 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

10.6.15 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)

■ ~~:= Delay acquisition command~~

10.6.16 Definition of timeouts

Parameter	**Default value**	**Remarks**	**Selected value**
t_0	30 s	Time-out of connection establishment	Configurable
t_1	15 s	Time-out of send or test APDUs	Configurable
t_2	10 s	Time-out for acknowledges in case of no data messages $t_2 < t_1$	Configurable

t_3	30 s	Time-out for sending test frames in case of a long idle state	Configurable

Recommended range for t_0 - t_2: 1 to 255 s, accuracy 1 s
Recommended range for t_3: 1 s to 48 hrs, accuracy 1 s

Long timeouts for t3 may be needed in special cases where satellite links or dialup connections are used (e.g. to establish connection and collect values only once per day or week.) For dialup connections it may be necessary to give up the connection supervision completely. This is achievable by setting the timeout t3 to zero.

10.6.17 Maximum number of outstanding I format APDUs k and latest acknowledge APDU (w)

Parameter	Default value	Remarks	Selected value
k	12 APDUs	Maximum difference receive sequence number to send state variable	Configurable
w	8 APDUs	Latest acknowledge after receiveing w I format APDUs	Configurable

Maximum range of values k: 1 to 32767 (215 - 1) APDUs, accuracy 1 APDU

Maximum range of values w: 1 to 32767 APDUs, accuracy 1 APDU
(Recommendation: w
should not exceed two-thirds of k).

10.6.18 Port number

Parameter	Value	Remarks
Port number	2404	In case IEC 62351-3 is disabled
Port number	19998	In case IEC 62351-3 is enabled

10.6.19 Redundant connections

Number of redundancy group connections used is described in chapter 9.

10.6.20 RFC 2200 suit

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.

11 Project specific information

11.1 Basic data

Project name: <project_name>

Station type: Controlling/Controlled

Assigned CAAs:

(More)

11.2 Exceptions

Only for this specific project, Svenska kraftnät allows the vendor <vendor name> for the following exceptions:

- Cyclic data and ASDU 113 are not supported
- Queue length: 3000 entries

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