

AUTOMAÇÃO, PROTEÇÃO, COMANDO, CONTROLO E COMUNICAÇÕES

Light Protocol Implementation Document (IEC 60870-5-104)

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Light Protocol Implementation Document
for IEC 60870-5-104

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1 INTRODUCTION

The IEC Technical Committee 57 (Working Group 03) has developed a protocol standard for telecontrol, teleprotection, and associated telecommunications for electric power systems. The result of this work is IEC 60870-5. Five documents specify the base IEC 60870-5. These documents are:

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

The IEC Technical Committee 57 has also generated a companion standard IEC 60870-5-101. In addition to the CS101 standard a further companion standard IEC 60870-5-104 called “Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles” which is closely related to IEC 60870-5-101 was defined. Both IEC 60870-5-101 and IEC 60870-5-104 are based on the five documents IEC 60870-5-1 till 5. In addition to these standards WG03 has defined conformance test procedures and testcases that are defined in IEC 60870-5-6.

In spite of the great care with which the authors have written this document, possible indistinctness and inaccuracies can still occur in this document. It is the responsibility of the vendor to identify possible indistinctness and inaccuracies in this document, and the consistency between the EDP-Energias de Portugal PID 104 and related IEC60870-5 standards. If indistinctness, inaccuracies, or inconsistencies between the EDP-Energias de Portugal PID 104 or other EDP-Energias de Portugal requirements, and the related IEC60870-5 standard are identified, it is the responsibility of the vendor to inform the contact person within EDP-Energias de Portugal to discuss these issues.

1.1 Purpose of this document

The interpretation of the IEC60870-5-104 protocol standard can vary from supplier to supplier. The purpose of this document is to unambiguously define and specify how the IEC 60870-5-104 protocol in controlled stations within EDP-Energias de Portugal will be used.

This Protocol Implementation Document, further called EDP-Energias de Portugal PID104 constitutes the basis of the CS104 implementations for EDP-Energias de Portugal that are going to be delivered by vendors of SCADA/Front-End, substation and distribution automation (DA) equipment. Figure 1 presents an overview of the scope of this PID.

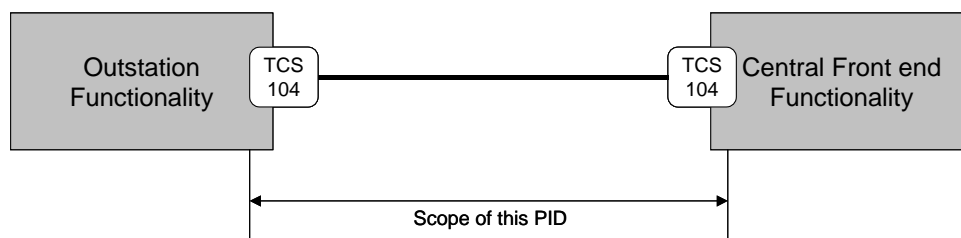


Figure 1: Scope of the EDP-Energias de Portugal PID 104

1.2 Normative references

This EDP-Energias de Portugal PID104 is based on the below mentioned IEC standards:

- IEC 60870-5-1: 1990, Telecontrol equipment and systems - Part 1: Transmission frame formats
- IEC 60870-5-2: 1992 Telecontrol equipment and systems - Part 2: Link transmission procedures
- IEC 60870-5-3: 1992 Telecontrol equipment and systems - Part 3: General structure of application data
- IEC 60870-5-4: 1993 Telecontrol equipment and systems - Part 4: Definition and coding of application information elements
- IEC 60870-5-5: 1995 Telecontrol equipment and systems - Part 5: Basic application functions
- IEC 60870-5-101 ed.2: 2003, Telecontrol equipment and systems - Section 101: Companion standard for basic telecontrol tasks
- IEC 60870-5-104 ed.2 2006, Telecontrol equipment and systems - Section 104: Network access for CS101 using standard transport profiles
- IEC 60870-5-6 Guidelines for conformance testing for the IEC 60870-5 companion standards

1.3 General structure of application data

IEC 870-5-3 describes the Basic Application Data Units in transmission frames of telecontrol systems. This subclass selects specific field elements out of that standard and defines Application Service Data Units (ASDU) used in the CS104 protocol.

The Application Service Data Units (ASDU) is composed of a Data Unit Identifier and one or more Information Objects. The Data Unit Identifier has always the same structure for all ASDUs. The Information Objects of an ASDU are always of the same structure and type, which are defined in the Type Identification field.

The structure of the Data Unit Identifier is:

- Type identification
- Variable structure qualifier
- Cause of transmission (Originator Address is not used in the EDP-Energias de Portugal PID104 and Therefore set to 0)
- Common address of ASDU
- Information object address

2 Protocol Implementation Conformance Statement (PICS)

Interoperability list

The marked functions and ASDUs in the interoperability list on the following pages represent the current minimum requirements for an IEC 60870-5-104 system according to the EDP-Energias de Portugal PID 104.

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

The interoperability list is defined as in IEC 60870-5-101 and IEC 60870-5-104. The text descriptions of parameters which are not applicable to the CS104 companion standard are strike-through (corresponding check box is marked black).

Note:

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

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

- Function or ASDU is not used
- Function or ASDU is used as standardized (default)
- Function or ASDU is used in reverse mode
- Function or ASDU is used in standard and reverse mode

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

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

System or device

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

- System definition (Definition for Master and Slave)
- Controlling station definition (Master)
- Controlled station definition (Slave)

Network configuration

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

- | | |
|--|---|
| <input checked="" type="checkbox"/> Point-to-point | <input checked="" type="checkbox"/> Multipoint-partyline |
| <input checked="" type="checkbox"/> Multiple-point-to-point | <input checked="" type="checkbox"/> Multipoint-star |

Physical layer

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

Transmission speed (control direction)

Unbalanced interchange
Circuit V.24/V.28
Standard

100 bit/s
 200 bit/s
 300 bit/s
 600 bit/s
 1 200 bit/s

Unbalanced interchange
Circuit V.24/V.28
Recommended if >1 200bit/s

2 400 bit/s
 4 800 bit/s
 9 600 bit/s

Balanced interchange
Circuit X.24/X.27

2 400 bit/s
 4 800 bit/s
 9 600 bit/s
 19 200 bit/s
 38 400 bit/s
 56 000 bit/s
 64 000 bit/s

Transmission speed (monitor direction)

Unbalanced interchange

Circuit V.24/V.28
Standard

100 bit/s
 200 bit/s
 300 bit/s
 600 bit/s
 1 200 bit/s

Unbalanced interchange

Circuit V.24/V.28
Recommended if >1 200bit/s

2 400 bit/s
 4 800 bit/s
 9 600 bit/s

Balanced interchange

Circuit X.24/X.27

2 400 bit/s
 4 800 bit/s
 9 600 bit/s
 19 200 bit/s
 38 400 bit/s
 56 000 bit/s
 64 000 bit/s

Link layer

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

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

Link transmission procedure

Balanced transmission
 Unbalanced transmission

Frame length

Maximum length L
(number of octets)

Address field of the link

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

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

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

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

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

Type identification	Cause of transmission

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

Application layer

Transmission mode for application data

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

Common address of ASDU

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

One octet Two octets

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)
 Originator address is set to zero if not used

Length of APDU

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

Maximum length of APDU per system

Selection of standard ASDUs

Process information in monitor direction

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

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

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

Process information in control direction

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

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

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

System information in monitor direction

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

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

System information in control direction

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

<input checked="" type="checkbox"/>	<100>:= Interrogation command	C_IC_NA_1
<input checked="" type="checkbox"/>	<101>:= Counter interrogation command	C_CI_NA_1
<input type="checkbox"/>	<102>:= Read command	C_RD_NA_1
<input checked="" type="checkbox"/>	<103>:= Clock synchronization command	C_CS_NA_1
<input type="checkbox"/>	<104>:= Test command	C_TS_NA_1
<input checked="" type="checkbox"/>	<105>:= Reset process command	C_RP_NA_1
<input type="checkbox"/>	<106>:= Delay acquisition command	C_CD_NA_1
<input checked="" type="checkbox"/>	<107>:= Test command with time tag CP56time2a	C_TS_TA_1

Parameter in control direction

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

<input type="checkbox"/>	<110>:= Parameter of measured value, normalized value	P_ME_NA_1
<input type="checkbox"/>	<111>:= Parameter of measured value, scaled value	P_ME_NB_1
<input checked="" type="checkbox"/>	<112>:= Parameter of measured value, short floating point value	P_ME_NC_1
<input type="checkbox"/>	<113>:= Parameter activation	P_AC_NA_1

File Transfer

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

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

Type Identifier and Cause of Transmission Assignments

(station-specific parameters)

Shaded boxes are not required.

Black boxes are not permitted in this companion standard

Blank = Function or ASDU is not used.

Mark Type Identification/Cause of transmission combinations:

'X' if only used in the standard direction

'R' if only used in the reverse direction

'B' if used in both directions

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

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

*) blank or X only

Station initialization

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



Remote initialization

Cyclic data transmission

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

Cyclic data transmission

Read procedure

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

Read procedure

Spontaneous transmission

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

Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

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

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

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

Station interrogation

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

- | | | |
|--|-----------------------------------|-----------------------------------|
| <input checked="" type="checkbox"/> global | <input type="checkbox"/> group 7 | <input type="checkbox"/> group 13 |
| <input type="checkbox"/> group 1 | <input type="checkbox"/> group 8 | <input type="checkbox"/> group 14 |
| <input type="checkbox"/> group 2 | <input type="checkbox"/> group 9 | <input type="checkbox"/> group 15 |
| <input type="checkbox"/> group 3 | <input type="checkbox"/> group 10 | <input type="checkbox"/> group 16 |
| <input type="checkbox"/> group 4 | <input type="checkbox"/> group 11 | |
| <input type="checkbox"/> group 5 | <input type="checkbox"/> group 12 | |
| <input type="checkbox"/> group 6 | | |
- Information Object Addresses assigned to each group must be shown in a separate table

Clock synchronization

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

- Clock synchronization (optional)

Command transmission

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

- Direct command transmission
- Direct set point command transmission
- Select and execute command
- Select and execute set point command
- C_SE ACTTERM used
- No additional definition
- Short pulse duration (duration determined by a system parameter in the outstation)
- Long pulse duration (duration determined by a system parameter in the outstation)
- Persistent output
- Supervision of maximum delay in command direction of commands and set point commands
- configurable** Maximum allowable delay of commands and set point commands

Transmission of integrated totals

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

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

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

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

Parameter loading

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

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

Parameter activation

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

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

Test procedure

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

- Test procedure

File transfer

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

Please note that the file transfer option is not required for suppliers of substation RTU equipment in case alternatives such as FTP via a management port are available. In case such an option is not supported, than file transfer according the below mentioned specifications is required.

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

Background scan

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

- Background scan

Acquisition of transmission delay

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

- Acquisition of transmission delay

Definition of time outs

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

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

Maximum number of outstanding I format APDUs k and latest acknowledge

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

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

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

Portnumber

Parameter	Value	Remarks
Portnumber	2404	In all cases

RFC 2200 suite

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

- Ethernet 802.3
- Serial X.21 interface
- Other selection from RFC 2200:

List of valid documents from RFC 2200

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

3 Protocol Implementation eXtra Information for Testing

3.1 Communication procedures

Table 3.1 shows a list of the basic communication procedures (basic application functions) that are applicable for EDP-Energias de Portugal.

Table 3.1 Basic Application Functions:

1. Station initialisation
2. Acquisition of events
3. General Interrogation
4. Clock synchronisation
5. Command transmission
6. Transmission of integrated totals
7. Parameter loading
8. Test procedure
9. File transfer

These application functions are further described in the subsequent sections.

3.1.1 Station initialisation procedure

The controlling station always performs connection establishment. In case a TCP/IP connection is established, a stopped CS104 connection is created. In order to start data exchange the Controlling station will send a Start DT ack. After the controlled station has confirmed the Start DT by sending a Start DT confirmation an active CS104 connection is established.

After a Start DT procedure the controlling station will in all cases sends the General Interrogation procedure by sending a general interrogation command (ASDU 100).

In case the controlled station was restarted or a power shutdown occurred the controlled station will send an End of Initialization (ASDU 70) in order to update the controlling station.

The controlling station can send a Reset process command (ASDU 105) to the controlled station to restart the controlled station. This is not an automatic function and shall only be initiated via manual interaction. The Reset process command confirmation is not required to be sent by the controlled station to the controlling station since the TCP connection may already be closed. As a result of the Reset process command the controlled station will close the CS104 connection by sending a close call to its TCP. When the TCP connection is closed the controlled station will be restarted. Then the controlling station tries to connect the controlled station by giving cyclic active opens to its TCP.

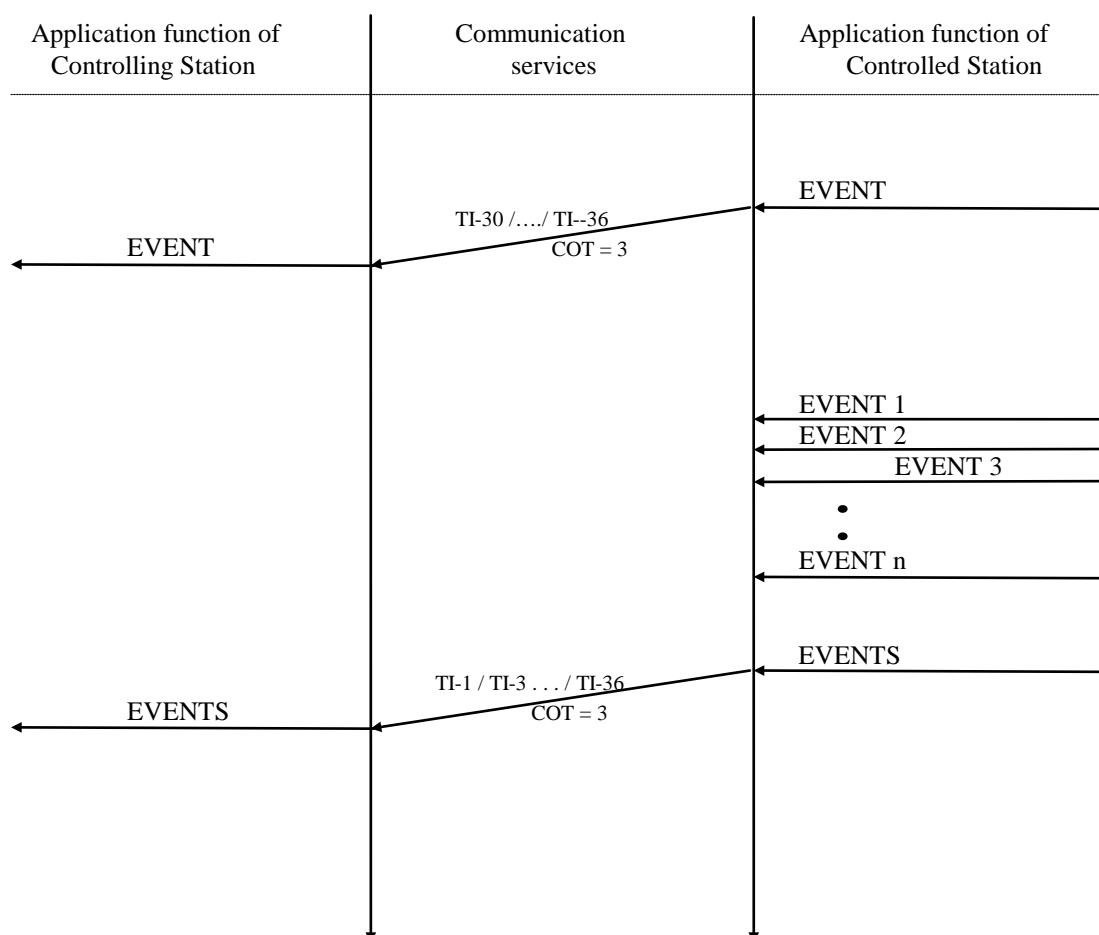
3.1.2 Acquisition of events procedure

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

Fig. 3.1 shows the sequential procedure for event acquisition. Events that arrive in the controlled station are transmitted to the controlling station as soon as possible after they appear. Events that arrive faster than transmission to the controlling station can be accomplished are buffered in the controlled station. The EDP-Energias de Portugal PID104 specifies that for event transmission only events with time tag are transmitted to the controlling station. The Cause of Transmission can, due to the initial reason of the event be, either COT=3 spontaneous, COT=11 remote command or COT=12 local command.

During the tender procedure suppliers of controlled station equipment should indicate in written if it is supported to send events during a general interrogation procedure. If this feature is supported vendors of controlled station equipment should explain the functional behaviour.

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



TI : Telegram Type Identification
COT : Cause Of Transmission

Figure 3.1: Acquisition of events

3.1.3 General interrogation procedure

The general interrogation application function is used to update the controlling station after Start DT, in case the controlling station receives an End of Initialization (ASDU 70) or when the controlling station detects a buffer overflow which is indicated via an IOA address that is specifically is defined for that purpose.

The general interrogation function of the controlling station requests the controlled station to transmit the actual values of all its process variables. Fig. 3.2 shows the sequential procedure. The information transfer is triggered by interrogation command activation from the controlling station to the controlled station, which responds with an general interrogation confirmation. The interrogation procedure completes when the controlling station receives a general interrogation message with COT=10 termination, indicating that all information has been transferred by the controlled station. The general interrogation abort function (COT=8 deactivation and COT=9 deactivation confirmation) is not applicable for the EDP-Energias de Portugal PID 104.

The Controlled Station algorithm must guarantee that the end-state of all data points after a general Interrogation is correct.

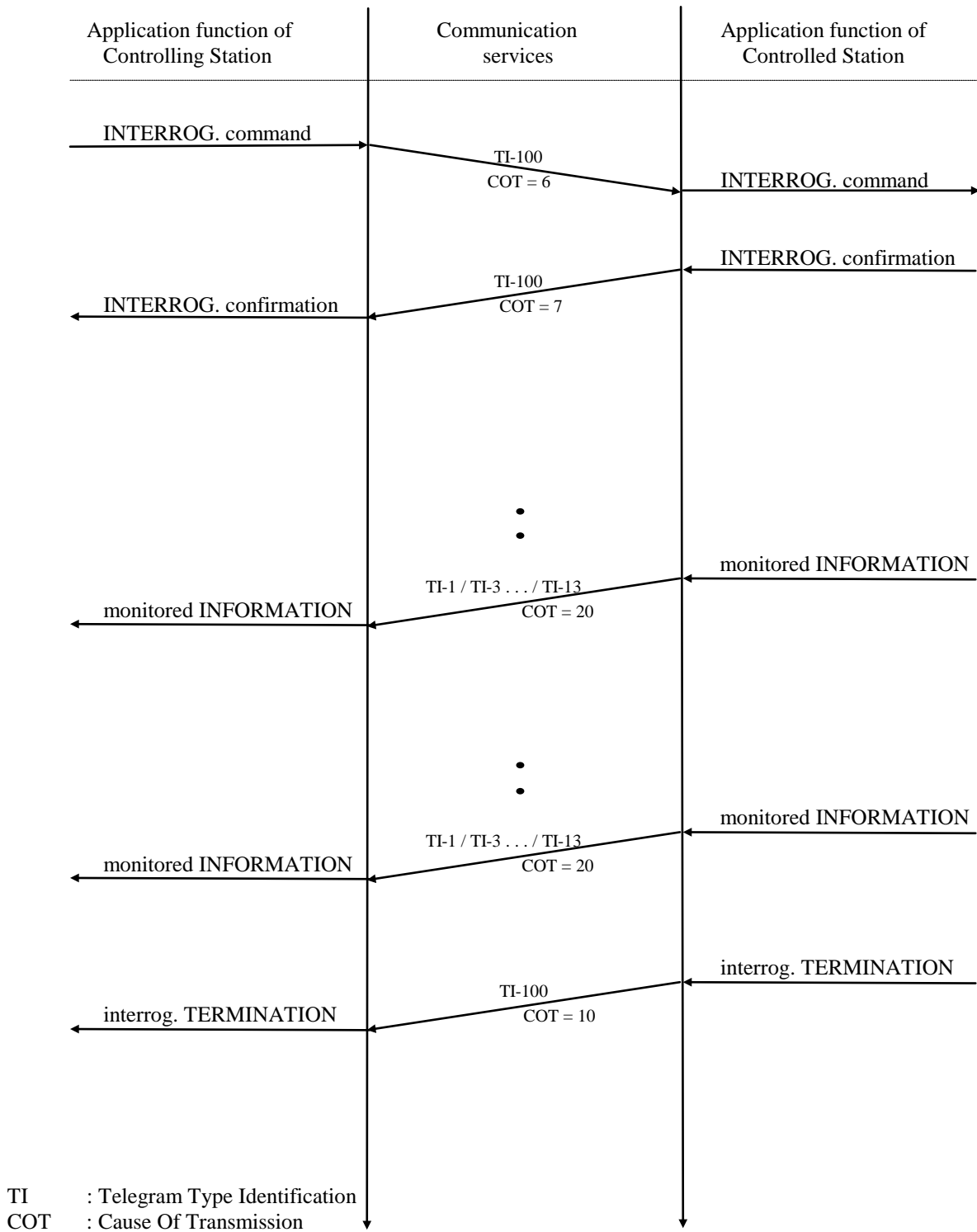


Figure 3.2: Interrogation procedure

3.1.4 Clock synchronisation procedure

The clock synchronisation command is used to synchronise the time in the controlled station with the time in the controlling station. Because there is less need for very accurate clock in the distribution automation equipment, the time synchronization for DA controlled stations is done via the CS104 clock synchronization command (ASDU 103). However, the controlled station equipment must be prepared to use clock synchronisation using GPS, without any necessary software or hardware changes. The definition of prepared in this context is that only connecting the GPS clock, by a connector, to the controlled station and changing a configuration parameter is the only action to take, after which the GPS will synchronise the controlled station clock.

3.1.5 Command transmission procedure

3.1.5.1 General

Commands are used in telecontrol systems to cause a change of state of operational equipment. The EDP-Energias de Portugal PID104 requires two standard procedures for command transmission:

1. Select and execute command
2. Direct command

Select/execute and direct commands may be assigned individually and independently to each commanded object (IOA) in the controlled station (by system configuration parameters in the controlling station). The EDP-Energias de Portugal PID104 requires to only use commands with time tag format CP56Time2a.

3.1.5.2 Select and execute command

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

- Prepare for a specific control operation in the controlled station
- Check that the control operation has been prepared.
- Execute the prepared operation if checks are positive

The sequential procedure for a select and execute command is shown in fig. 3.3. The controlling station sends a SELECT command message to the controlled station, which responds by a SELECT confirmation message if it is ready to accept the announced command. The time from the SELECT command to the SELECT confirmation is controlled by a configurable time-out interval in the controlling station.

A not successful select procedure may be deactivated by a "Break off" command. This command is transmitted by a BREAK OFF command message and the controlled station responds by a BREAK OFF confirmation message. The time between these messages is controlled by a timeout in the controlling station.

A successful select procedure may be executed by an EXECUTE command message. The EXECUTE command message is sent to the controlled station, which responds by an EXECUTE confirmation message. The time from the EXECUTE command to the EXECUTE confirmation is controlled by a configurable time-out interval in the controlling station.

An EXECUTE termination message is issued from the controlled station when the command is sent out by the controlled station to the addressed field device/equipment. The addressed field device/equipment should now change its state. When the new state is reached, this is indicated to the controlling station by a spontaneous data message (COT = 11 or 12: return information caused by a command).

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

In case an object in the controlled station is configured as select before execute and the controlled station receives an execute (without a preceding select) the controlled station shall reply with a negative confirmation message.

The application in the controlling station must check in all cases if the command has been properly executed.

3.1.5.3 Direct commands

Direct commands are used for immediate control operations, and the sequential procedure is identical to the procedure that starts with the EXECUTE command message as described in paragraph 3.1.5.2 and in fig. 3.3.

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

3.1.5.4 Delayed commands

The time tag of a command is always to be checked by the receiving (controlled) station to determine if the command is excessively delayed. In case of a delayed command no command confirmation is to be returned by the protocol, and the command is not executed. The parameter that defines the acceptable time delay must be configurable per controlled station and is applicable for all commands/objects in that controlled station. It should be possible to remotely change this parameter via the management port.

3.1.5.5 General comments

While waiting for a SELECT / BREAK OFF / EXECUTE confirmation other (new) SELECT / BREAK OFF / EXECUTE command can be sent. Because of that, multiple commands may run at the same time in one controlled station.

When a select and execute command (single, double command, etc) has been given by the user process to a specific object, no new select and execute or direct command for that specific object is accepted by the controlled station until the ongoing select and execute command has reached any of the following states:

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

These rules are also applicable per controlled object. The aim is that only one controlling station can control a specific object at the same time, for security reasons.

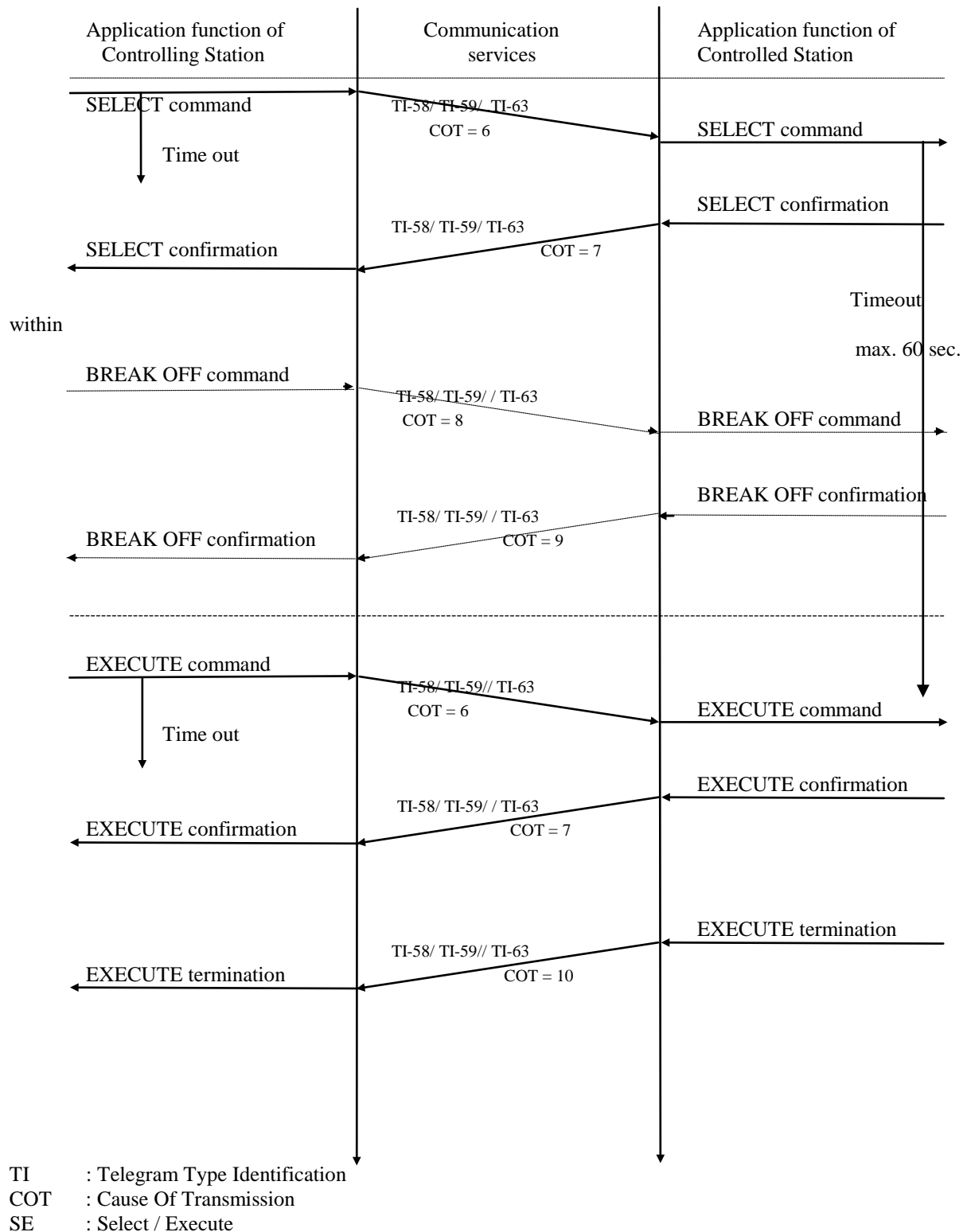


Figure 3.3: Command transmission procedure

3.1.6 Integrated totals procedure

Integrated totals will be used by EDP-Energias de Portugal to receive counter information. This counter information can i.e. be used to exchange counter information from the controlled station to the controlling station about the amount of times a switch moved position.

EDP-Energias de Portugal requires that integrated totals can be sent with Mode A and D. EDP-Energias de Portugal requires that counters are sent with Mode A periodically via COT=3. The parameter to define the time interval should be configurable with a minimum range of each hour and a maximum range of one a month. For every counter the time interval should be configured independently.

In addition EDP-Energias de Portugal requires the possibility to request counters via Mode D. An operator will trigger the controlling station to send a counter request (ASDU 101) to the applicable controlled station. The controlled station will be triggered to send all counter information spontaneous via COT=3.

3.1.7 Parameter load procedure

EDP-Energias de Portugal is going to use parameter load in order to remotely change parameters i.e. such as protection settings. Parameters are loaded and activated in two steps. Step 1 is to first load the parameters to the controlled station (ASDU 110-112). Afterwards (step 2) the loaded parameters are activated via an object address specifically defined for this purpose.

The controlling station will send to the controlled station the parameter load command with COT=6. When the controlled station receives the parameter load command, the controlled station first checks if the parameter can be loaded i.e. if the parameter value is in the acceptable range. If all checks have been performed positively, the controlled station will send the parameter load activation confirmation (COT=7). All parameters can thus first be loaded to the controlled station. By doing so the controlling station can verify if all individual loaded parameters can be activated. If all parameters have been sent to the controlled station, and a positive confirmation was received for all parameters the controlling station can decide to activate all previously loaded parameters at the same time. A parameter command (ASDU 110-112) with a specific IOA address will then be sent to the controlled station in order to activate all previously loaded parameters. By sending the parameter load activation confirmation (COT=7) for this object address the controlling station will be informed that all loaded parameters have been activated.

Both the controlling and controlled station can have two parameters values for one object, the actual parameter and the loaded but not yet activated parameter. When sending the parameter load activation confirmation in step 1 the controlled station informs the controlling station that the parameter was successfully loaded. In case the parameter load activation confirmation for the specific object address was received the controlling station knows that the previously loaded parameters in step 1 are successfully activated and are the actual loaded parameter. By using this information¹, the controlling station can keep track of the actual and loaded parameters.

3.1.8 Test procedure

The test command (ASDU 105) is used by EDP-Energias de Portugal to test end-to-end the communication chain. The testcommand is send automatically by the controlling station via a configurable time interval. This time interval should be configurable per controlled station. The time interval should be configurable with a minimum range every minute up to once every 24 hours.

At 30/31 January 2003 TC57 WG03 has decided that the TCS response must match the request. The requesting station may choose any TCS value. The time in the response must exactly match the time in the request.

In case the testcommand fails a message is provided to the operator via the HMI indicating that the testcommand has failed and that the maintenance department should be informed.

¹ Both parameters (step 1 and step 2) in the parameter confirmations shall be sent as soon as they are accepted / changed in the controlled station to the controlling station so the operator is aware of the parameters that he is going to activate in step 2 and/or are activated.

3.1.9 File transfer procedure

As defined in chapter 2 of this PID, the PICS, all file transfer functions in both monitor and control direction are required. File transfer in control direction can be used to send (new) configuration files to the controlled station. An automatic function in the controlled station can then load the new configuration to the RTU. This automatic function is not described in this PID and should be defined per project / vendor.

Please be aware that file transfer via CS104 is required for controlled stations in case no other file transfer method (i.e. FTP) is supported. If other file transfer methods (other than file transfer via CS104 using ASDU 120-126) are available i.e. FTP, then file transfer via CS104 (ASDU 120-126) is not required. Please note that file transfer should have the lowest priority in the CS104 buffer queue.

Note that there will only be one physical interface for CS104 and (if FTP instead of file transfer via CS104 is chosen) FTP. The distinction between CS104 and FTP traffic thus has to be made via TCP portnumbers.

The file transfer by FTP (and not by CS104), via a management port, shall be used.

3.2 Functions

This paragraph contains additional information about functionality that is not necessarily covered by the standard. However, the functions described in this chapter are functions needed within EDP-Energias de Portugal and should thus be implemented as described in this chapter.

3.2.1 General

It may never appear that a CS104 protocol link goes in a stop/halt/abort state as a result of a not correct received or erroneous data-frame/quality flag etc. The device should log the event with additional relevant data in the system event list for maintenance engineers.

In the controlled station it could be integrated a lot of system events. If the system events should be transferred to the controlling station it has to be done with standard ASDUs.

3.2.2 Time tags

Within EDP-Energias de Portugal CS104 events (COT=3, 11 and 12) and commands are always sent with time tag. During the summertime period, EDP-Energias de Portugal uses the summertime. For this reason the summertime bit within the CP56Time2a timetag will be used.

It is the responsibility of the vendor that there will be no mismatch in the time tags (i.e. at summer/wintertime changes, etc.) when displaying time tagged data, exchange time tagged data and storing this time tagged data.

3.2.3 Quality bits

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

3.2.4 Transfer of data from Controlled Station to Controlling Station

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

3.2.5 Event Buffers

The buffer size for CS104 frames is not defined in this PID however it must be configurable. It is required that suppliers of RTU equipment shall clearly indicate in the tender procedure the maximum size of the event buffer.

To prevent consecutive overflow EDP-Energias de Portugal requires from the vendor of the RTU that after a buffer overflow has been sent, the buffer has been empty for at least 50% of its capacity before the next buffer overflow indication will be sent. The RTU vendor shall describe in detail how the system prevents from sending consecutive buffer overflows if the transmission channel has problems.

If a vendor has an other mechanism implemented to prevent sending consecutive buffer overflow indications, it is decided by EDP whether this can be accepted by EDP.

In case a buffer overflow occurs the controlled station should be triggered to send an object, via an IOA address (an event is sent with IOA to ON) that is specifically defined for that purpose, to indicate to the controlling station that a buffer overflow has occurred. When the buffer has been empty for at least 50% of its capacity an event with configured IOA address to OFF will be sent. In addition to the above mentioned, the following rules apply:

- For objects defined as a digital: Delete the newest event.
- For objects configured as a analog: Delete the oldest event.

3.2.6 Security

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

3.3 Addressing

3.3.1 Portnumber

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

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

3.3.2 Common Address of ASDU

The Common Address of ASDU (CAA) is common number used for all objects in one Controlled Station. In the case of EDP-Energias de Portugal, one controlled station will only have one CAA. Since every controlled station only has one CAA the EDP-Energias de Portugal PID104 specifies that the broadcast address for the Common address of ASDU (FFFF) is not used.

3.3.3 Information Object Address

The Information Object Address is a number given to each data point or object within one controlled station.

3.3.4 Addressing rules

All the addresses can be set to any valid number taking into account that: the total address built together by the Common Address of ASDU and Information Object Address shall be a unique identifier for all data points (objects) for every logical link between a controlling- and a controlled station.

3.4 Test requirements

EDP-Energias de Portugal has defined a strict test approach, which is described in document 40630030-Consulting 07-0711 “EDP QA Phase II, Document 2 Suppliers Quality System Demands (ITP)”. This chapter, chapter 3.4 test requirements, describes the specific test criteria for the CS104 data communication interfaces in order to prove that the protocol implementation delivered by the vendors is according to the IEC standards and the EDP-Energias de Portugal PID104.

The test criteria will consist of a:

- Type (conformance) test
- Special (FAT) test
- Commissioning (SAT) test

3.4.1 Type (conformance) Test

EDP-Energias de Portugal requires all CS104 communication interfaces implemented in all delivered equipment to be type (conformance) tested and certified by an independent third party test institute. Protocol type (conformance) testing is the process of verifying that an CS104 implementation performs in accordance with the applicable documents as the IEC standard and the EDP-Energias De Portugal PID104.

A manufacturer may claim: “*my equipment conforms to standard ISO/IEC xxx-x*”. Type (conformance) testing enables such a claim to be investigated and assessed by an objective and independent third party test institute to establish its validity. The below mentioned requirements are applicable:

- An objective and (vendor/supplier) independent third party test and certification institute must perform the type (conformance) test. The test and certification institute will be organized according to the international standard ISO.IEC17025. Besides this standard the test and certification organisation and the test procedures must follow a quality system such as ISO9001: 2000 or a comparable quality system. If requested EDP-Energias de Portugal can supply contact information of at least one independent test and certification institute.
- The type (conformance) test must be performed for all to be delivered types of controlling and controlled station protocol implementations.
- The type (conformance) test will be performed against type (conformance) test plans that, before the conformance test will be performed, need to be approved by EDP-Energias de Portugal. The type (conformance) test plans will be delivered by the third party test and certification institute.
- If necessary a retest must be done. When the test results are according to the requirements the test and certification institute will issue an Attestation of Conformance.
- An Attestation of Conformance remains valid as long as the vendor guarantees that no changes in communication hard- and software have been made that can influence the certified protocol implementation. If changes have been made, a retest is mandatory to update the Attestation of Conformity and to assure conformance.

A paper version of the Attestation of Conformance must be handed over to EDP-Energias de Portugal. The supplier shall also provide the belonging test reports, model numbers, software and firmware references, etc. as necessary, to clearly identify the functionality covered by the protocol implementation. All this documents, information etc. must be handed over prior to the special (FAT) test.

3.4.2 Special (Factory Acceptance Test) Test

The vendor will adopt a flexible and cooperative attitude in order to identify and describe all required tests needed to perform a complete special (FAT) test. The special (FAT) test should be performed in a realistic test environment. The vendor will deliver an inspection test plan (ITP) that describes all tests as proposed by the vendor. It is in the power of EDP-Energias de Portugal to review this ITP and decide if additional tests in the ITP are needed, existing tests need to be re-described and how the test will be organized.

3.4.3 Commissioning (Site Acceptance Test) test

The vendor will adopt a flexible and cooperative attitude in order to identify and describe all required tests needed to perform a complete commissioning (SAT) test. The commissioning (SAT) test should be performed at location of EDP-Energias de Portugal integrated in the EDP-Energias de Portugal (test) environment. The vendor will deliver an inspection test plan (ITP) that describes all tests as proposed by the vendor. It is in the power of EDP-Energias de Portugal to review this ITP and decide if additional tests in the ITP are needed, existing tests need to be re-described and how the test will be organized.