Remote Terminal Unit Protocols Specifications

This document describes UP 2015, the Remote Terminal Unit for telecontrol and supervision of Medium Voltage distribution network; it provides functional and construction requirements for the provision.

Countries' I&N – NT/RCP	Elaborated by	Verified by	Approved by
Argentina			-
Brazil			**Victor Manuel Galvao Macedo Costa**
Chile			**Hans Christian Rother Salazar**
Colombia			**Cesar Augusto Rincon Alvarez**
Iberia			**Maria Avery Fernandez**
Italy			**Lilia Consiglio**
Peru			**Roberto Leonidas Sanchez Vargas**
Romania			**Marius Mihai Domnicu**

	Elaborated by	Verified by	Approved by
Global I&N – NT/RCP	Di Lembo/Consiglio	Maria Avery Fernandez Calero Aparicio José Luis	Giorgio Di Lembo

Revision	Data	List of modifications
00	02.11.2015	First version

Index

1 ACRONYMS

APCI	Application Protocol Control Information
APDU	Application Protocol Data Unit
ASDU	Application Service Data Unit.
IGMP	Internet Group Management Protocol (RFC 1112).
IOA	Information Object Address.
IP	Internet Protocol (RFC 791).
ITU-T	International Telecommunication Union – Telecommunication: http://www.itu.int/ITU-T/recommendations/index.aspx
OSI	Open Systems Interconnection protocols
PPP	Point to Point Protocol
RCF	Request for Comments (document series contain technical and organizational notes about the Internet: http://www.rfc-editor.org/search/rfc_search.php)
TCP	Transmission Control Protocol (RFC 793).
UDP	User Datagram Protocol (RFC 768).

2 OBJECT AND SCOPE

This document describes the communication procedures between the generic Center and the new Peripheral Unit (RTU).

3 NORMATIVE REFERENCIES

Specification	Description
IEC 60870-5-1	IEC 60870-5-1: 1990, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 1: Transmission frame formats.
IEC 60870-5-2	IEC 60870-5-2: 1992, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 2: Link transmission procedures.
IEC 60870-5-3	IEC 60870-5-3: 1992, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 3: General structure of application data.
IEC 60870-5-4	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	IEC 60870-5-5: 1995, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 5:Basic application functions.
IEC 60870-5-6	IEC 60870-5-6 Guidelines for conformance testing for the IEC 60870-5 companion standards
IEC60870-5-101	IEC 60870-5-101: 1996, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 101: Companion standard for basic telecontrol tasks. Draft IEC 60870-5-101: 1998, Telecontrol equipment and systems - Part 5: Transmission protocols – Addendum to Section 101: Extension of time tags
IEC60870-5-104	IEC 60870-5-104: 1998, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 104: Network access for IEC 60870-5-101 using standard transport profiles.
GSTR001/1	Remote Terminal Unit for secondary substations
GSTR001/1/A1	Remote Terminal Unit Configuration and Application Program Interface specifications

4 INTRODUCTION

The overall system has the following components:

1. Control Centers. They perform the data acquisition and control functions for the different remote units. The proposed approach permits the existence of more than one Control Center per system. Although each of the different control centers connected may be multi-protocol, this document specifies the use of protocols IEC60870-5-101 and IEC60870-5-104 only.

2. **RTUs**: Remote Terminal Units. Their function is basically to collect the data in the electricity substations, transmit it to the corresponding Control Centers, and execute commands received from the Control Center.

3. **Communication channel**: it interconnects the different RTUs with the control center. This document analyzes the different communication channels, including the message switched networks and the multiple point-to-point data links. Hybrid combinations involving elements of both of these approaches are also possible, as they will be examined in the subsequent chapters.

Each RTU can communicate with the Center by adopting one of the following two communication protocols:

- IEC 60870-5-101, on the RS232 serial port (GSM/PSTN modem or direct mode).
- IEC 60870-5-104, on either the ethernet port or the RS232 serial port (GPRS modem or direct mode).

5 IEC 60870-5-101 PROTOCOL

It is necessary to refer to the profile specified in the IEC 870-5-101 specification [the profile consists of three OSI levels: 7 (Application), 2 (Data-Link) and 1 (Physical), see Table 1 for the “unbalanced transmission mode”, and in compliance with the details/changes/integrations listed below for every OSI level.

Table 1 - Selected standard provisions of the defined telecontrol companion standard

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

Level 1:

The RTU utilizes the following transmission networks:

- GSM 900 network;
- DCS - 1800 network;

- PSTN network;
- Direct interconnection to dedicated circuits (4W Leased Line);
- Radio;
- Satellite network.

The DTE (RTU) must interface with these transmission networks by means of a physical interface to an external modem (external DCE).

Physical interface to the external modem

The physical interface for the connection to an external modem must have the following characteristics:

- Type: ITU-T V.24/V.28.
- Connector: ISO 2110, D type, 25.pole, “male”.
- Managed interchange circuits: see GSTR001/1.

Power supply for the external modem

- The 12 V_{DC} and 24 V_{DC} power supply for the DCE is available at the appropriate terminals (DV25 terminal board).

Data interchange with the modem

In order to achieve the data interchange between the RTU and the modem, the following instructions must be adhered to:

- Transmission rate of reference data: 9600bps; nonetheless, the RTU must be designed to operate at higher speeds also, up to a maximum of 115.2 kbps, whereas other transmission systems and technologies are able to support them.
- Data format: asynchronous transfer mode, 1 start bit, 8 bit data, no parity bit, 1 stop bit.
- Flow control: software, by using DC1 – DC3 (XON - XOFF) characters, and hardware, by using C.106 (CTS) and C.105 (RTS) circuits.

Modem management

Funtions of the modem must be handled by the RTU according to the standard mode:

- AT commands (GSM 07.05, GSM 07.07, V.25ter);
- V.25bis.

The DCE GSM/DCS connection cable, which is always included in the supply of each UE, must be at least 2m long, and must include the following:

- a D25 type connector, female poles, on the RTU side;
- a D9 type connector, male poles, on the GSM modem side;

In the case of PSTN, GSM, and 1800 DCS networks, a mechanism for restoration of the connection (with related time-out period) is provided, in case the line drops.

Level 2:

- The Center and the RTU will respectively play the role of “Master” and “Slave”;

- the address field must consist of two octets;
- the “single control character” must not be used;
- In the case of GSM/DCS and PSTN transmission networks:
  - the parity bit of each character of 11 bits must be omitted (violation of the R2 rule, each character will then be composed of 10 bits), with the activation of:
    - in the case of GSM/DCS, a “non-transparent” data transmission mode;
    - in the case of PSTN, a V.42 error correction;
  - the initial idle character must be omitted (violation of the R1 rule);
  - During the data reception, there must be discontinuity between the characters (inter-character time window) of the same frame (violation of the R3 rule), according to the typical time-out of the GSM/DCS and PSTN transmission networks, as a function of the set out conditions of use.
- In the case of a spontaneous call (level 1) of the RTU, the "Master" launches an identification procedure for the recognition of the "Slave", and the subsequent initiation of the data exchange;
- The standard time-outs provided are valid beginning from the validation time of the physical connection (level 1).

Level 7:

- The application protocol must be implemented according to the instructions provided in the standard and according to the interoperability profile inside the reference document;
- the chosen subset of messages, selected from the overall set provided in the standard, supports the implementation of the application activities, as illustrated in the reference document;

5.1 Level 2 procedures (link layer)

The communication functions are managed by specific procedures which govern the data exchange between the Control Center (CC) and the remote substations (RTU).

At this level, the main procedure are the following two:

- Substation startup;
- SEND/NO REPLY, SEND/CONFIRM and REQUEST/RESPOND base services.

For the detailed descriptions of the procedures at the link layer level, refer to IEC 60870-5-101, IEC 60870-5-101 and GSTR001/1 specifications.

5.1.1 Substation startup

During the startup, the Center decides with which of the controlled substations it can communicate with.

The procedure requested is defined in the diagram of Figure 1.

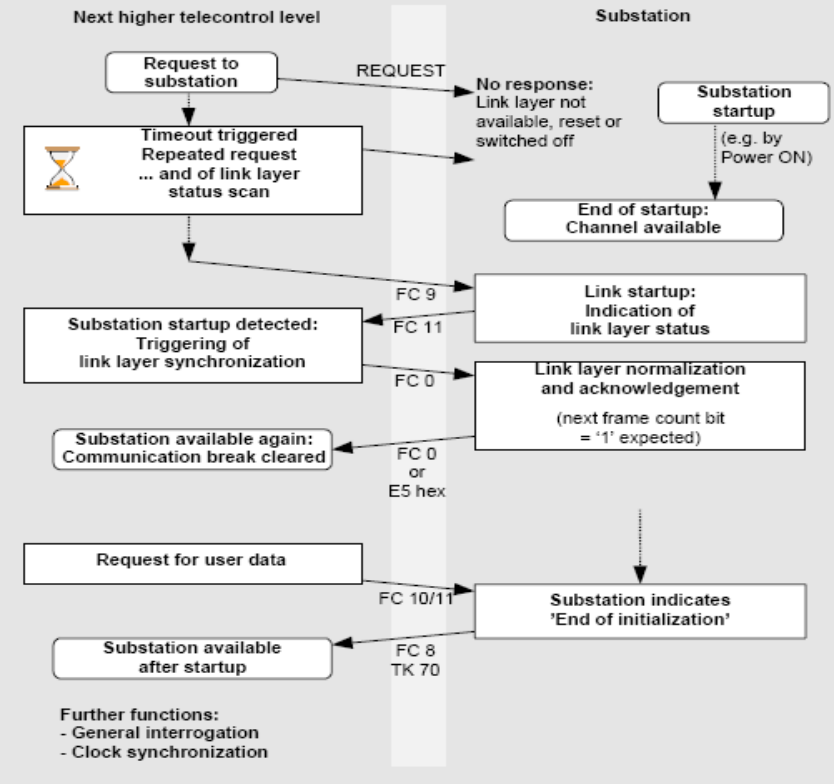

Figure 1- Substation Startup (RTU)

The center recognizes the interruption of a communication with a substation at the time when the request made is not acknowledged with a response. After a predefined number of consecutive attempts, an indication of interruption of communication ("communication break") is generated.

Subsequently, the Center tries to reestablish the communication with the substation, by sending the demand for the communication status ("Request status of link"), once per scan cycle,.

As soon as the communication is restored, the substation responds by sending the communication status ("Status ok button"). At this point, the Center "understands" that the communication has been restored, normalizes the communication channel and generates an indication of cancellation of the interruption of communication ("communication break cleared").

After the synchronization at the link layer and the initiation of the application level, the substation generates an indication of the end of the initialization ("End of initialization (TK 70)").

5.1.2 Base services

The link layer provides a set of base transmission services useful for the echange of data and telegrams managed by the transmission protocol IEC 60870-5-101.

These services are:

- SEND/NO REPLY
- SEND/CONFIRM

- REQUEST/RESPOND

The operative principle of these three base services is shown in Figure 2.

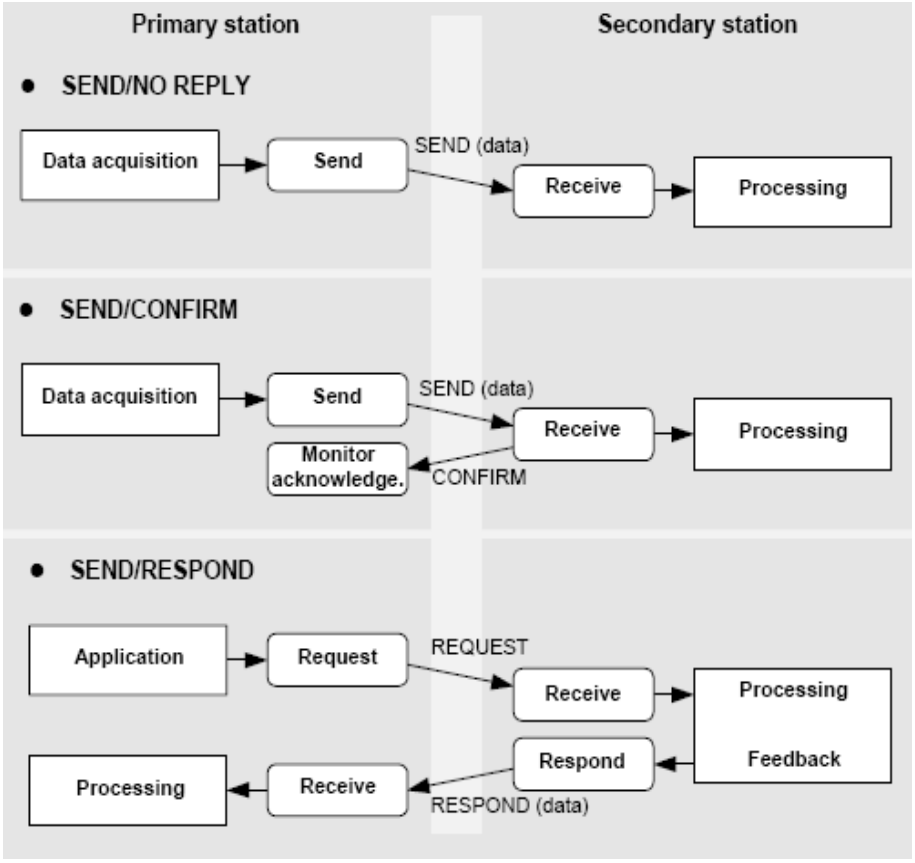

Figure 2 - Base services for the data exchange.

By way of the **SEND/NO REPLY** service, the Center (primary substation) does not expect a response from the substation (secondary substation).

By way of the **SEND/CONFIRM** service, the center always expects a ("Confirm") response from the substation; in the event where no response is sent, the primary station may resend the telegram.

The **REQUEST/RESPOND** service is the base service utilized by the Center in order to capture the information process in the unbalanced mode.

Base services usage

In an asymmetrical transmission, there is a unique transmission channel for both the monitoring and the control. This channel is shared by the connected substations. For this reason, the exchange of data is always explicitly demanded from the Center, and a station then transmits data only when it is required.

The following services are available for the transmission of the primary substations:

- ❑ SEND/NO REPLY: for the cyclic transmission of the set-points. It is also utilized for the transmission of all of the broadcast telegrams (e.g. the time syncronization).
- ❑ SEND/CONFIRM: for the transmission of all of the configurations commands and telegrams to the substation. The substation must confirm the receipt.
- ❑ REQUEST/RESPOND: utilized by the Center to request the application data of the substation and the status of the communication at the link layer.

In response to the base services listed above, the following types of telegrams can be sent:

- ❑ CONFIRM: the confirmation telegram, which can be a single character (E5 hex) or a short telegram indicating a positive or negative response, and is sent from the substation to the Center as an acknowledgment upon receipt of a SEND / CONFIRM telegram.
- ❑ RESPOND: in response to a REQUEST telegram from the Center, the interface module of the central control station generates a RESPOND telegram, whose meaning is provided below:
  - o User data (FC8);
  - o Required data unavailable (FC9);
  - o Link status (FC11).

The Center periodically send requests to the substation in class 1 and class 2.

The data is sent to the Center by the substation as a function of the request for class 1 or 2.

The rules that govern the exchange of data through requests in class 1 or class 2 are compliant with the IEC 69570-5-101 protocol in all the cases, except for the initial conversation between the Control Center UC and the RTU. In the latter, to retrieve the stored data in the RTU, the Center makes a request to the RTU in class 1 for a maximum of N times (currently 15, although configurable) in order to retrieve the data stored prior to any other information.

5.2 Procedures of Level 7 (application layer)

The base application function, selected by the IEC 60870-5-5 protocol, are the following:

1. Substation initialization (IEC 60870-5-5, 6.1)
2. Data acquisition by polling (IEC 60870-5-5, 6.2)
3. Cyclic data transmission (IEC 60870-5-5, 6.3)
4. Acquisition of events (IEC 60870-5-5, 6.4)
5. General interrogation (IEC 60870-5-5, 6.6)
6. Clock synchronization (IEC 60870-5-5, 6.7)
7. Command transmission (IEC 60870-5-5, 6.8)
8. Transmission of integrated totals (IEC 60870-5-5, 6.9)
9. Parameter loading (IEC 60870-5-5, 6.10)
10. Test procedure (IEC 60870-5-5, 6.11)
11. File transfer (IEC 60870-5-5, 6.12)
12. Acquisition of transmission delay (IEC 60870-5-5, 6.13)

After the successful initialization of the station, all of the application functions must be available in order to function at the same time.

If the RTU has data which is ready for the transmission of more than one ASDU type among those reported in the following table, these must be sent according to the order indicated below, regardless of what have been generated previously.

Table 2 neither defines the order according to which the Center requests data nor indicates that the RTU must not transmit data until another data type is available. Different types of ASDU which are on the same line can be sent according in any order.

The requirements for the transmission of information according to a chronological order are those reported at §7.2.2.2 of the IEC 60870-5-101 specification.

Table 2 – Order of priority of the response for the RTU

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

5.2.1.1. *Initialization procedure of the RTU station*

Upon the commencement from the Center or the station (RTU), the initialization procedure is recalled. This procedure is different as a function of the communication line (dial-up or dedicated line).

The initialization procedure for the dial-up line (currently in use by ENEL) is shown in Figure 3.

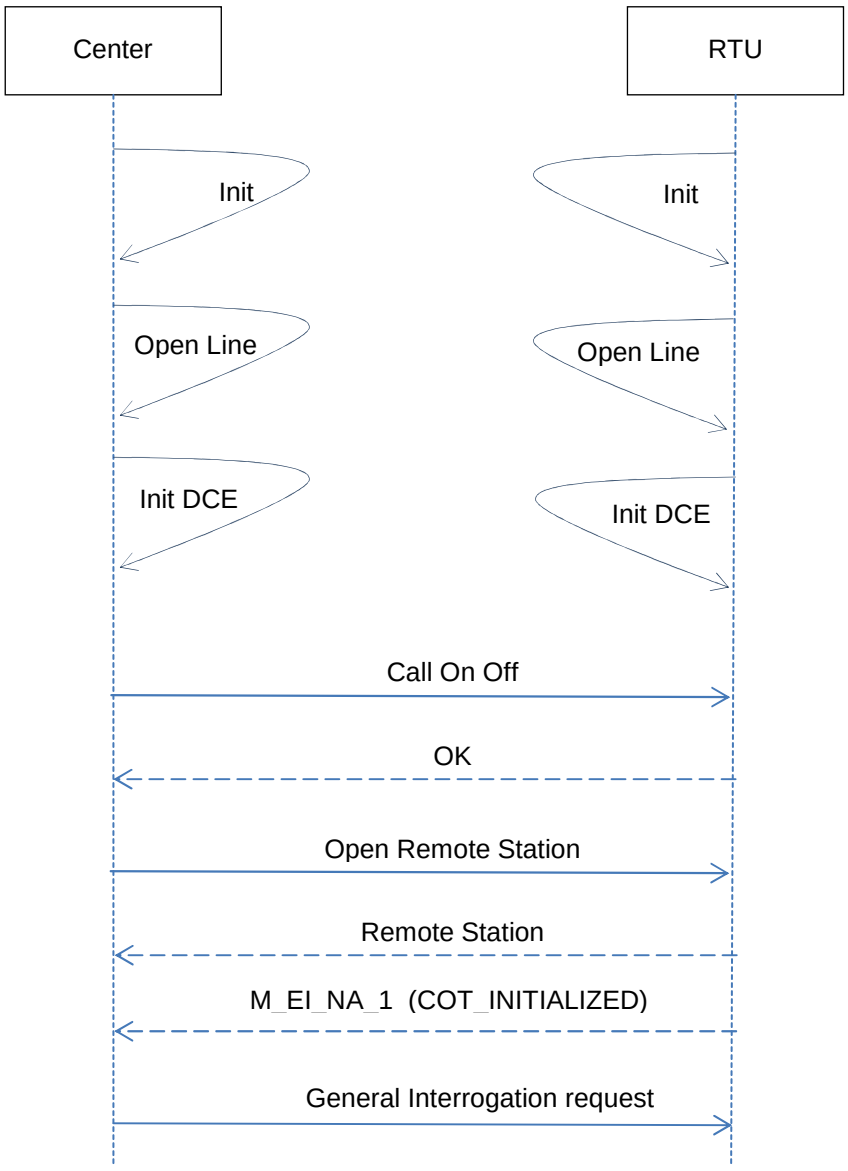

Figure 3 - Initialization procedure on the dial-up line.

At the startup, both the Center and the RTU recall the Init API, which initializes the interface: the call to this function, which must be made only once at the start, determines the initialization of the entire interface as a set of threads or processes, resources of memory, and an operating system.

The function has suspensive states following the start-up synchronization and requires a certain time, however limited, to complete the operations.

The system then calls the *OpenRemoteLine* function, which the application requires in order for the interface to allocate the resources necessary for the communication with a remote communication line. The function has suspensive states necessary to complete all of the operations necessary for the opening of the line and needs a certain time, however limited, to complete the operations.

The next step is represented by the initialization of the modem, which requires a given time (depending upon the response times of the modem) for its execution. Upon the return of the function, if the result is succesfull, the procedure is launched and the outcome is communicated by the callback *CbUserNotify* function, otherwise the procedure must be considered completed.

Subsequently, the *CallOnOff* procedure is recalled, which the application interface requires in order to the activate or deactivate of the line. The function returns immediately after the start of the procedure, and the outcome of the latter is then notified through the special events of the modem. If the line is active and the activation is requested, the function returns immediately and successfully. If the line is not active and the deactivation is requested, the function returns immediately and successfully. The function is only available for dial-up lines. Figure 4 demonstrated a detailed diagram of the main initialization functions.

A special authentication procedure is included inside the *CallOnOff* function, which involves the exchange of messages (keys) between the Center and the RTU. This authentication process applies to dial-up line only.

The next step is the call to the *OpenRemoteStation* function, which establishes a communication between the Center and the RTU at the application layer. This function must be recalled for every remote RTU. Following this call, the interface allocates the resources necessary for the communication with the RTU and places the same on the scan list for periodic polling. The function has suspensive states necessary to complete all of the operations required for the registration of the RTU and requires a given time, however limited, in order to complete the operations. The return of this function communicates the Remote Station Id to the Center, which then starts the communication at the application level.

Before the closure of the procedure, the General Interrogation request is invoked. Refer to §5.2.1.2 for details.

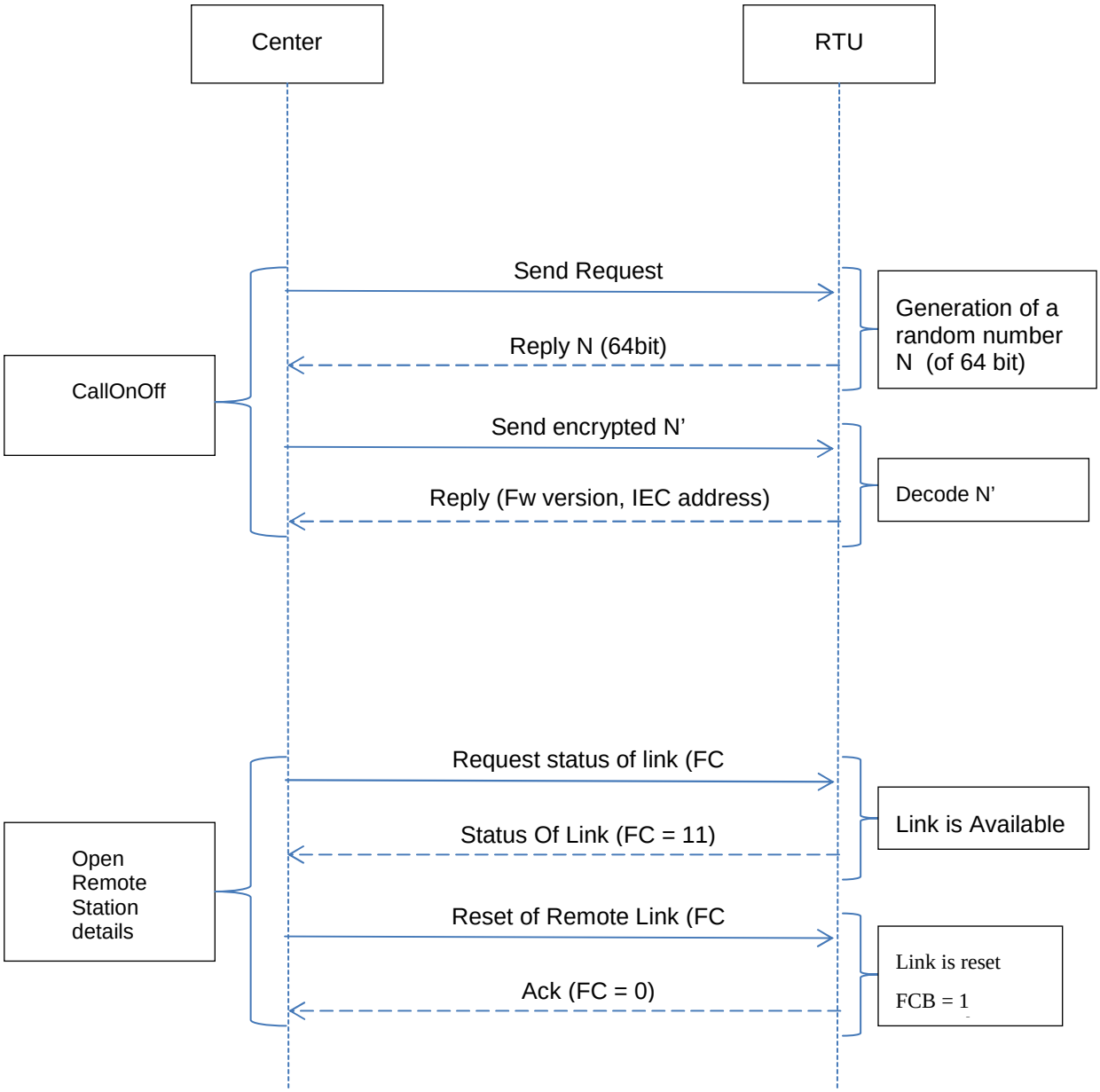

Figure 4 – Initialization procedure: details.

Figure 5 shows the initialization procedure used for the dedicated line.

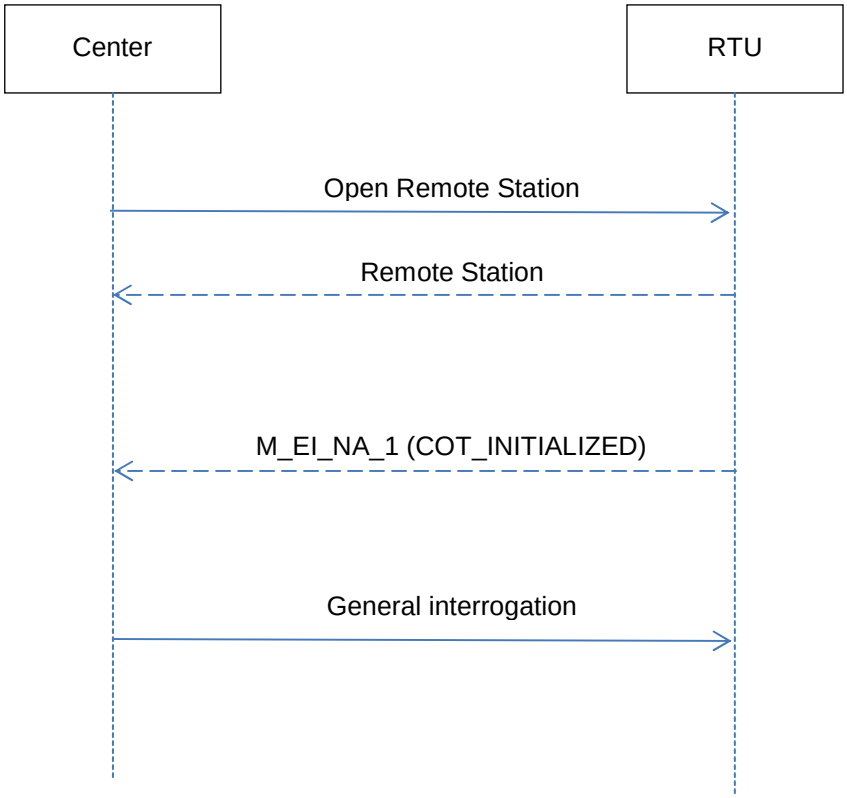

Figure 5 –Initialization procedure on the dedicated line.

5.2.1.2. *Procedure of General Interrogation*

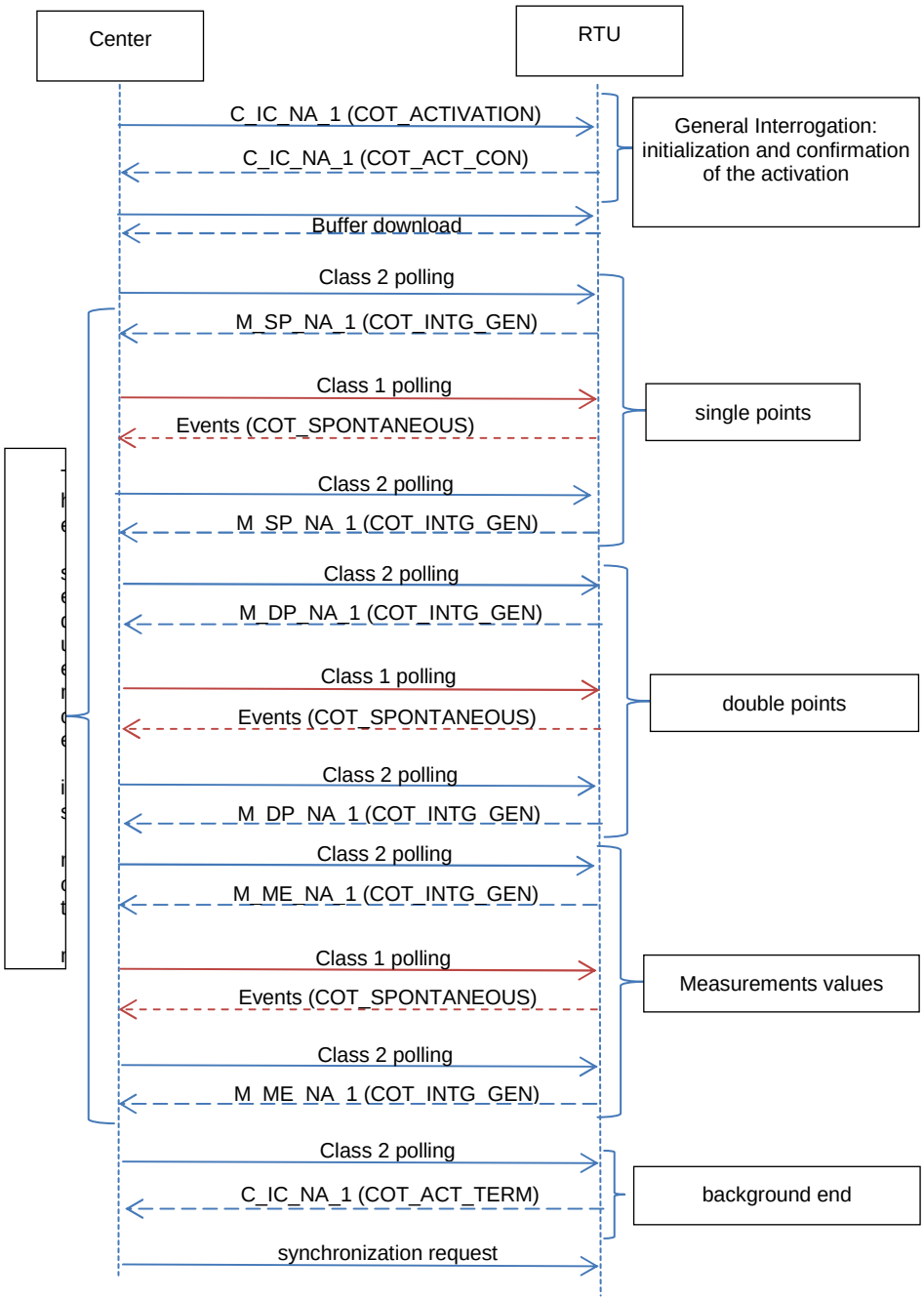

Figure 6 – Procedure of the General Interrogation.

The procedure of General Interrogation is invoked at different times, in particular at the end of the initialization process of the Center or of the RTU, whose sequence is shown in Figure 6

After the General Interrogation request and the activation confirmation, the buffer emptying procedure is established (see § 5.2.1.3).

After the emptying procedure, the RTU constantly queries the RTU in Class 1 and in Class 2. During the queries in class 2, the RTU returns the status of both the single and the double points, and of the values of the measurements, all containing the COT_GEN_INT code.

In addition to the actual field measurements, the three measurements with IEC 501, 502 and 503 indexes must be transmitted, which represent the information contained in the RTU (see attached IEC database):

- IEC 501 – Manufacturer code (Finmek=2, Selta=3, Ducati=4, Areva=5, Siemens=6, Col=7, Abb=8, Alstom=9, Advanced Devices=10, Sindi=12)
- IEC 502 - SW Boot/Eprom Version, according to the format X.YY (102 for 1.02)
- IEC 503 – RTU Application SW version, according to the format X.YY

This information is sent from the RTU in the background mode only.

At the end of the emptying process, the RTU responds with the message of general interrrogation end (C_IC_NA_1, with code COT_ACT_TERM) in class 2.

Immediately following a synchronization request is sent by the Center to the RTU.

5.2.1.3. *Measurements and events buffer download*

The buffer contains 200 variations at most and is downloaded by the Center, which queries the RTU in class 1, for a consecutive number of times (currently equal to 15). The RTU responds by sending the stored data, by compacting the maximum permissible number in every message. Chapter 7.2 provides the details concerning the contraints relating to the maximum number of messages.

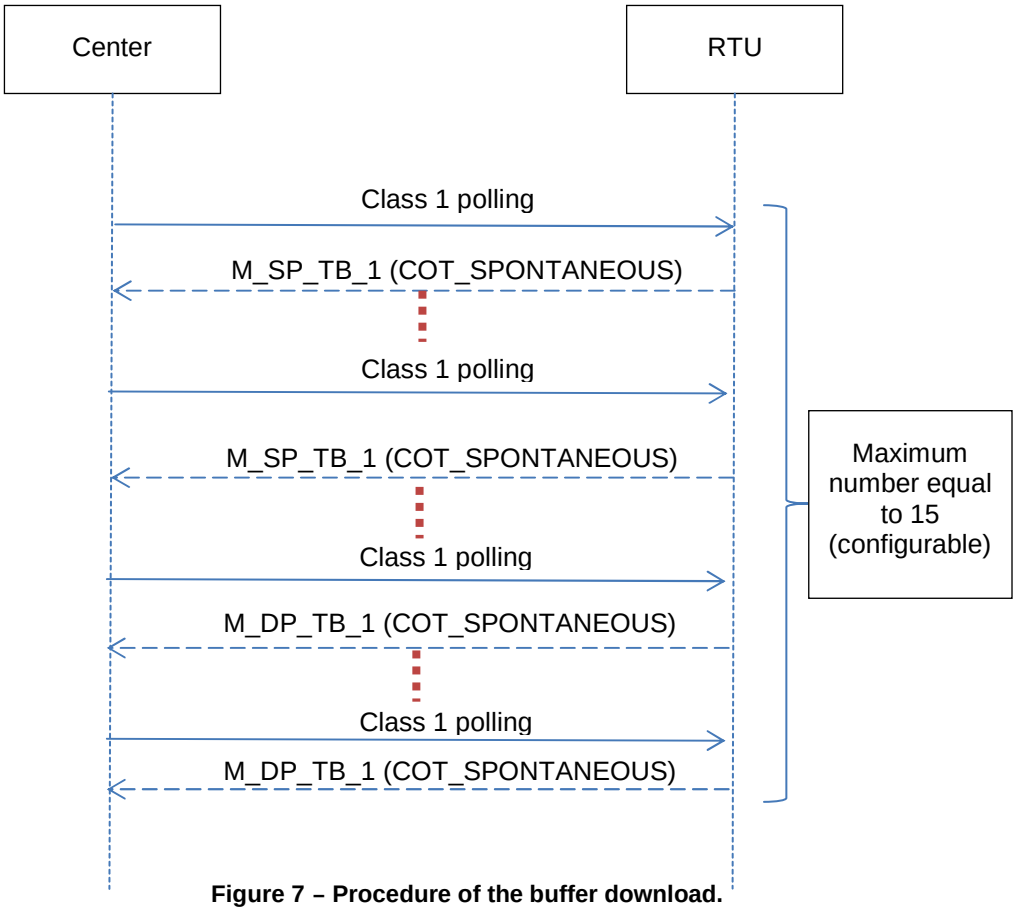

Figure 7 – Procedure of the buffer download.

5.2.1.4. *By-polling acquisition procedure*

In polling systems, the basic transmission procedure uses the REQUEST/RESPOND-service function code 11 (request user data class 2).
Class 1 data are indicated via the ACD-bit (Access Demand) of Control Field as defined in IEC 60870-5-2.
The assignment of the causes of transmission to the two classes is:
- class 1: time tagged or spontaneously transmitted ASDUs;
- class 2: ASDUs containing the causes of transmission periodic/cyclic (other ASDUs with other causes of transmission of low priority such as background scan).

Controlled stations that have no data of data class 2 available may respond to the class 2 request with class 1 data. Figure 8 demonstrates the behaviour in the case of polling in class 1 and in class 2.

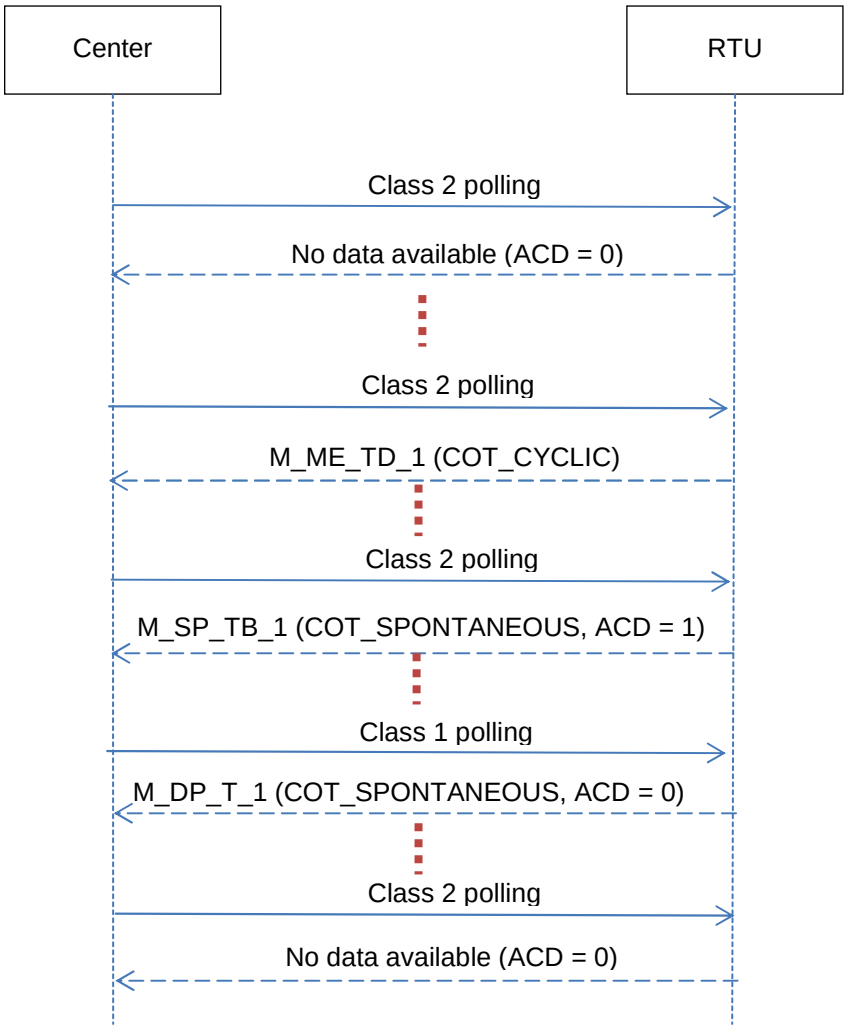

Figure 8 - By-polling acquisition procedure (class 1 and 2).

5.2.1.5. *Time syncronization procedure*

The time synchronization procedure is asynchronous, and the message is then sent to the RTU and does not wait for a response ad demonstrated in Figure 9. Located within the synchronization message are the current date and time, while in the eventual return message the previous date and time of the RTU are, with the date set equal to zero in the case of a RTU reset.

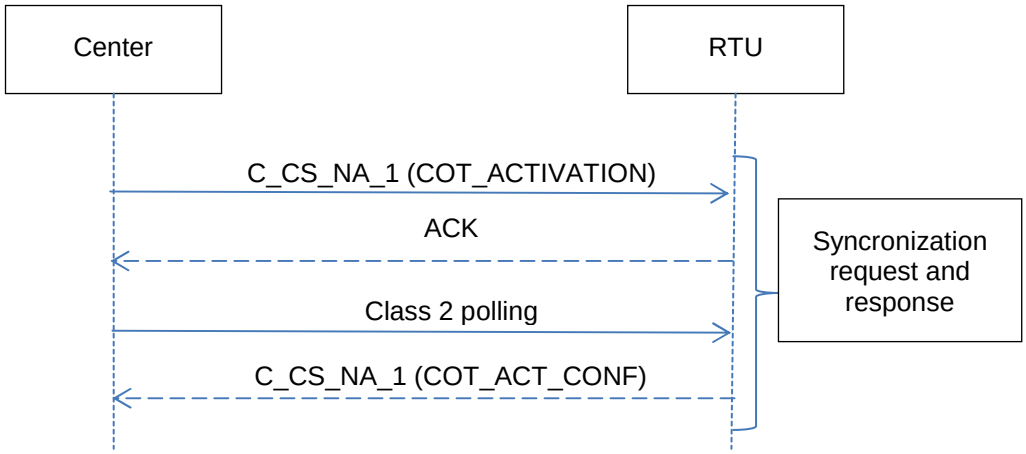

Figure 9 – Time syncronization procedure

5.2.1.6. *Procedure of remote control transmission*

The transmission of the remote controls from the Center to the RTU can be fulfilled in two different modes as follows:

- SELECT/EXECUTE, for all of the controls on the actuators;
- EXECUTE for software controls.

The SELECT/EXECUTE procedure is described in Figure 10.

.

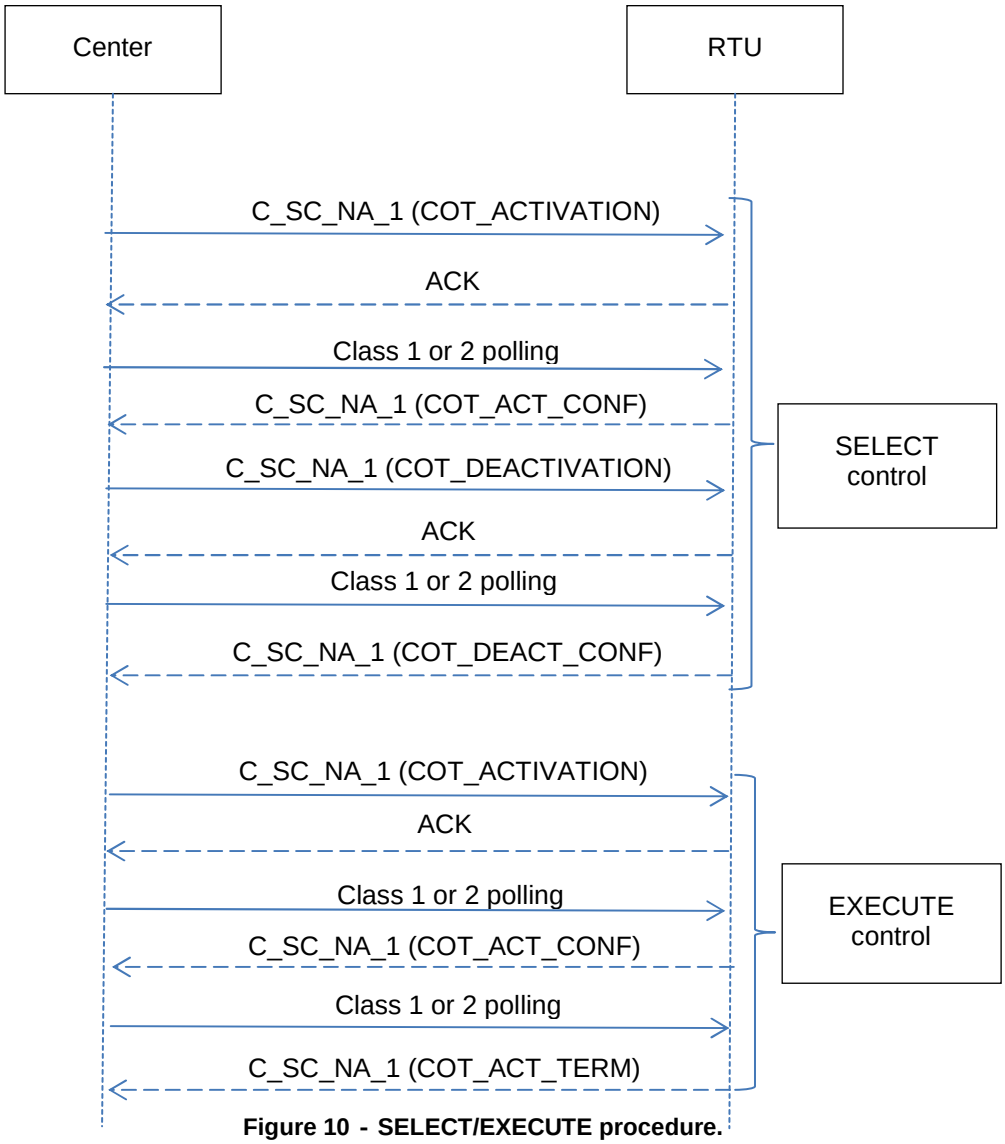

Figure 10 - SELECT/EXECUTE procedure.

The EXECUTE procedure is described in Figure 11.

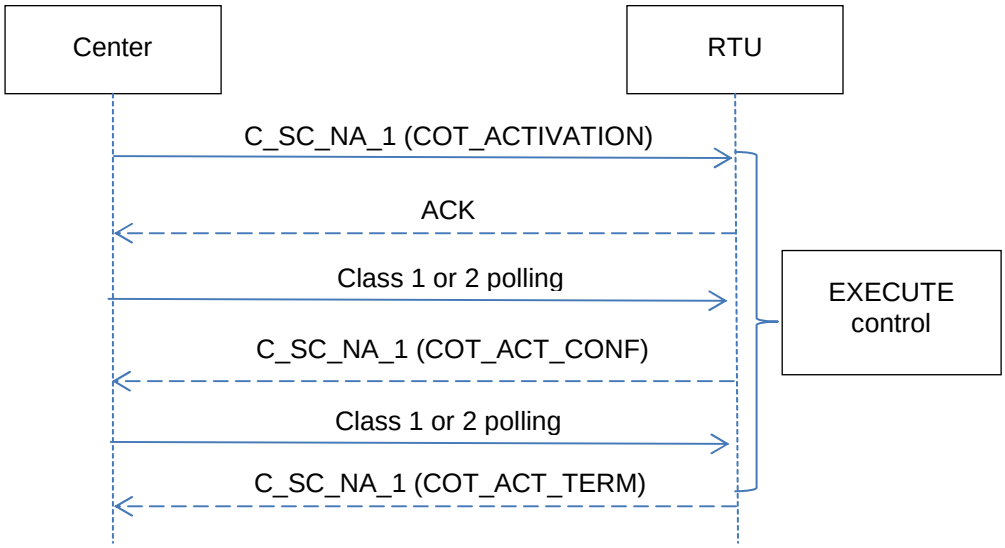

Figure 11 – EXECUTE procedure.

The SELECT/EXECUTE procedure is always utilized in the case where the controls on the actuators relais, though it can also be utilized from the Center for the software controls: in this last case, the RTU must accept the request of execution of the control in this mode also.

The EXECUTE procedure is utilized for the software only controls; when it is sent in error for a control to an actuator relay, the RTU must deny the request or execution of the control. The message which the RTU must send to the Center is reported in Figure 12

Figure 12.

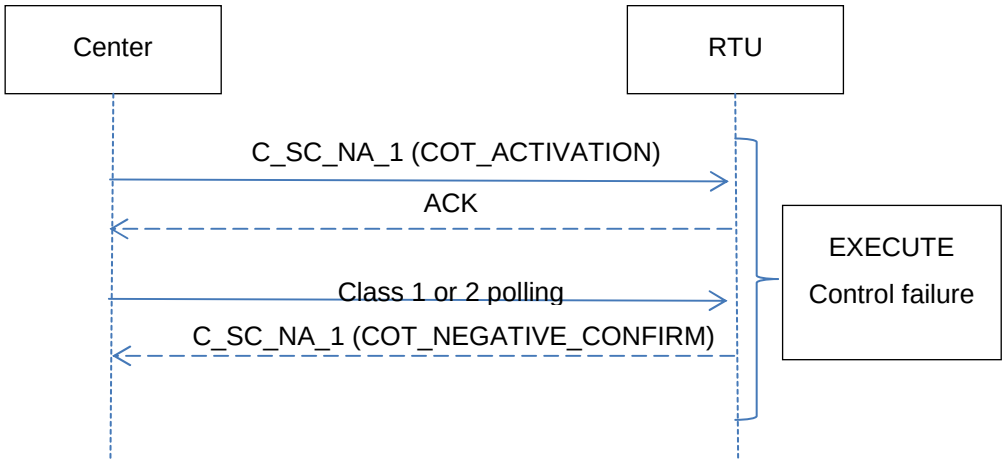

Figure 12 - EXECUTE procedure for the controls to actuators.

5.2.1.7. File transmission procedure from the Center to the RTU

Two types of different files may be sent from the Center to the RTU. The first type is the configuration file, and may be sent:

1. with all of the hardware parameters only, indicated by the code RTU_CONFIG_FILE_2008 (see GSTR001/1 Annex1)
2. with all of the automation parameters only, indicated by the code AUTOMATION_CONFIG_FILE_2008;
3. with some of the parameters of the RTU_GENERAL type or the RTU_COMMUNICATION type (update) only, indicated by the code RTU_UPD_CONFIG_FILE_2008.

The file which contains the automation parameters will be sent to the RTU in the following cases:

- when the Center receives the warning “parameters not configured” from the RTU (see Figure 13);
- upon updating the parameters of the configuration of the automatisms by the Center.

All three files can be sent separately upon explicit request from the Center by transmission of the parameters of the RTU.

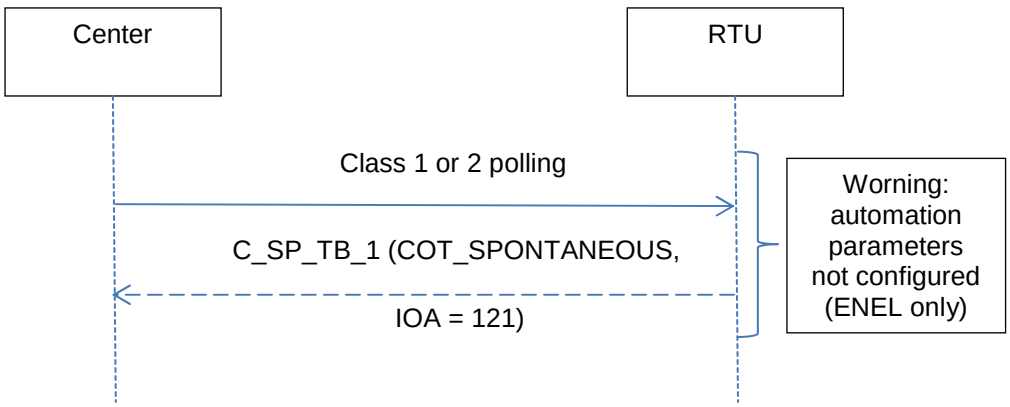

Figure 13 - **Request of the configuration parameters file**

The second file type is represented by the firmware of the RTU, indicated by the code FW_FILE_BINARY_2008. When the firmware file transfer is completed, the reset procedure may be recalled. See chapter 5.2.1.10 for the activation of the new firmware.

The file transmission procedure is defined in

.

When the configuration file is received in its entirety, and prior to the application of the new configuration, the RTU must verify:

- the syntactical consistency: all of the parameters must be properly formatted, no information must be left out; it is not necessary to have the presence of all of the possible parameters;
- the semantical consistency: all of the parameters must be applicable, and no additional parameter must be present with respect to the set of the possible configurable parameters (for example, the file must be rejected if it contains 9 points because only 8 points are configurable), nor should any parameters be outside of the prescribed range.

At the end of the syntactical and semantical checks, the file is applied by the RTU. A restart of the RTU is needed only in the case when the file parameters are completed, applying the parameters received online along with the update file.

Upon restart, the communication between the RTU and the Center will be interrupted. If the file received by the RTU presents syntactical or semantical errors (the corresponding IOA value of the IEC data base is reported in the appendix: GSTR001_1A4 (IOA IEC_DB).xls), the RTU rejects it and a message must be sent to the Center as demonstrated in Figure 15.

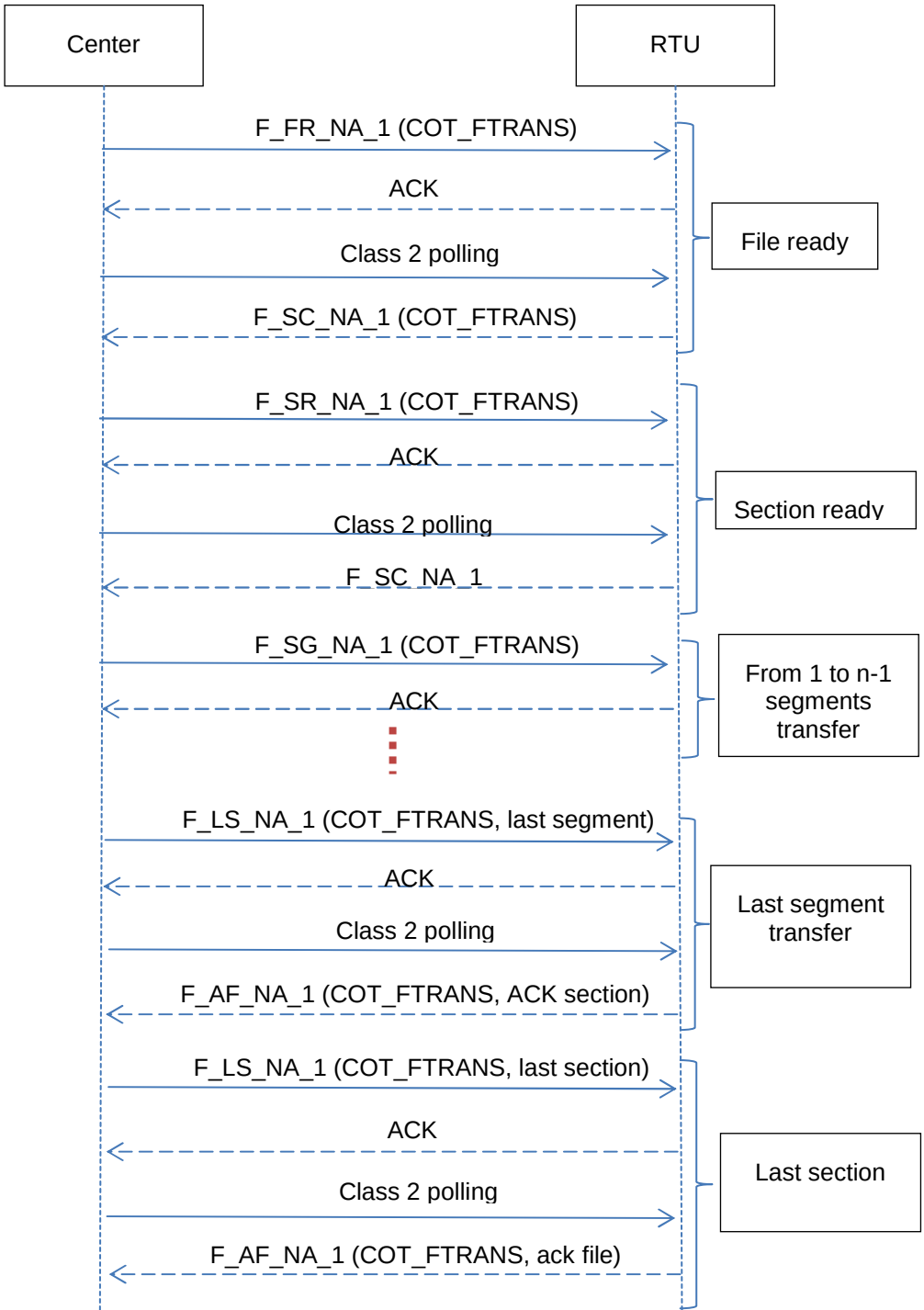

Figure 14- Transmission procedure of the configuration parameters file.

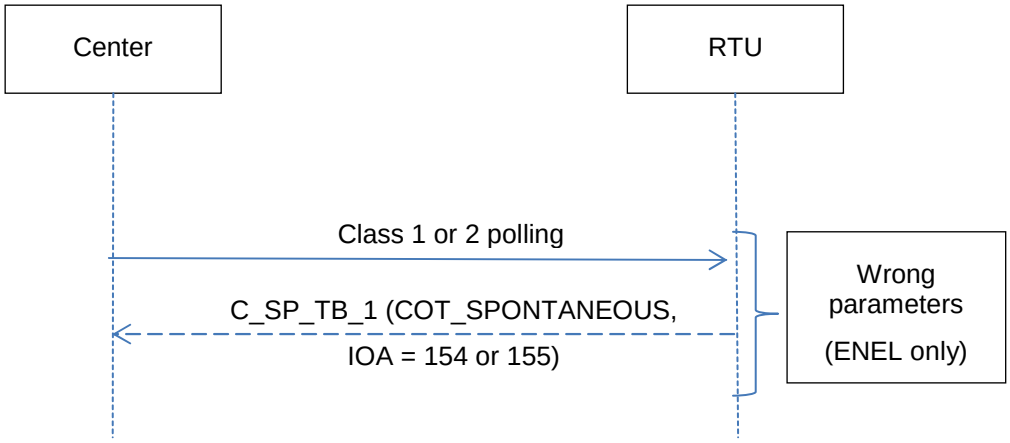

Figure 15 - Erroneous syntax or semantics of the configuration file.

5.2.1.8. *Procedure of the acquisition of the trend measurements*

The trend measurements are represented by 8 (or 16) measurements files, one for every point, according to the type of the RTU, and an additional file of the point which represents the temperature (T_{amb}), which is independent of the RTU configuration type.

The selection of the requested file is in the “NOF” (Name Of File) field, as defined in chapter 7.2.6.33 of the IEC60870-5-101 specification, and must be as found in the following table:

NOF	Tele measurement channel	Note
21	1	1° Tele Measurement channel
22÷28	2÷8	2°÷8° Tele Measurement channel
29	9	9° Tele Measurement channel
30÷36	10÷16	10°÷16° Tele Measurement channel
37	T_CAB	Temperature channel

The transmission of a trend measurements file is carried out according to the scheme reported in Figure 16.

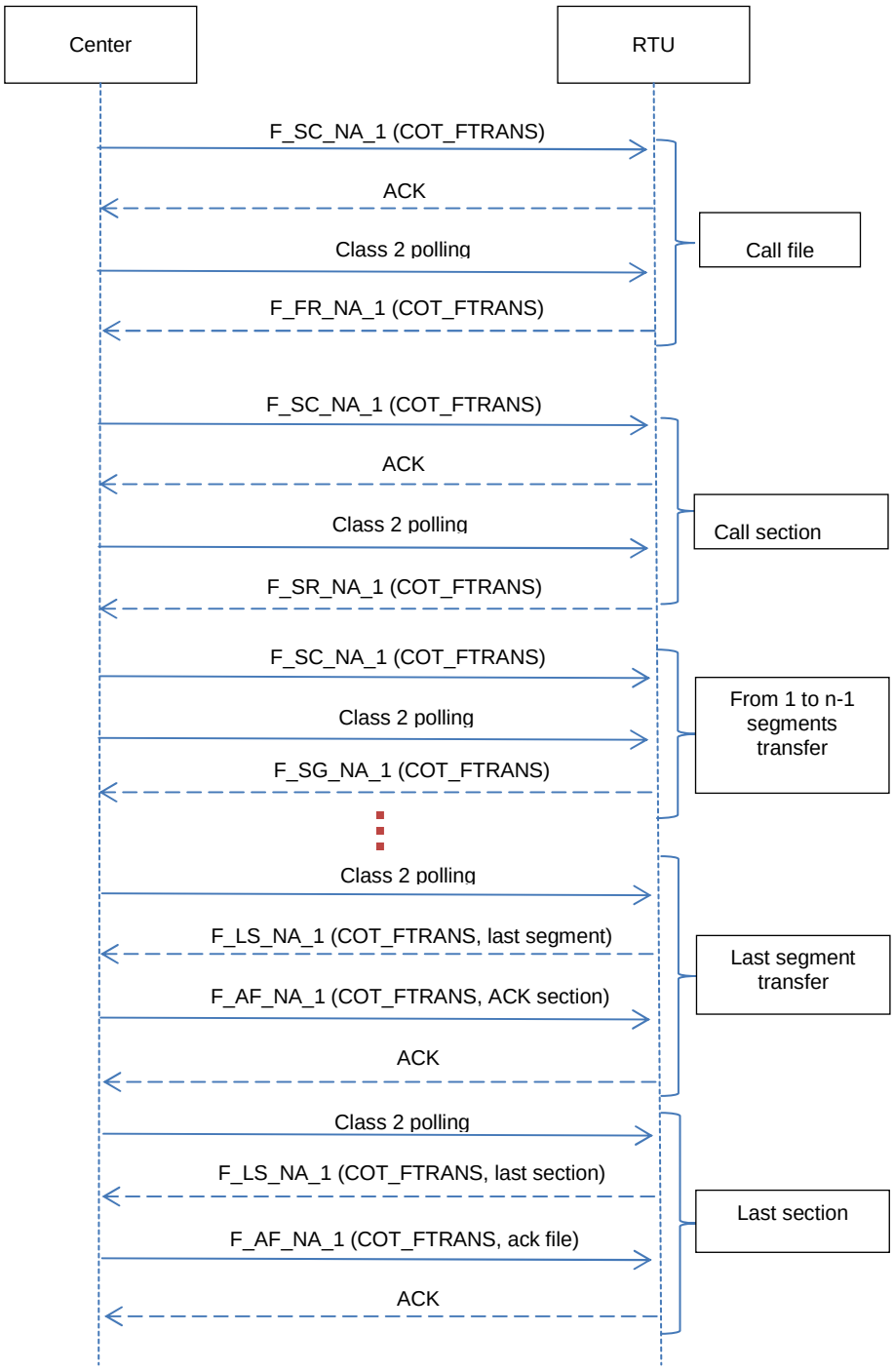

Figure 16 - **Procedure of file acquisition.**

5.2.1.9. *Procedure for the acquisition of the configuration file*

The Center's request of the configuration file currently used by the RTU is realized according to what is described into the scheme reported in Figure 16.

The selection of the configuration file is made within the structure COT_FTRANS.

5.2.1.10. *Reset procedure*

After the download of the application software from the Center towards the RTU, it is possible to send the reset command, so that the RTU can restart with the new firmware.

The procedure is reported in Figure 17.

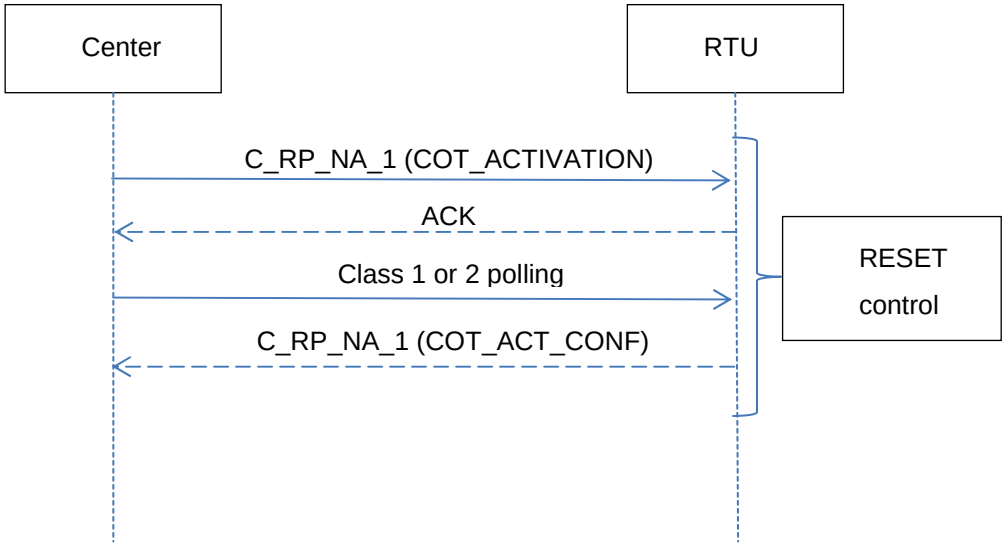

Figure 17 - Reset procedure

The new firmware is then utilized and loaded only AFTER the reset command is sent by the Center.

6 IEC 60870-5-104 PROTOCOL

It is necessary to refer to the profile specified in the standard IEC 870-5-101. The profile consists of five OSI levels: 7 (Application), 4 (Transport), 3 (Network), 2 (Data-Link) and 1 (Physical), in compliance with the details/changes/integrations listed in Table 3 for every OSI level.

Table 3 – Selected standard provisions of the defined telecontrol companion standard.

<table>
<tr><td colspan="2">Selection of the application functions of the
IEC 60870-5-5 according to the IEC 60870-5-101</td><td>inizialization</td><td>User process</td></tr>
<tr><td colspan="3">Selection of ASDUs from IEC 60870-5-101 and IEC 60870-5-104</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">RFC 793 (TCP)</td><td>Transport (layer 4)</td></tr>
<tr><td colspan="3">RFC 791 (IP)</td><td>Network (layer 3)</td></tr>
<tr><td colspan="2">RFC 1661 (PPP)</td><td rowspan="2">RFC 894
(Transmission of the IP datagrams over Ethernet networks)</td><td rowspan="2">Data link (layer 2)</td></tr>
<tr><td colspan="2">RFC 1662
(PPP in HDLC-like framing)</td></tr>
<tr><td colspan="2">X.21</td><td>IEEE 802.3</td><td rowspan="2">Physical (layer 1)</td></tr>
<tr><td colspan="2">Serial Line (GPRS)</td><td>Ethernet</td></tr>
</table>

For the management of the IEC 60870-5-104 protocol, the following differentiating methods of communication can be adopted, through the local configuration:

1. data exchange through the Ethernet port, or
2. data exchange through the GPRS modem on the RS232serial port. In this case the RTU may be configured with TCP/IP and PPP stack management. The GPRS modem has the function of a simple transmission medium adaptor (level 1 ISO/OSI). The RTU will manage each ISO/OSI higher level.

Level 1:

The RTU uses the following transmission network:

- IP Ethernet network;
- GPRS network;

The physical interface, useful for the connection to a possible external modem, must have the following features:

- Type: ITU-T V.24/V.28
- Connector: ISO 2110, type D, 25 poles, male
- Managed interchanging circuits: see Appendix

Power supply for the external modem

The DCE $12V_{cc}$ and $24V_{cc}$ power supply is provided through appropriate terminals (DV25 terminal board).

Interchange with the modem

The following indications must be respected for the data interchange between modem and RTU,:

- Data transfer speed of 9600 bps. In any case the RTU must be able to work at higher data transfer standard speed as well, and if enabled by either other technologies or transmission systems;
- Data format: asynchronous, 1 bit start, 8 bit data, no parity, 1 bit stop
- Flow control: software using DC1 – DC3 (XON – XOFF) characters, and hardware using circuits C.106 (CTS) e C.105 (RTS)

Modem management

The modem functionalities must be managed by the RTU through the standard mode:

- AT commands (GSM 07.05, GSM 07.07, V.25ter);
- V.25bis

Level 2:

- the Center will be “Master” and the RTU the “Slave”;
- the address field must consist of two octets;
- the “single control character” must not be utilized;
- The time-out defined in the standard are effective from the moment of validation of the physical connection (level 1).

Level 7:

- The application protocol must be performed according to the indications contained in the standard, and according to the interoperability profile defined in the detailed document;
- The messages subset selected, chosen from the set defined in the standard, supports the application activities explained in the detailed document.

6.1 Communication procedure

The Center will communicate with the RTU (via TCP/IP) by using the procedure defined in the IEC 60870-5-106, chapter 5.3. A summary of the procedure is reported below.

STARTDT (Start Data Transfer) and STOPDT (Stop Data Transfer) are used by the controlling station (for example, Station A), to control the data transfer from a controlled station (Station B) as show in Figure 18 and Figure 19. This is useful, for example, when more than one connection between the stations is open and therefore available, but only one connection at a time is used for the data transfer. The defined functionality for STARTDT and STOPDT avoids loss of data in the case of switchover from one connection to another.

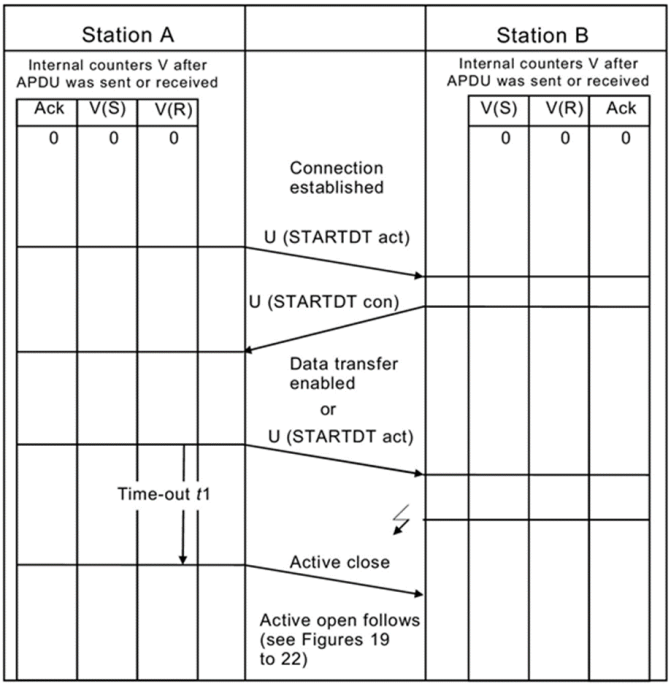

Figure 18 – Start data transfer procedure.

STARTDT and STOPDT are al so used with single connections between the stations to control the traffic on the connection. STARTDT/STOPDT is a mechanism for the controlling station to activate/deactivate the monitoring direction. The controlling station may send commands or set-points even if it has not yet received the activation confirmation.

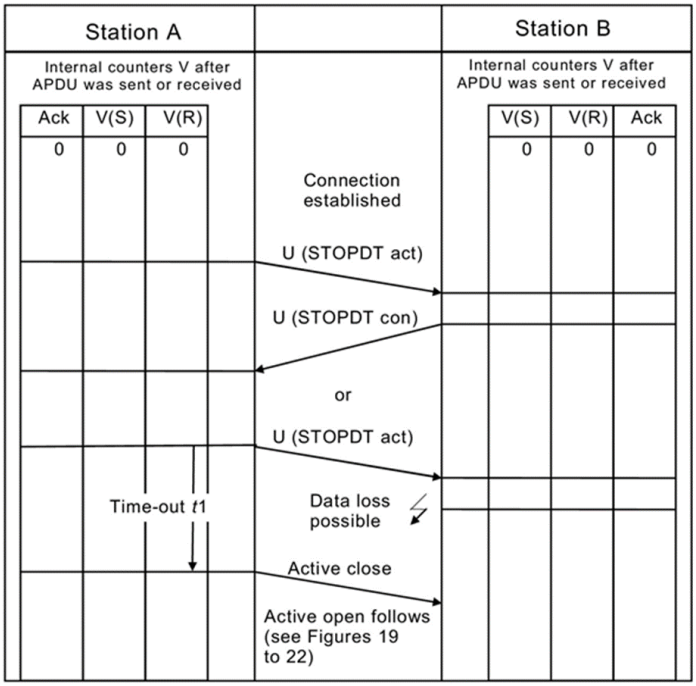

Figure 19 - Stop data transfer procedure

See the IEC 60870-5-104 specification, chapter 5.4, for details regarding the test mode, the flow control and the methods to avoid duplication and message loss. As a function of to the communication network, the parameters reported in Table 4 will be selected.

Table 4 – Parameters for IEC104

Parameters	Description	Default ENEL	Default ENDESA
ASDU Max Lenght	Maximum length of the ASDU part of a message	249 byte	
T_0	Timeout of connection establishment.	30s	
T_1	Timeout of sending or testing APDUs.	15s	
T_2	Timeout for acknowledge in case of no data messages ($\mathbf{t_2 < t_1}$)	30s	
T_3	Timeout for sending test messages (S-Frame) in case of a long idle state ($\mathbf{t_3 < t_1}$)	30s	
k	Maximum difference receiving sequence number to send state variable	12	
w	Latest acknowledge after receiving w data messages (I-frame)	8	

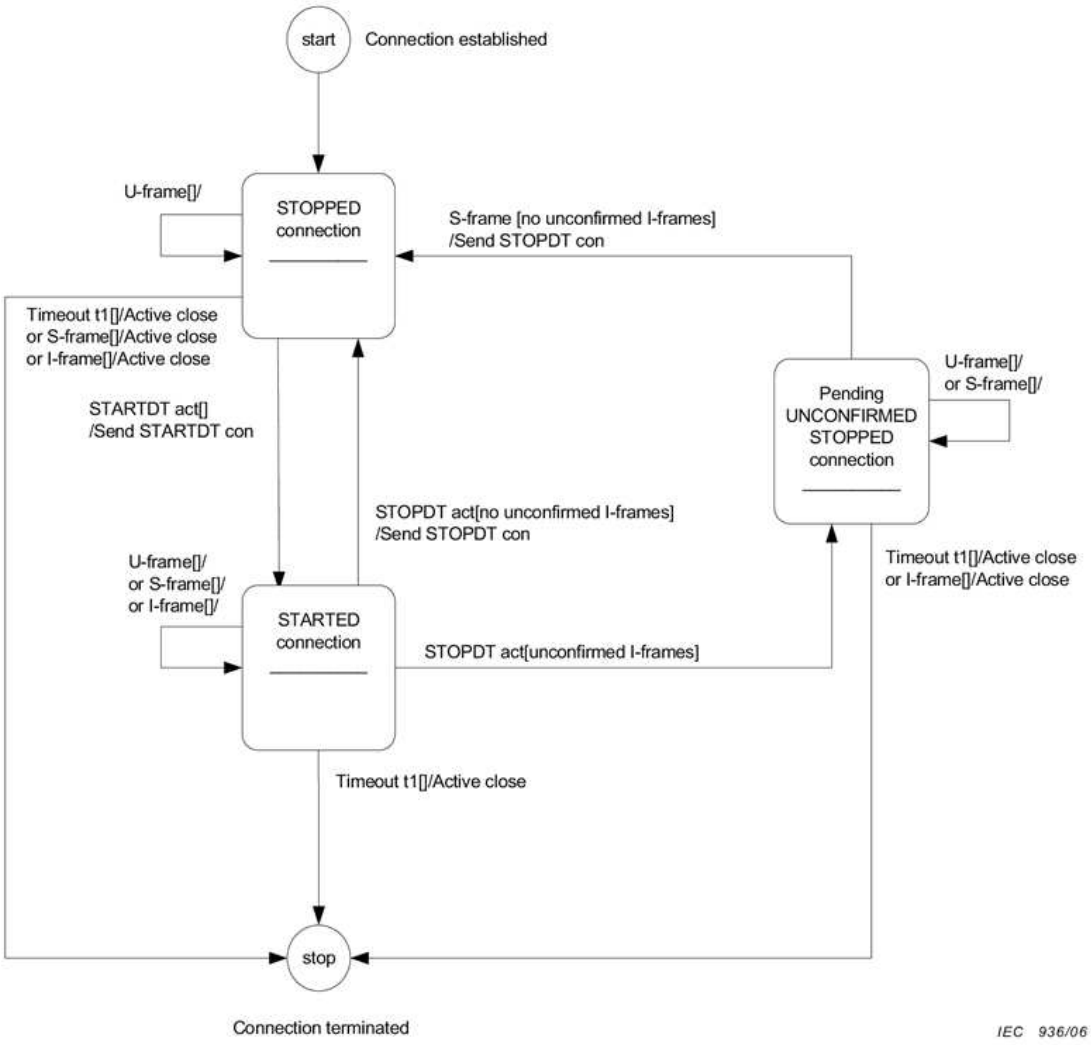

Figure 20– State transition diagram for the Start/Stop procedure (controlled station).

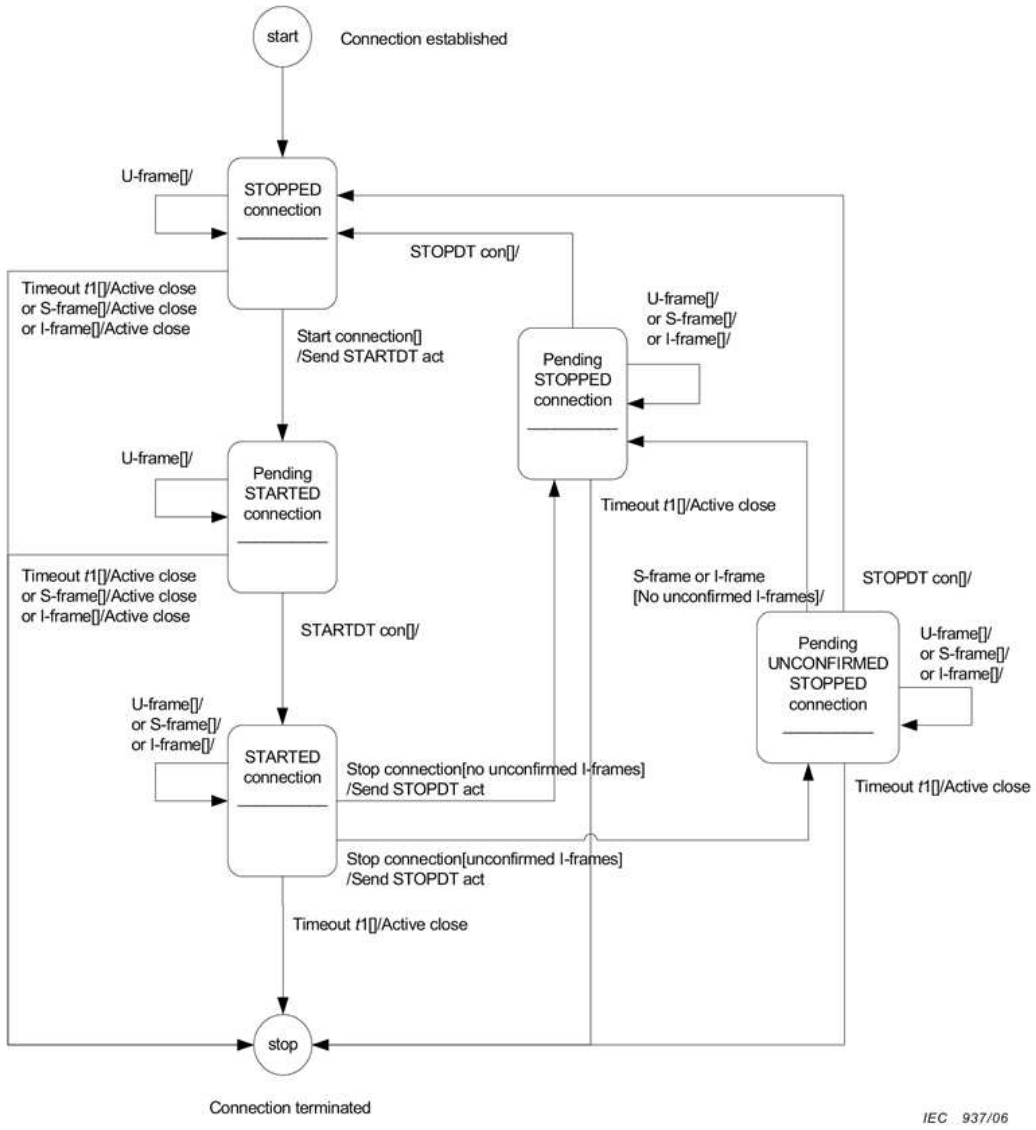

Figure 21 – State diagram for the Start/Stop procedure (controlling station).

6.2 Station initialization

Release of connections may be initiated by either the controlling or the controlled station.

Figure 22 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.

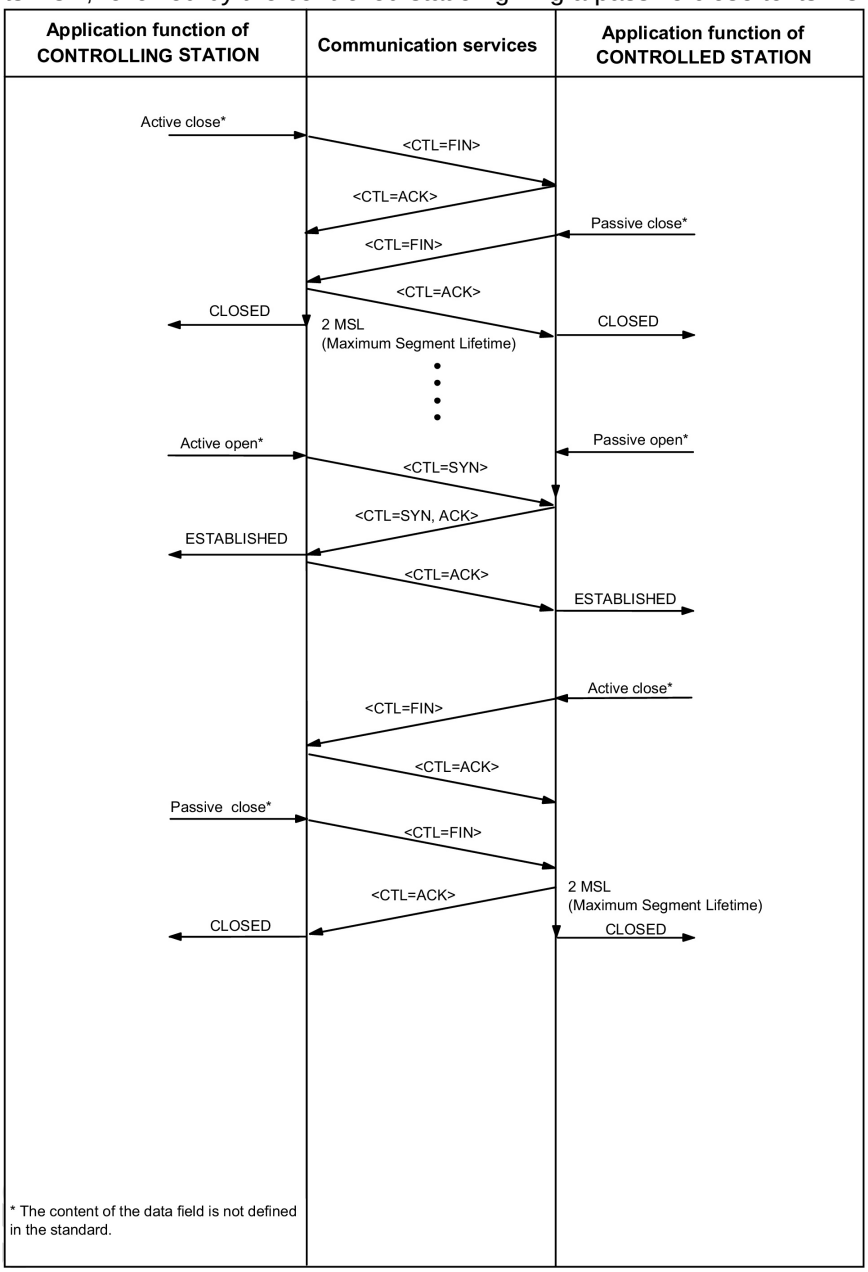

Figure 22 – TCP connection establishment and close

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.

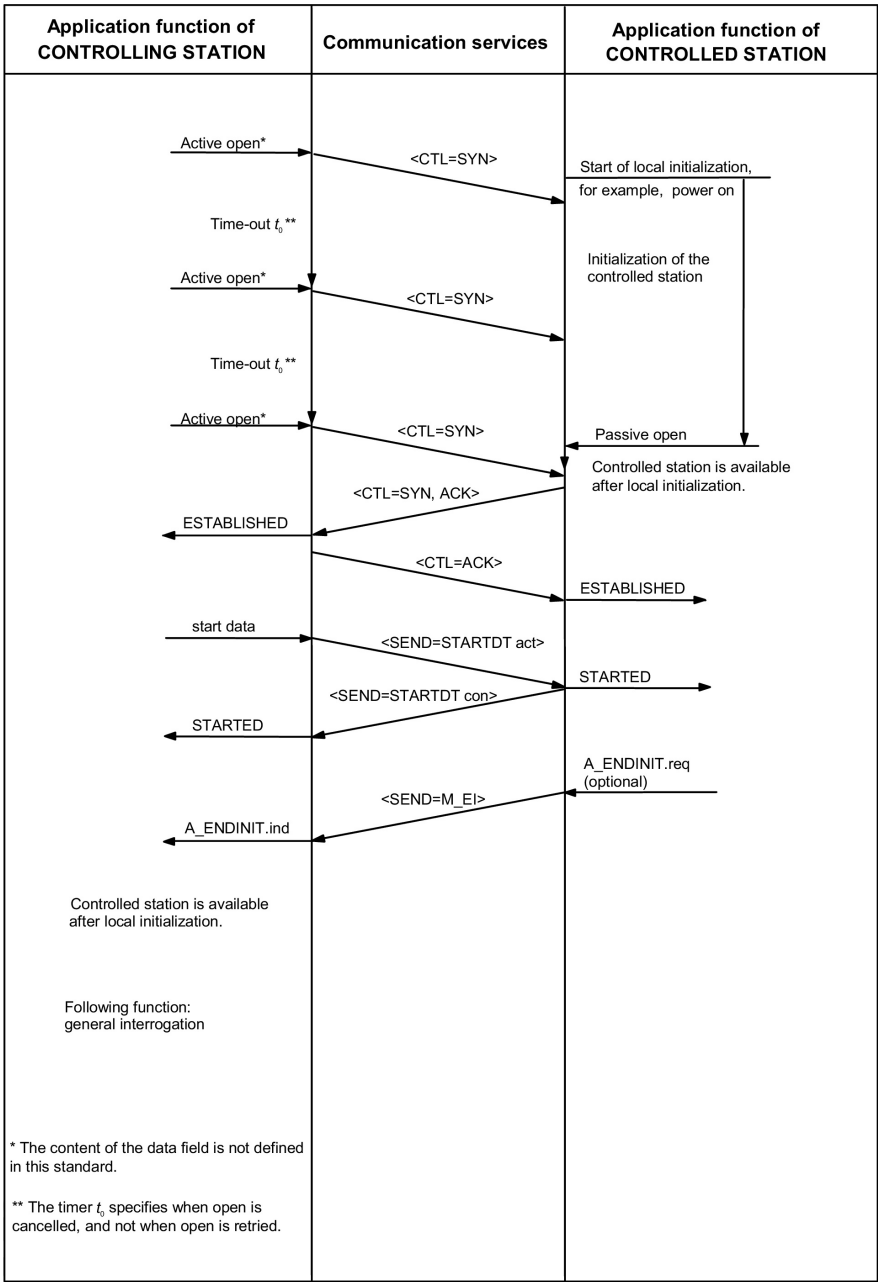

Figure 23 – Local inizialization of the controlled station.

Figure 23 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 initialization and given a passive open cali to its TCP which has then acquired the listen status (status not shown in the figure).

6.3 Data acquisition by polling

Request of user data class 1 and 2 are link functions of IEC 60870-5-2 and therefore not available in this standard. However, data may be read (requested) as shown in the bottom part of figure 10 of IEC 60870-5-5. The requesting of data by cyclic requests (see Figure 24) is permitted for measurements data only.

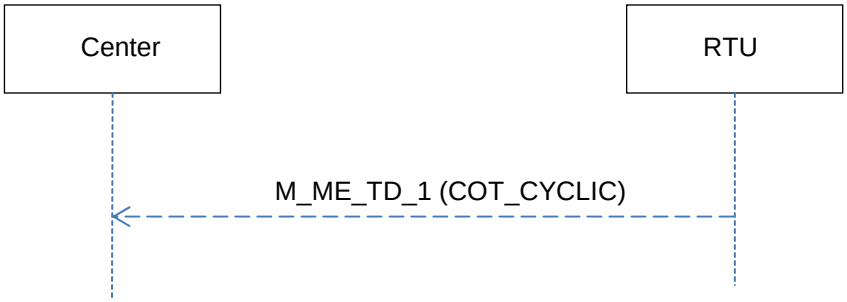

Figure 24 - Cyclic data transmission (6.3 of IEC 60870-5-5)

6.4 Acquisition of events

Upon the occurrence of one of the configured events, the RTU must send the update of the related status, complete with time-tag (CP56Time2a).

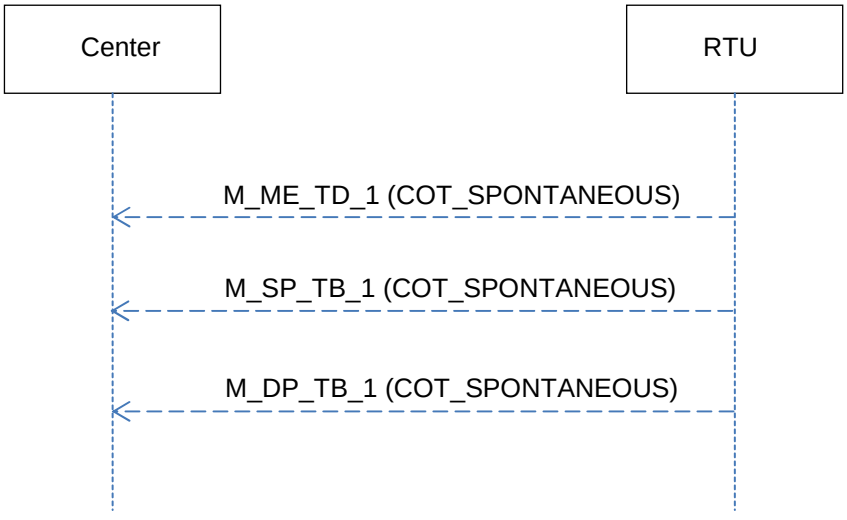

Figure 25– Acquisition of events (6.4 of IEC 60870-5-5)

6.5 General interrogation

The general interrogation is carried out according to the procedure indicated in the standard **IEC 60870-5-101**.

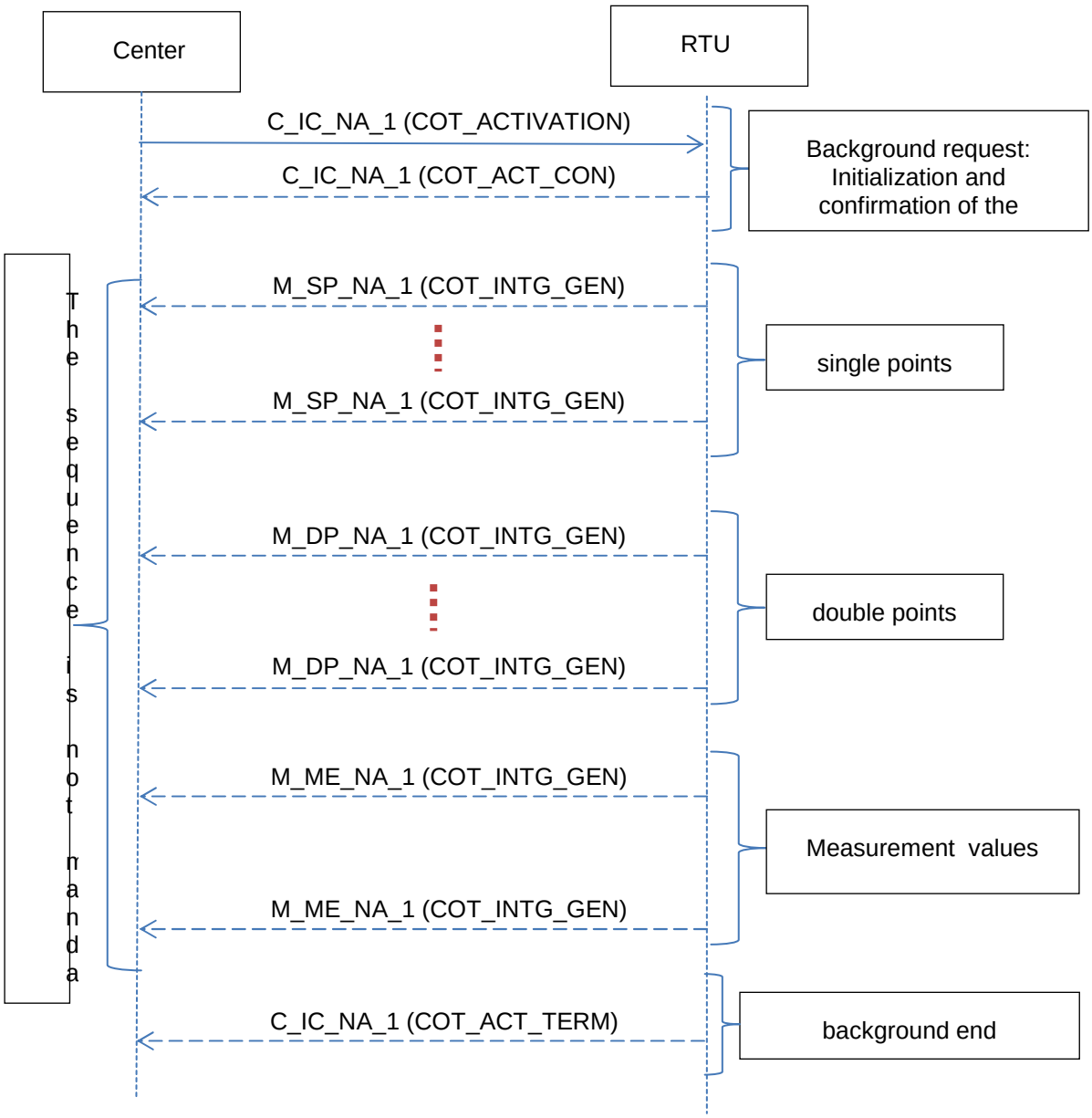

Figure 26– General interrogation (6.6 of IEC 60870-5-5).

6.6 Clock synchronization

The clock synchronization procedure defined in IEC 60870-5-5 cannot be used in this standard because the link layer according to IEC 60870-5-2, which provides the exact time of sending the dock command, is no longer available.

However, clock synchronization may be used in configurations where the maximum network delay is less than the required accuracy of the clock in the receiving station. For example, if the network provider guarantees that the delay in the network will never be more than 400 ms (a typical X.25 WAN value) and the required accuracy in the controlled station is 1 s, the clock synchronization procedure is useful. Use of this procedure avoids the necessity of installing clock synchronization receivers or similar equipment in potentially several hundreds or thousands of controlled stations.The procedure is a copy of that of 6.7 of IEC 60870-5-5, with the "first bit" and "time correction" requirements and link layer options (SEND/NO REPLY or SEND/CONFIRM) removed.

Clocks in controlled stations have to be synchronized with the dock in the controlling station to provide correct chronological sets of time-tagged events or information objects, whether they are transmitted to the controlling station or logged locally. The clocks are initially synchronized by the controlling station after system initialization and then re-synchronized periodically by agreement by transmitting C_CS ACT PDUs.

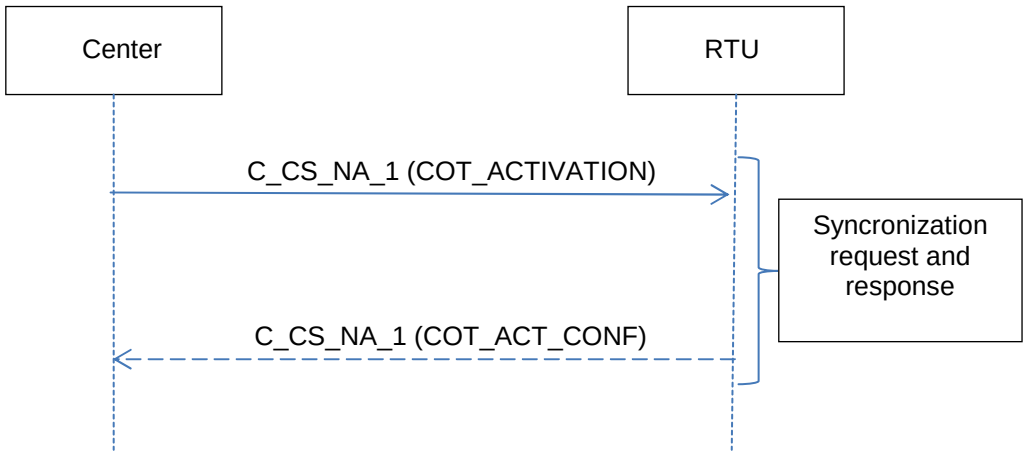

Figure 27– Clock synchronization (6.7 of IEC 60870-5-5)

In any case it is necessary to implement time synchronization via NTP server according to the configuration described in paragraph 5.2.3.3 of GSTR001/1 A1

6.7 Command transmission

A controlled station receiving a command or set point which has exceeded the maximum allowable delay (system-specific parameter) will not return a protocol response (i.e. the controlled station does not return a positive ACTCON nor a negative ACTCON). This is because the confirmation could be significantly delayed, and might not readily be associated with the original request. The command is passed to the controlled station application so that it can identify that the command was received "too

late", but must not perform any command action. The time tag contains the time at which the command is initiated in the controlling station.

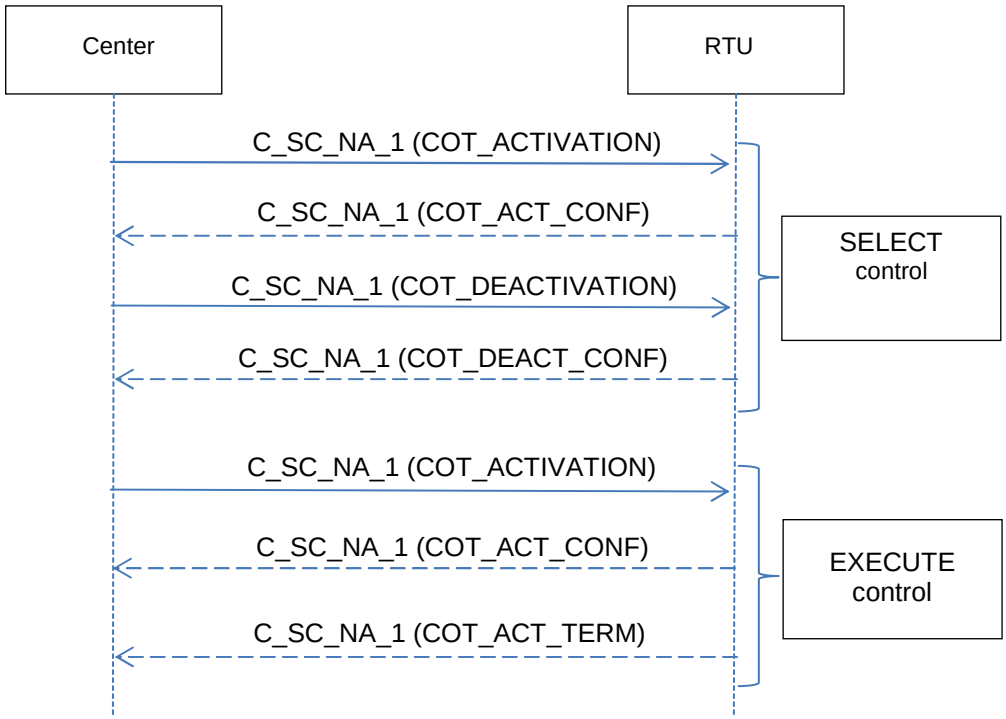

Figure 28– Command transmission (6.8 of IEC 60870-5-5)

6.8 Test procedure

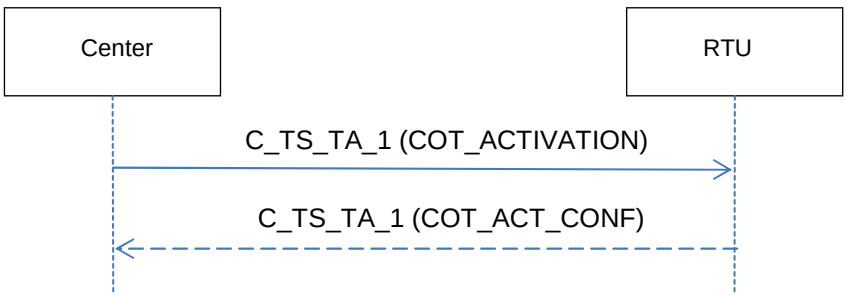

Figure 29 – Test procedure (6.11 of IEC 60870-5-5)

6.9 File transfer

The procedure for the file transfer is analogous to the one described for the IEC 60870-5-101 protocol.

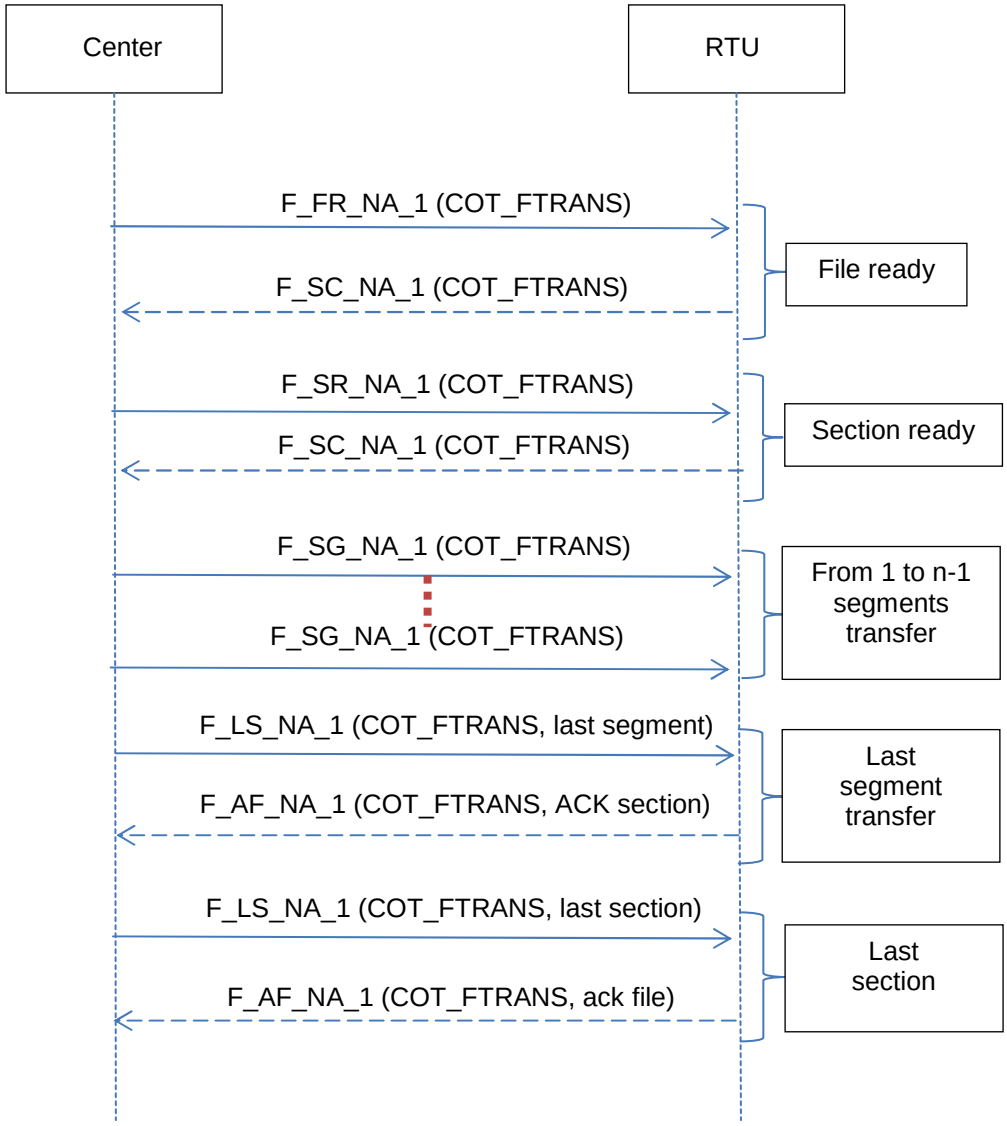

Figure 30 – File transfer (6.12 of IEC 60870-5-5)

7 ADDITIONAL RTU SPECIFICATIONS

7.1 Spontaneous call management (only IEC 870-5-101 protocol)

The RTU must be able to manage a list of three Center telephone numbers, to be called in order to activate the communication with the Center and send the spontaneous variations.

The telephone numbers must be configurable both locally and from the Center, even fewer than the maximum allowed.

It must be possible to configure either the overall number of recalls to make in the case of no response from the Center, or the minimum time interval between a call and the subsequent.

At the RTU level, it must be possible to enable at least two different telephone numbers usage policies, both locally and from the Center:

- **According to a predefined order rotation**: the three configured telephone numbers are always used in a sequence, according to the order configured by the user (default). In case a call to one of the three number is unanswered, after a first attempt, the RTU starts to call the following number in the sequence. The unanswered number will be re-used when the entire cycle is completed. The RTU stops the sequence for each telephone number, when the maximum number of attempts is reached,. At the successive call, the RTU employs the subsequent modem utilized last, independent from the result.
- **First number:** the RTU always begins to call the first telephone number, according to the sequence configured by the user. In the single case when a call to a number is unanswered, after a first attempt, the RTU begins to call the subsequent number in the sequence. When the maximum number of attempts is reached, the RTU concludes the sequence. Upon the successive call, the RTU restarts to call the first number of the sequence.

If a communication error occurs with one or more of the telephone numbers, the RTU prepares an ASDU message (always with the 3 IOA involved) as reported in Figure 31, in order to inform the Center.

Once the ASDU message (For each telephone number there is a different IOA value in the IEC data base, as reported in the excel file GSTR001_1A4 (IOA IEC_DB).xls) is successfully delivered, the RTU restores the diagnostic status of the telephone numbers.

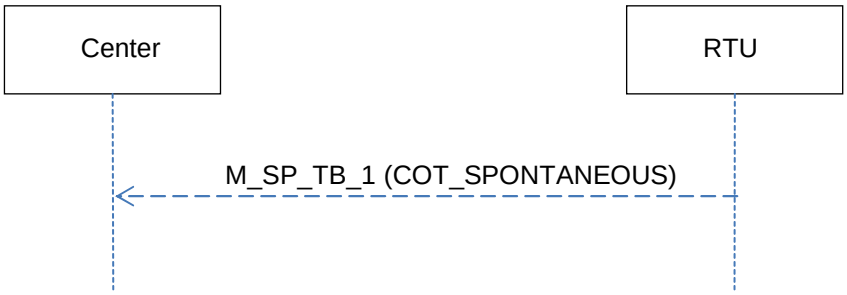

Figure 31– Communication error on telephone number

7.2 Performance constraints

At the commencement of the connection between the Center and the RTU, the General Interrogation command is requested and the status changes, which are then stored in the local buffer of the RTU, are downloaded with priority, until they are exhausted (or at most through N queries in class 1).

Either the changes or, generally speaking, any information, must be "packed" into ASDU messages, as described in the paragraph §5.2.1.3. The maximum number of points for each ASDUs managed by the Center is equal to 48, though generally the number of IOA present in an ASDU is smaller due to other limits of the protocol (the link layer).

It is however required that the RTUs make the most of the single ASDU, consistent with the maximum number of bytes at the physical level, however.

During the General Interrogation, single and double points as well as the measurements are sent without the *TimeTag,* and the maximum number of values that can be inserted in a single ASDU is equal to 80. Only the information relating to points of the database which are configured must be sent.

During the download of the buffer of the memorized data, always located within the general interrogation, the values are sent with the relating TimeTag and the maximum number for each ASDU is 22.

Regarding the sizing of the buffers of the RTU, the following is taken into account for IEC 870-5-101 protocol:

1. the interval between one polling and the next one, currently equal to 0.5 seconds (range 0 through 3 seconds;
2. Maximum number of points per message;
3. Number of downloading requests in class 1, currently set to be equal to 15;
4. The measurements acquired must not be stored into the buffer, rather into the trend files; the instantaneous measurements are sent to the Center only when the RTU is connected (every second, even if they are not modified);

   The time necessary for the acquisition of the overall background of the points of the RTU (field signals, software signals, measurements) is particularly critical. The timing of the General Interrogation also depends upon:

1. Maximum number of points per message;
2. Polling time interval, currently equal to 0.5 seconds (though it can be reset during the configuration).

7.3 Method of data buffering

When the RTU buffers the events, it must group them by type (SP Single Point, DP Double Point, etc ...), regardless of the real time sequence according to which they are actually generated. During the period of data transfer to the Center, the packets which respond to the polling will contain a maximum amount of data (except for the last packet per type, which can be of partial size).

The undisputed advantage of this mode of data buffering is highlighted by the minimization of the number of packages needed (and thus of time) in order to transfer the information to the Center. This is the case in which many events, often of heterogeneous type, are generated, such as during the cycles of automation. The correct chronological reconstruction of the events is the responsibility of the Center, by utilizing the hourly time stamp information which the UP associates with such events.

During the General Interrogation, the events are always sent by type, and, in this case, without the hourly time stamp.

7.4 Trend of the measurements

The trend of the measurements must be downloaded via file transfer, as specified by the process of transferring files from the RTU to the Center, which is described in paragraph § 5.2.1.8. These measurements, stored by the RTU, can be downloaded only through files, whereas, conversely, the instantaneous measurements are transferred via the related to ASDU.

The feasible files are 8 or 16, depending upon the type of RTU, one for each measurement point of the RTU, with the addition of 1 file representative of the T_{amb} point for the acquisition of the ambient temperature.

The file will be transferred upon the request of the Center, and the number of the desired file is specified by the Center at the beginning of the communication procedure.

The measurements file is managed in a circular manner (circular buffer management similar to the one implemented for the events). The file is emptied upon successful transfer of all of the values contained within it.

The file will be composed according to a specific structure, consisting of a header and a body, whose formats are respectively shown in Table 5 and in Table 13.

Table 5 – Header format of the trend of the measurements file

Description	bytes
IOA Measurement	2
CP56Time2a (binary time)	7
Number of measurements into the buffer	2
Reserved (set to 0)	5

Table 6 – Body format of the trend of the measurements file

Description	bytes
Value of the measuerement	2
QoS (quality of the service)	1

The maximum number of measurements for files equal to 2016 (6 measurements/hour x 24 hours x 14 days) → 6064 bytes/file.

The file will be generated in a binary and then divided into more segments within a unique session, so as defined by the specifications of the IEC 60870-5-101 / 104 protocol.

7.5 Daylight saving time management

Daylight saving time is defined by the start date and the end date of the period in which the clock is brought forward by 60 minutes compared to winter time.

The necessary parameters for the autonomous management of the daylight saving time by the RTU must be configurable onto the RTU either locally or from the Center. In the absence of a configuration, the RTU, although synchronized from the Center, does not implement any management of daylight saving time.

If the definition of the range of daylight saving time changes over time, the Center may whenever notify the RTU with the file containing the updated configuration parameters.

It is significant to note that:

- The UP has no indication of the beginning and end of daylight saving time by default (the general parameter "Daylight Savings Time Interval" is equal to 00000000) and thus it assumes winter time.
- Upon start-up (or reset) of the RTU, it sets 01-01-2000 00:00 “winter time” as the starting date.
- The date / time that the Center sends to the RTU (synchronization) must be set onto the UP as it is received, neither by implementing any logic of comparison with the winter regime time/daylight savings time known to the RTU, nor with the possible start/end of the daylight saving time (i.e. the parameter above).
- This parameter must be utilized by the RTU only on the two days indicated to move its clock autonomously and even its regime (especially!) in the absence of communication with the Center.
- The UP must send all of the messages provided with the *TimeTag* with the correct winter/daylight savings time indication, i.e. with the information received by the Center during the phase of synchronization.

7.6 Testing of the communicaton

The supplier must interface with the Center via the software (application API interfaces) provided by ENEL and described in the detailed document which will be made available after the tender is awarded.

The exchange procedures, related to each activity required, will fully proceed automatically and without any involvement from the operator.

Regarding the execution of the remote controls measures must be adopted (in the process of exchange and/or into the coding of data) which allow a level of integrity of the data equivalent to the I3 (IEC 60870-5-1) to obtained.

Each activity must also include the procedure of opening and closing of the Communication Session; also this procedure must also be performed automatically and without involving the operator, and must also be realized so as to prevent unwanted access to the system by third parties. *Any procedures which relate to the security of access to the network will be eventually provided subsequently to the award of the tender (ENEL utilizes a security procedure based upon the exchange of dynamic passwords in the case of dial-up connection).*

8 TABLES OF INTEROPERABILITY

The present chapter contains the interoperability tables with the ENEL and ENDESA Centers. The interoperability tables are in compliance with the standard IEC 60870-5-101/104, section 8.

It is worthwhile to note that the Center is able to manage the *summer time* bit, so that all of the information marked with the CP56Time2a time tag must have this bit set correctly.

8.1 IEC60870-5-101 ENEL Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives.

This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications.

This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

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

☐	Function or ASDU is not used
X	Function or ASDU is used as standardized (default)
R	Function or ASDU is used in reverse mode
B	Function or ASDU is used in standard and reverse mode

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

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

8.1.1 System or device

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

☐	System definition
☐	Controlling station definition (Master)
X	Controlled station definition (Slave)

8.1.2 Network configuration

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

[X]	Point-to-point	[X]	Multipoint-party line
[ ]	Multiple point-to-point	[X]	Multipoint-star

8.1.3 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	[x] 2400 bit/s	[ ] 2400 bit/s	[ ] 56000 bit/s
[ ] 200 bit/s	[x] 4800 bit/s	[ ] 4800 bit/s	[ ] 64000 bit/s
[ ] 300 bit/s	[x] 9600 bit/s	[ ] 9600 bit/s	
[ ] 600 bit/s		[ ] 19200 bit/s	
[x] 1200 bit/s		[ ] 38400 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	[x] 2400 bit/s	[ ] 2400 bit/s	[ ] 56000 bit/s
[ ] 200 bit/s	[x] 4800 bit/s	[ ] 4800 bit/s	[ ] 64000 bit/s
[ ] 300 bit/s	[x] 9600 bit/s	[ ] 9600 bit/s	
[ ] 600 bit/s		[ ] 19200 bit/s	
[x] 1200 bit/s		[ ] 38400 bit/s	

8.1.4 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
- [X] Unbalanced transmission

Frame

- [255] Maximum length L (control direction)
- [255] Maximum length L (monitor direction)

Address field of link

- [ ] Not present (balanced transmission only)
- [ ] One octet
- [X] Two octets
- [ ] Structured
- [X] 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.

8.1.5 Application layer

Transmission mode for application data - Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU - (system-specific parameter, all configurations that are used are to be marked "X")

- [ ] One octet
- [X] Two octects

NBNon è possibile definire più Common Address of ASDU per una sola RTU

Information object address - (system-specific parameter, all configurations that are used are to be marked "X")

☐	One octet	☒	Structured
☒	Two octets	☒	Unstructured
☐	Three octets		

Cause of transmission - (system-specific parameter, all configurations that are used are to be marked "X")

☒	One octet	☐	Two octets (with originator address) Set to zero in case of no originator

8.1.6 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)

☒	<1>	:=	Single-point information	M_SP_NA_1
☐	<2>	:=	Single-point information with time tag	M_SP_TA_1
☒	<3>	:=	Double-point information	M_DP_NA_1
☐	<4>	:=	Double-point information with time tag	M_DP_TA_1
☐	<5>	:=	Step position information	M_ST_NA_1
☐	<6>	:=	Step position information with time tag	M_ST_TA_1
☐	<7>	:=	Bitstring of 32 bit	M_BO_NA_1
☐	<8>	:=	Bitstring of 32 bit with time tag	M_BO_TA_1
☒	<9>	:=	Measured value, normalized value	M_ME_NA_1
☐	<10>	:=	Measured value, normalized value with time tag	M_ME_TA_1
☐	<11>	:=	Measured value, scaled value	M_ME_NB_1
☐	<12>	:=	Measured value, scaled value with time tag	M_ME_TB_1
☒	<13>	:=	Measured value, short floating point value	M_ME_NC_1

☐	<14>	:=	Measured value, short floating point value with time tag	M_ME_TC_1
☐	<15>	:=	Integrated totals	M_IT_NA_1
☐	<16>	:=	Integrated totals with time tag	M_IT_TA_1
☐	<17>	:=	Event of protection equipment with time tag	M_EP_TA_1
☐	<18>	:=	Packed start events of protection equipment with time tag	M_EP_TB_1
☐	<19>	:=	Packed output circuit information of protection equipment with time tag	M_EP_TC_1
☐	<20>	:=	Packed single-point information with status change detection	M PS NA 1
☐	<21>	:=	Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30>	:=	Single-point information with time tag CP56Time2a	M_SP_TB_1
☒	<31>	:=	Double-point information with time tag CP56Time2a	M_DP_TB_1
☐	<32>	:=	Step position information with time tag CP56Time2a	M_ST_TB_1
☐	<33>	:=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
☒	<34>	:=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☐	<35>	:=	Measured value, scaled value with time tag CP56Time2a	M_ME TE 1
☒	<36>	:=	Measured value, short floating point value with time tag CP56Time2a	M_ME TF 1
☐	<37>	:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38>	:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39>	:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40>	:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

8.1.7 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)

☒	<45>	:=	Single command	C_SC_NA_1

☐	<46>	:= Double command	C_DC_NA_1
☐	<47>	:= Regulating step command	C_RC_NA_1
☐	<48>	:= Set point command, normalized value	C_SE_NA_1
☐	<49>	:= Set point command, scaled value	C_SE_NB_1
☐	<50>	:= Set point command, short floating point value	C_SE_NC_1
☐	<51>	:= Bitstring of 32 bit	C_BO_NA_1

8.1.8 System information in monitor direction

(station-specific parameter, mark "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

8.1.9 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
☐	<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

8.1.10 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

8.1.11 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 sectio n	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
☐	<126>	:=	Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1

8.1.12 Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used.

Mark type identification/cause of transmission combinations:

"X" if used only in the standard direction

"R" if used only in the reverse direction

"B" if used in both directions

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20	21 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1			X											X						
<2>	M_SP_TA_1			X																	
<3>	M_DP_NA_1			X											X						
<4>	M_DP_TA_1			X																	
<5>	M_ST_NA_1																				
<6>	M_ST_TA_1																				
<7>	M_BO_NA_1																				
<8>	M_BO_TA_1																				
<9>	M_ME_NA_1			X											X						
<10>	M_ME_TA_1																				
<11>	M_ME_NB_1																				
<12>	M_ME_TB_1																				
<13>	M_ME_NC_1																				
<14>	M_ME_TC_1																				
<15>	M_IT_NA_1																				
<16>	M_IT_TA_1																				
<17>	M_EP_TA_1																				
<18>	M_EP_TB_1																				
<19>	M_EP_TC_1																				
<20>	M_PS_NA_1																				
<21>	M_ME_ND_1																				
<30>	M_SP_TB_1			X											X						
<31>	M_DP_TB_1			X											X						
<32>	M_ST_TB_1																				
<33>	M_BO_TB_1																				
<34>	M_ME_TD_1			X		X									X						
<35>	M_ME_TE_1																				
<36>	M_ME_TF_1																				
<37>	M_IT_TB_1																				
<38>	M_EP_TD_1																				
<39>	M_EP_TE_1																				
<40>	M_EP_TF_1																				
<45>	C_SC_NA_1						X	X			X										
<46>	C_DC_NA_1						X	X			X										
<47>	C_RC_NA_1																				
<48>	C_SE_NA_1																				
<49>	C_SE_NB_1																				

<50>	C_SE_NC_1																				
<51>	C_BO_NA_1																				
<70>	M_EI_NA_1				X																
<100>	C_IC_NA_1						X	X			X										
<101>	C_CI_NA_1																				
<102>	C_RD_NA_1																				
<103>	C_CS_NA_1						X	X													
<104>	C_TS_NA_1																				
<105>	C_RP_NA_1						X	X													
<106>	C_CD_NA_1																				
<110>	P_ME_NA_1																				
<111>	P_ME_NB_1																				
<112>	P_ME_NC_1																				
<113>	P_AC_NA_1																				
<120>	F_FR_NA_1													B							
<121>	F_SR_NA_1													B							
<122>	F_SC_NA_1													B							
<123>	F_LS_NA_1													B							
<124>	F_AF_NA_1													B							
<125>	F_SG_NA_1													B							
<126>	F_DR_TA_1*																				

* Blank or X only.

8.1.13 Basic application functions

Station initialization

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

☐ Remote initialization

Cyclic data transmission

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

☐ Cyclic data transmission

Read procedure

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

☐ Read procedure

Spontaneous transmission

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

[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.

[X] Single-point information M_SP_NA_1, M_SP_TA_1, M_SP TB_1 and M_PS NA_1

[X] Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

[ ] Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

[ ] Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1

(if defined for a specific project, see 7.2.1.1)

[ ] Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1

[X] Measured value, scaled value M ME NB 1, M ME TB 1 and M ME TE1

[X] Measured value, short floating point number M_ME_NC_1, M_ME_TC_1

8.1.13.1. *Station interrogation*

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

[X] Global

[ ] group 1	[ ] group 7	[ ] group 13
[ ] group 2	[ ] group 8	[ ] group 14

☐	group 3	☐	group 9	☐	group 15
☐	group 4	☐	group 10	☐	group 16
☐	group 5	☐	group 11	Information object addresses assigned to each group must be shown in a separate table	
☐	group 6	☐	group 12		

8.1.13.2. *Clock synchronization*

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

☒ Clock synchronization

8.1.13.3. *Command transmission*

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

☒ Direct command

☐ Direct set point command

☒ Select and execute

☐ Select and execute set point

☐ C_SE ACTTERM

☐ No additional definition

☐ Short-pulse duration (duration determined by a system parameter in the controlled)

☐ Long-pulse duration (duration determined by a system parameter in the controlled station)

☐ Persistent output

8.1.13.4. *Transmission of integrated totals*

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

☐ Mode A: local freeze with spontaneous

☐ Mode B: local freeze with counter

☐ Mode C: freeze and transmit by counter interrogation

☐ Mode D: freeze by counter-interrogation command, frozen values reported

☐ Counter read

☐ Counter freeze without reset

☐ Counter freeze with reset

☐ Counter reset

☐ General request

☐ Request counter group 1

☐ Request counter group 2

☐ Request counter group 3

☐ Request counter group 4

8.1.13.5. *Parameter loading*

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

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

8.1.13.6. *Parameter activation*

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

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

8.1.13.7. *Test procedure*

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

☐ Test

8.1.13.8. *File transfer*

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

File transfer in monitor direction

☒ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☒ Transparent file

8.1.13.9. *Background scan*

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

☐ Background scan

8.1.13.10. *Acquisition of transmission delay*

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

☐ Acquisition of transmission delay

8.2 IEC60870-5-104 ENEL Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives.

This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications.This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

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

☐	Function or ASDU is not used
X	Function or ASDU is used as standardized (default)
R	Function or ASDU is used in reverse mode
B	Function or ASDU is used in standard and reverse mode

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

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

8.2.1 System or device

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

☐	System definition
X	Controlling station definition (Master)
☐	Controlled station definition (Slave)

8.2.2 Network configuration

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

☐	~~Point-to-point~~	☐	~~Multipoint-party line~~
☐	~~Multiple point-to-point~~	☐	~~Multipoint-star~~

8.2.3 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	☐ 56000 bit/s
☐ 200 bit/s	☐ 4800 bit/s	☐ 4800 bit/s	☐ 64000 bit/s
☐ 300 bit/s	☐ 9600 bit/s	☐ 9600 bit/s	
☐ 600 bit/s		☐ 19200 bit/s	
☐ 1200 bit/s		☐ 38400 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	☐ 56000 bit/s
☐ 200 bit/s	☐ 4800 bit/s	☐ 4800 bit/s	☐ 64000 bit/s
☐ 300 bit/s	☐ 9600 bit/s	☐ 9600 bit/s	
☐ 600 bit/s		☐ 19200 bit/s	
☐ 1200 bit/s		☐ 38400 bit/s	

8.2.4 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

☐ ~~0~~ ~~Maximum length L (control direction)~~

☐ ~~0~~ ~~Maximum length L (monitor direction)~~

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 causes of transmission:~~

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

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

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

~~Type identification~~	~~Cause of transmission~~

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

8.2.5 Application layer

Transmission mode for application data - Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU (system-specific parameter, all configurations that are used are to be marked "X")

☐ ~~One octet~~ ☒ Two octects

NBNon è possibile definire più Common Address of ASDU per una sola RTU

Information object address - (system-specific parameter, all configurations that are used are to be marked "X")

☐ ~~One octet~~ ☐ Structured

[ ] ~~Two octets~~

[X] Three octets

[X] Unstructured

Cause of transmission - (system-specific parameter, all configurations that are used are to be marked "X")

[ ] ~~One octet~~

[X] Two octets (with originator address)
Set to zero in case of no originator

Length of APDU - (system-specific parameter, specifiy the maximum length of the APDU per system)

The maximum length of the APDU is 253 (default). The maximum length may be reduced by the system.

[**253**] Maximum length of APDU per system

8.2.6 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)

X	<1>	:=	Single-point information	M_SP_NA_1
X	<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
X	<9>	:=	Measured value, normalized value	M_ME_NA_1
	<11>	:=	Measured value, scaled value	M_ME_NB_1
X	<13>	:=	Measured value, short floating point value	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
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
	<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
	<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

8.2.7 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
	<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

8.2.8 System information in monitor direction

(station-specific parameter, mark "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

8.2.9 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
	<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~~

8.2.10 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

8.2.11 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 sectio n	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
☐	<126>	:=	Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1

8.2.12 Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used.

Mark type identification/cause of transmission combinations:

"X" if used only in the standard direction

"R" if used only in the reverse direction

"B" if used in both directions

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20	21 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1			X											X						
<2>	M_SP_TA_1			X																	
<3>	M_DP_NA_1			X											X						
<4>	M_DP_TA_1			X																	
<5>	M_ST_NA_1																				
<6>	M_ST_TA_1																				
<7>	M_BO_NA_1																				
<8>	M_BO_TA_1																				
<9>	M_ME_NA_1			X											X						
<10>	M_ME_TA_1																				
<11>	M_ME_NB_1																				
<12>	M_ME_TB_1																				
<13>	M_ME_NC_1																				
<14>	M_ME_TC_1																				
<15>	M_IT_NA_1																				
<16>	M_IT_TA_1																				
<17>	M_EP_TA_1																				
<18>	M_EP_TB_1																				
<19>	M_EP_TC_1																				
<20>	M_PS_NA_1																				
<21>	M_ME_ND_1																				
<30>	M_SP_TB_1			X											X						
<31>	M_DP_TB_1			X											X						
<32>	M_ST_TB_1																				
<33>	M_BO_TB_1																				
<34>	M_ME_TD_1			X		X									X						
<35>	M_ME_TE_1																				
<36>	M_ME_TF_1																				
<37>	M_IT_TB_1																				
<38>	M_EP_TD_1																				
<39>	M_EP_TE_1																				
<40>	M_EP_TF_1																				
<45>	C_SC_NA_1						X	X			X										
<46>	C_DC_NA_1						X	X			X										
<47>	C_RC_NA_1																				
<48>	C_SE_NA_1																				
<49>	C_SE_NB_1																				
<50>	C_SE_NC_1																				
<51>	C_BO_NA_1																				
<70>	M_EI_NA_1				X																
<100>	C_IC_NA_1						X	X			X										
<101>	C_CI_NA_1																				
<102>	C_RD_NA_1																				
<103>	C_CS_NA_1						X	X													
<104>	C_TS_NA_1																				
<105>	C_RP_NA_1						X	X													
<106>	C_CD_NA_1																				
<110>	P_ME_NA_1																				
<111>	P_ME_NB_1																				
<112>	P_ME_NC_1																				
<113>	P_AC_NA_1																				
<120>	F_FR_NA_1													B							
<121>	F_SR_NA_1													B							
<122>	F_SC_NA_1													B							

<123>	F_LS_NA_1													B						
<124>	F_AF_NA_1													B						
<125>	F_SG_NA_1													B						
<126>	F_DR_TA_1*																			

* Blank or X only.

8.2.13 Basic application functions

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 used only in the standard direction, "R" if used only 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 used only in the standard direction, "R" if used only in the reverse direction, and "B" if used in both directions)

[X] Read procedure

Spontaneous transmission

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

[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.

[X] Single-point information M_SP_NA_1, M_SP_TA_1, M_SP TB_1 and M_PS NA_1

[X] Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

[ ] Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

[ ] Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1

(if defined for a specific project, see 7.2.1.1)

[X] 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 TE1

[X] Measured value, short floating point number M_ME_NC_1, M_ME_TC_1

8.2.13.1. *Station interrogation*

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

[X] Global

[ ] group 1	[ ] group 7	[ ] group 13
[ ] group 2	[ ] group 8	[ ] group 14
[ ] group 3	[ ] group 9	[ ] group 15
[ ] group 4	[ ] group 10	[ ] group 16
[ ] group 5	[ ] group 11	Information object addresses assigned to each group must be shown in a separate table
[ ] group 6	[ ] group 12	

8.2.13.2. *Clock synchronization*

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

[X] Clock synchronization

8.2.13.3. *Command transmission*

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

[X] Direct command

[ ] Direct set point command

[X] Select and execute

[ ] Select and execute set point

X	C_SE ACTTERM
X	No additional definition
X	Short-pulse duration (duration determined by a system parameter in the controlled)
X	Long-pulse duration (duration determined by a system parameter in the controlled station)
X	Persistent output
X	Supervision of maximum delay in command direction of commands and set point commands
30	Maximum allowable delay (seconds) of command and set point commands

8.2.13.4. *Transmission of integrated totals*

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

	Mode A: local freeze with spontaneous
	Mode B: local freeze with counter
	Mode C: freeze and transmit by counter interrogation
	Mode D: freeze by counter-interrogation command, frozen values reported
	Counter read
	Counter freeze without reset
	Counter freeze with reset
	Counter reset
	General request
	Request counter group 1
	Request counter group 2
	Request counter group 3
	Request counter group 4

8.2.13.5. *Parameter loading*

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

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

8.2.13.6. *Parameter activation*

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

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

8.2.13.7. *Test procedure*

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

☐ Test

8.2.13.8. *File transfer*

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

File transfer in monitor direction

☒ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☒ Transparent file

8.2.13.9. *Background scan*

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

☒ Background scan

8.2.13.10. *Definition of timeouts*

Parameters	Default value	Remarks	Selected value
ASDU Max Lenght	249 byte	Maximum length of the ASDU part of a message	249 byte
T_0	30s	Timeout of connection establishment.	30s
T_1	15s	Timeout of send or test APDUs.	15s
T_2	30s	Timeout for acknowledge in case of no data messages ($\mathbf{t_2} < \mathbf{t_1}$)	30s
T_3	30s	Timeout for sending test messages (S-Frame) in case of a long idle state ($\mathbf{t_3} < \mathbf{t_1}$)	30s
k	12	Maximum difference receive sequence number to send state variable	12
w	8	Latest acknowledge after receiving w data messages (I-frame)	8

Maximum range of values for all timeouts: 1 to 255s, accuracy 1s.

8.2.13.11. *Maximum number of outstanding I-format APDUs and latest acknowledge APDUs*

Parameters	Default value	Remarks	Selected value
k	12	Maximum difference receive sequence number to send state variable	12
w	8	Latest acknowledge after receiving w data messages (I-frame)	8

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

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

8.2.13.12. *Portnumber*

Parameters	Value	Remarks
Portnumber	2404	Listening port number (in all cases)

8.2.13.13. *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.

[X] Ethernet 802.3

[ ] Serial interface X.21

☐ Other selection from RFC 2200

List of RFC-2200 documents to be used:

1. .....

2. .....

1. .....

2. .....

1. .....

2. .....

1. .....

etc. .....

.....

8.3 IEC60870-5-101 ENDESA Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives.

This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications.

This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

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

☐	Function or ASDU is not used
X	Function or ASDU is used as standardized (default)
R	Function or ASDU is used in reverse mode
B	Function or ASDU is used in standard and reverse mode

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

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

8.3.1 System or device

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

☐	System definition
☐	Controlling station definition (Master)
X	Controlled station definition (Slave)

8.3.2 Network configuration

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

X	Point-to-point	**X**	Multipoint-party line
☐	Multiple point-to-point	**X**	Multipoint-star

8.3.3 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	☐ 56000 bit/s
☐ 200 bit/s	☐ 4800 bit/s	☐ 4800 bit/s	☐ 64000 bit/s
☐ 300 bit/s	☒ 9600 bit/s	☐ 9600 bit/s	
☐ 600 bit/s	☒ 19200 bit/s	☐ 19200 bit/s	
☒ 1200 bit/s		☐ 38400 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	☐ 56000 bit/s
☐ 200 bit/s	☐ 4800 bit/s	☐ 4800 bit/s	☐ 64000 bit/s
☐ 300 bit/s	☒ 9600 bit/s	☐ 9600 bit/s	
☐ 600 bit/s	☒ 19200 bit/s	☐ 19200 bit/s	
☒ 1200 bit/s		☐ 38400 bit/s	

8.3.4 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

[x] Balanced transmission

[X] Unbalanced transmission

Frame

[126] Maximum length L (control direction)

[126] Maximum length L (monitor direction)

Address field of link

[ ] Not present (balanced transmission only)

[ ] One octet

[X] Two octets

[ ] Structured

[X] Unstructured

8.3.5 Application layer

Transmission mode for application data - Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU - (system-specific parameter, all configurations that are used are to be marked "X")

[ ] One octet [X] Two octects

NBNon è possibile definire più Common Address of ASDU per una sola RTU

Information object address - (system-specific parameter, all configurations that are used are to be marked "X")

[ ] One octet

[ ] Two octets

[x] Three octets

[X] Structured

[ ] Unstructured

Cause of transmission - (system-specific parameter, all configurations that are used are to be marked "X")

[ ] One octet

[x] Two octets (with originator address)
Set to zero in case of no originator

Length of APDU (system-specific parameter)

The maximum L length of the APDU is 253 (default value). The maximum L length may be reduced for the system to 123 (this value is equal to the maximum size of an ASDU + the size of the APCI, the latter having a value of 0 under protocol 101 and 4 under protocol 104).

8.3.6 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)

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
	<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
	<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
X	<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

☐	<32>	:=	Step position information with time tag CP56Time2a	M_ST_TB_1
☐	<33>	:=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
☐	<34>	:=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☐	<35>	:=	Measured value, scaled value with time tag CP56Time2a	M_ME TE 1
☐	<36>	:=	Measured value, short floating point value with time tag CP56Time2a	M_ME TF 1
☐	<37>	:=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38>	:=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39>	:=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40>	:=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

8.3.7 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
☐	<47>	:=	Regulating step command	C_RC_NA_1
X	<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

8.3.8 System information in monitor direction

(station-specific parameter, mark "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

8.3.9 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, "B" if used in both directions and "Y" not supported by the CC but it should be supported by the RTU)

X	<100>	:=	Interrogation command	C_IC_NA_1
	<101>	:=	Counter interrogation command	C_CI_NA_1
	<102>	:=	Read command	C_RD_NA_1
Y	<103>	:=	Clock synchronization command	C_CS_NA_1
	<104>	:=	Test command	C_TS_NA_1
Y	<105>	:=	Reset process command	C_RP_NA_1
	<106>	:=	Delay acquisition command	C_CD_NA_1

8.3.10 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

8.3.11 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, "B" if used in both directions and "Y" not supported by the CC but it should be supported by the RTU)

Y	<120>	:=	File ready	F_FR_NA_1
Y	<121>	:=	Section ready	F_SR_NA_1
Y	<122>	:=	Call directory, select file, call file, call sectio n	F_SC_NA_1

Y	<123>	:=	Last section, last segment	F_LS_NA_1
Y	<124>	:=	Ack file, ack section	F_AF_NA_1
Y	<125>	:=	Segment	F_SG_NA_1
Y	<126>	:=	Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1

8.3.12 Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used.

Mark type identification/cause of transmission combinations:

"X" if used only in the standard direction

"R" if used only in the reverse direction

"B" if used in both directions

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

<38>	M_EP_TD_1																				
<39>	M_EP_TE_1																				
<40>	M_EP_TF_1																				
<45>	C_SC_NA_1						X	X			X										
<46>	C_DC_NA_1						X	X			X										
<47>	C_RC_NA_1																				
<48>	C_SE_NA_1																				
<49>	C_SE_NB_1																				
<50>	C_SE_NC_1																				
<51>	C_BO_NA_1																				
<70>	M_EI_NA_1				X																
<100>	C_IC_NA_1						X	X			X										
<101>	C_CI_NA_1																				
<102>	C_RD_NA_1																				
<103>	C_CS_NA_1						X	X													
<104>	C_TS_NA_1																				
<105>	C_RP_NA_1						X	X													
<106>	C_CD_NA_1																				
<110>	P_ME_NA_1																				
<111>	P_ME_NB_1																				
<112>	P_ME_NC_1																				
<113>	P_AC_NA_1																				
<120>	F_FR_NA_1													B							
<121>	F_SR_NA_1													B							
<122>	F_SC_NA_1													B							
<123>	F_LS_NA_1													B							
<124>	F_AF_NA_1													B							
<125>	F_SG_NA_1													B							
<126>	F_DR_TA_1*																				

* Blank or X only.

8.3.13 Basic application functions

Station initialization

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

☐ Remote initialization

Cyclic data transmission

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

☐ Cyclic data transmission

Read procedure

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

☐ Read procedure

Spontaneous transmission

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

☐ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

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

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

☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP TB_1 and M_PS NA_1

☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1

☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1

☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1

(if defined for a specific project, see 7.2.1.1)

☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1

☐ Measured value, scaled value M ME NB 1, M ME TB 1 and M ME TE1

☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1

8.3.13.1. *Station interrogation*

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

☒ Global

☐ group 1	☐ group 7	☐ group 13
☐ group 2	☐ group 8	☐ group 14
☐ group 3	☐ group 9	☐ group 15
☐ group 4	☐ group 10	☐ group 16
☐ group 5	☐ group 11	Information object addresses assigned

☐ group 6 ☐ group 12 to each group must be shown in a separate table

8.3.13.2. *Clock synchronization*

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

☒ Clock synchronization

8.3.13.3. *Command transmission*

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

☐ Direct command

☒ Direct set point command

☒ Select and execute

☐ Select and execute set point

☐ C_SE ACTTERM

☐ No additional definition

☐ Short-pulse duration (duration determined by a system parameter in the controlled)

☐ Long-pulse duration (duration determined by a system parameter in the controlled station)

☐ Persistent output

8.3.13.4. *Transmission of integrated totals*

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

☐ Mode A: local freeze with spontaneous

☐ Mode B: local freeze with counter

☐ Mode C: freeze and transmit by counter interrogation

☐ Mode D: freeze by counter-interrogation command, frozen values reported

☐ Counter read

☐ Counter freeze without reset

☐ Counter freeze with reset

☐ Counter reset

☐ General request

☐ Request counter group 1

☐ Request counter group 2

☐ Request counter group 3

☐ Request counter group 4

8.3.13.5. *Parameter loading*

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

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

8.3.13.6. *Parameter activation*

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

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

8.3.13.7. *Test procedure*

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

☐ Test

8.3.13.8. *File transfer*

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

File transfer in monitor direction

[Y] Transparent file

[ ] Transmission of disturbance data of protection equipment

[ ] Transmission of sequences of events

[ ] Transmission of sequences of recorded analogue values

File transfer in control direction

[Y] Transparent file

8.3.13.9. *Background scan*

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

[ ] Background scan

8.3.13.10. *Acquisition of transmission delay*

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

[ ] Acquisition of transmission delay

8.4 IEC60870-5-104 ENDESA Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives.

This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications.This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

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

☐	Function or ASDU is not used
X	Function or ASDU is used as standardized (default)
R	Function or ASDU is used in reverse mode
B	Function or ASDU is used in standard and reverse mode
W	Function or ASDU used by Wind Farms only

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

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

8.4.1 System or device

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

☐	System definition
☐	Controlling station definition (Master)
X	Controlled station definition (Slave)

8.4.2 Network configuration

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

☐	~~Point-to-point~~	☐	~~Multipoint-party line~~
☐	~~Multiple point-to-point~~	☐	~~Multipoint-star~~

8.4.3 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~~	☐ ~~56000 bit/s~~
☐ ~~200 bit/s~~	☐ ~~4800 bit/s~~	☐ ~~4800 bit/s~~	☐ ~~64000 bit/s~~
☐ ~~300 bit/s~~	☐ ~~9600 bit/s~~	☐ ~~9600 bit/s~~	
☐ ~~600 bit/s~~		☐ ~~19200 bit/s~~	
☐ ~~1200 bit/s~~		☐ ~~38400 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~~	☐ ~~56000 bit/s~~
☐ ~~200 bit/s~~	☐ ~~4800 bit/s~~	☐ ~~4800 bit/s~~	☐ ~~64000 bit/s~~
☐ ~~300 bit/s~~	☐ ~~9600 bit/s~~	☐ ~~9600 bit/s~~	
☐ ~~600 bit/s~~		☐ ~~19200 bit/s~~	
☐ ~~1200 bit/s~~		☐ ~~38400 bit/s~~	

8.4.4 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

- [255] Maximum length L (control direction)
- [255] Maximum length L (monitor direction)

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 causes of transmission:~~

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

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

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

~~Type identification~~	~~Cause of transmission~~

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

8.4.5 Application layer

Transmission mode for application data - Mode 1 (least significant octet first), as defined in 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU (system-specific parameter, all configurations that are used are to be marked "X")

☐ ~~One octet~~ [X] Two octects

NBNon è possibile definire più Common Address of ASDU per una sola RTU

Information object address - (system-specific parameter, all configurations that are used are to be marked "X")

☐ ~~One octet~~ [X] Structured

☐ ~~Two octets~~

☐ Unstructured

☒ Three octets

Cause of transmission - (system-specific parameter, all configurations that are used are to be marked "X")

☐ ~~One octet~~

☒ Two octets (with originator address)
Set to zero in case of no originator

Length of APDU - (system-specific parameter, specifiy the maximum length of the APDU per system)

The maximum length of the APDU is 253 (default). The maximum length may be reduced by the system.

☐ _____ Maximum length of APDU per system

8.4.6 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)

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
	<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
W	<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
X	<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
	<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
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

8.4.7 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
X	<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

8.4.8 System information in monitor direction

(station-specific parameter, mark "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

8.4.9 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
[ ]	<102>	:=	Read command	C_RD_NA_1
[ ]	<103>	:=	Clock synchronization command	C_CS_NA_1
[ ]	<104>	:=	Test command	C_TS_NA_1
[ ]	<105>	:=	Reset process command	C_RP_NA_1
[ ]	<106>	:=	Delay acquisition command	C_CD_NA_1
[ ]	<107>	:=	Test command with time tag CP56Time2a	C_TS_TA_1

8.4.10 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

8.4.11 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 sectio n	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

[ ] <126> := Directory {blank or X, only available in monitor (standard) direction} F_DR_TA_1

8.4.12 Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes are not required.

Blank = function or ASDU is not used.

Mark type identification/cause of transmission combinations:

"X" if used only in the standard direction

"R" if used only in the reverse direction

"B" if used in both directions

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

<36>	M_ME_TF_1																				
<37>	M_IT_TB_1																				
<38>	M_EP_TD_1																				
<39>	M_EP_TE_1																				
<40>	M_EP_TF_1																				
<45>	C_SC_NA_1						X	X			X										
<46>	C_DC_NA_1						X	X			X										
<47>	C_RC_NA_1																				
<48>	C_SE_NA_1																				
<49>	C_SE_NB_1																				
<50>	C_SE_NC_1																				
<51>	C_BO_NA_1																				
<70>	M_EI_NA_1				X																
<100>	C_IC_NA_1						X	X			X										
<101>	C_CI_NA_1																				
<102>	C_RD_NA_1																				
<103>	C_CS_NA_1						X	X													
<104>	C_TS_NA_1																				
<105>	C_RP_NA_1						X	X													
<106>	C_CD_NA_1																				
<110>	P_ME_NA_1																				
<111>	P_ME_NB_1																				
<112>	P_ME_NC_1																				
<113>	P_AC_NA_1																				
<120>	F_FR_NA_1													B							
<121>	F_SR_NA_1													B							
<122>	F_SC_NA_1													B							
<123>	F_LS_NA_1													B							
<124>	F_AF_NA_1													B							
<125>	F_SG_NA_1													B							
<126>	F_DR_TA_1*																				

* Blank or X only.

8.4.13 Basic application functions

Station initialization

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

[ ] Remote initialization

Cyclic data transmission

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

[X] Cyclic data transmission

Read procedure

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

[ ] Read procedure

Spontaneous transmission

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

[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, see 7.2.1.1)

[ ] Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1

[ ] Measured value, scaled value M ME NB 1, M ME TB 1 and M ME TE1

[ ] Measured value, short floating point number M_ME_NC_1, M_ME_TC_1

8.4.13.1. *Station interrogation*

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

[X] Global

[ ] group 1	[ ] group 7	[ ] group 13
[ ] group 2	[ ] group 8	[ ] group 14
[ ] group 3	[ ] group 9	[ ] group 15
[ ] group 4	[ ] group 10	[ ] group 16
[ ] group 5	[ ] group 11	Information object addresses assigned to each group must be shown in a separate table
[ ] group 6	[ ] group 12	

8.4.13.2. *Clock synchronization*

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

[X] Clock synchronization

8.4.13.3. *Command transmission*

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

[ ] Direct command

[X] Direct set point command

[X] Select and execute

[ ] Select and execute set point

[ ] C_SE ACTTERM

[X] No additional definition

[ ] Short-pulse duration (duration determined by a system parameter in the controlled)

[ ] Long-pulse duration (duration determined by a system parameter in the controlled station)

[ ] Persistent output

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

[60] Maximum allowable delay (seconds) of commands and set point

8.4.13.4. *Transmission of integrated totals*

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

[X] Mode A: local freeze with spontaneous

[ ] Mode B: local freeze with counter

☐ Mode C: freeze and transmit by counter interrogation

☐ Mode D: freeze by counter-interrogation command, frozen values reported

☐ Counter read

☐ Counter freeze without reset

☐ Counter freeze with reset

☐ Counter reset

☐ General request

☐ Request counter group 1

☐ Request counter group 2

☐ Request counter group 3

☐ Request counter group 4

8.4.13.5. *Parameter loading*

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

☐ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

8.4.13.6. *Parameter activation*

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

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

8.4.13.7. *Test procedure*

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

☒ Test

8.4.13.8. *File transfer*

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

File transfer in monitor direction

☐ Transparent file

☐ Transmission of disturbance data of protection equipment

☒ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

8.4.13.9. *Background scan*

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

☐ Background scan

8.4.13.10. *Definition of timeouts*

Parameters	Default value	Remarks	Selected value
ASDU Max Lenght	249 byte	Maximum length of the ASDU part of a message	249 byte
T_0	30s	Timeout of connection establishment.	30s
T_1	15s	Timeout of send or test APDUs.	15s
T_2	30s	Timeout for acknowledge in case of no data messages ($\mathbf{t_2 < t_1}$)	30s
T_3	30s	Timeout for sending test messages (S-Frame) in case of a long idle state ($\mathbf{t_3 < t_1}$)	30s
k	12	Maximum difference receive sequence number to send state variable	12
w	8	Latest acknowledge after receiving w data messages (I-frame)	8

Maximum range of values for all timeouts: 1 to 255s, accuracy 1s.

8.4.13.11. *Maximum number of outstanding I-format APDUs and latest acknowledge APDUs*

Parameters	Default value	Remarks	Selected value
k	12	Maximum difference receive sequence number to send state variable	12
w	8	Latest acknowledge after receiving w data messages (I-frame)	8

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

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

8.4.13.12. *Portnumber*

Parameters	Value	Remarks
Portnumber	2404	Listening port number (in all cases)

8.4.13.13. *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.

[X] Ethernet 802.3

[ ] Serial interface X.21

[ ] Other selection from RFC 2200

List of RFC-2200 documents to be used:

1. **PPP "The Point-to-Point-Protocol (PPP)" RFC 1661**
2. **PPP-LCP "PPP LCD" RFC 1570**
1. **PPP-IPCP "the PPP Internet Protocol Control Protocol (IPCP)" RFC 1332**
2. .....
1. .....
2. .....
1. .....

etc. .....

.....