Eskom	Standard	Technology

Title: **ESKOM MASTER DEVICE IEC 60870-5-101 IMPLEMENTATION STANDARD**

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Content

1. Introduction

This document provides an overview and implementation of the IEC 60870-5-101 protocol on an Eskom Master device.

Annex A is the interoperability table for the Eskom implementation of the IEC60870-5-101 protocol that identifies the functional profile for the basic telecontrol tasks to be used in Eskom. The PICS document is normally referenced as PICS 8.x and clause 8 of PICS 8.x is Appendix A in this document.

It should be noted that there is no difference between the Eskom implementation and the IEC 60870-5-101 standard [1].

Annex B explains the use of the bitstring of 32 bit command which is used by Automatic Generation Control to send raise/lower pulses to power stations and embedded generators.

Annex C lists the information object address values for the different ASDUs used on the Eskom system.

Annex D lists additional information.

Annex E is the PIXIT document.

2. Supporting clauses

2.1 Scope

Supplier/Contractor shall reference this document when implementing IEC 60870-5-101 on an Eskom Master device. This document supersedes all prior documents including 32-1101 - TEMSE IEC 60870-5-101 Implementation.

This document defines the following:

- Inter-operability table
- Information object address values for use for the different ASDUs and address structure
- Implementation requirements
- Automatic Generation Control Implementation

2.1.1 Purpose

The purpose of this document is to provide users with an indication of which ASDUs, in the IEC 60870-5-101 protocol suite, to use on an Eskom Master device.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] IEC 60870 – TELECONTROL EQUIPMENT AND SYSTEMS – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks – BS EN 60870-5-101:2003+A1:2016

[2] IEC 60870 – TELECONTROL EQUIPMENT AND SYSTEMS – Part 5-601: Conformance Test cases for the IEC 60870-5-101 companion standard – First edition – 2006-06.

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Master device	Master device refers to a device that communicates to a slave device such as a RTU, DCS or gateway.
Power station SCADA or DCS	Power station SCADA or DCS refers to a group of power station unit controllers, balance of plant controllers, HMI and historian systems to form a unified power station control system controlling all unit and non-unit based plant. This includes the remote communication equipment required to interface to NCC and SCC
Slave device / Remote Terminal Equipment	The slave device/remote terminal equipment refers to any of the following remote devices, such as a RTU, DCS or gateway.
Unit Controller	The unit controller is an autonomous automation equipment that is responsible for the open and closed loop control of a power station generating unit, ancillary and auxiliary systems. The unit controller can be used to control individual units or as a joint unit controller for multiple units

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
AGC	Automatic Generation Control
ASDU	Application Service Data Units
DCS	Distributed Control System
EMS	Energy Management System
GPS	Global Positioning System
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardisation
LPDU	Logical Processing Data Unit
NCC	National Control Centre
OSI	Open Systems Interconnect
PICS	Protocol Implementation Conformation Statement
PIXIT	Protocol Implementation eXtra Information for Testing
PLC	Programmable Logic Controller
RTU	Remote Terminal Unit
STABNAC	Standby National Control Centre

2.5 Roles and responsibilities

Not applicable.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

Not applicable.

3. Requirements

This standard is to be used as the basis for implementing the Application Service Data Units (ASDUs) as listed in Appendix A of this document.

It is essential that all defined ASDUs are implemented and tested to ensure that any future changes at the slave device shall be able to accommodate any or all of the specified ASDU messages should it be necessary in future.

The behaviour for each ASDU is defined in reference [1].

3.1 Adherence to protocol implementation

The Supplier/Contractor shall implement the IEC 60870-5-101 protocol as specified in Annex A - Interoperability table for the Eskom implementation of the IEC60870-5-101 protocol, on the equipment provided.

The services offered by each layer and the manner in which these services are specified, shall be adhered to as specified in the protocol implementation.

The IEC60870-5-101 protocol implementation on the Master device shall be tested against the Eskom slave device to ensure interoperability and compatibility.

The implementation of the IEC 60870-5-101 protocol on the Master device shall comply with the Master device implementation as described in Annex A of this document.

3.2 Automatic Generation Control

Eskom requires the unit output of individual units at a multi-unit power station on Automatic Generation Control to be raised or lowered at the same time. Eskom may choose to implement one of the three solutions when dispatching generating units, namely:

1) Standard bitstring of 32 bit command to deliver a maximum of 16 simultaneous raise or lower signals to the power station control system, which in turn delivers the respective raise or lower signal to each of the units at a power station.

2) Standard bitstring of 32 bit command to deliver a single raise or lower signal to the power station control system and in turn to the power station joint unit controller which changes or modifies the overall power station output.

3) Set-point command, which is sent to the power station joint unit controller, to change or modify the overall power station output.

The implementation of the *bitstring of 32 bit* command is defined in more detail in Annex B.

3.3 Testing

All tests as listed in Tables 1 to 32 of reference [2] shall be performed for ASDUs listed in Annex A.

The results of the tests shall be documented in Tables 33 to 37 of reference [2] and shall be provided to Eskom at least 6 weeks prior to the start of the factory acceptance testing.

Protocol message logs captured by a protocol analyser, in both hexadecimal and decoded format, for the tests listed in Tables 1 to 32 of reference [2], should be sent to Eskom. These logs shall be used to confirm the contents of test results listed in Tables 33 to 37 of reference [2].

It is recommended that as soon as the test results are available, these should be forwarded to Eskom for analysis. This is to allow for verification of the performance and accuracy of the implemented functionality prior to commencement of FAT.

4. Authorization

This document has been seen and accepted by:

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5. Revisions

Date	Rev	Compiler	Remarks
June 2021	2	D Gojela	Updated AGC cycle time
April 2014	1	D Gojela	First Release

6. Development team

The following people were involved in the development of this document:

- Dumisani Gojela
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7. Acknowledgements

Not applicable.

Annex A – Interoperability Table for the Eskom Implementation of IEC 60870-5-101

This interoperability table identifies the functional profile for the basic telecontrol tasks in the IEC60870-5-101 protocol for use on an Eskom Master device.

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 [1] 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

1) System device

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

- ☐ System definition
- X Controlling station definition (master)
- ☐ Controlled station definition (slave)

2) Network Configuration

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

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

3) Physical Layer

(network-specific parameter, all interfaces and data rates that are used are to be marked with an “X”)

Transmission speed (control direction)

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

4) Link Layer

(network-specific parameter, all options that are used are to be marked with an “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 procedures

- [ ] Balanced transmission
- [X] Unbalanced transmission

Address

- [ ] Not present (balanced transmission only)
- [X] One octect
- [X] Two octect
- [X] Unstructured
- [X] Structured

5) Frame Length

255 Maximum length (monitor direction)

5 Maximum length (control direction)

Time during which repetitions are permitted (Trp) or number of repetitions

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
5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 32, 33, 34, 35, 36, 37, 38	<3>

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.

6) 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 with an "**X**")

X One octet

X Two octets

Information object address

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

[X]	One octet	[X]	Structured
[X]	Two octets	[X]	Unstructured
[X]	Three octets		

Cause of transmission

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

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

7) Selection of Standard ASDUs

Process information in monitor direction

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

[X]	<1> := Single-point information	M_SP_NA_1
[X]	<2> := Single-point information with time tag	M_SP_TA_1
[X]	<3> := Double-point information	M_DP_NA_1
[X]	<4> := Double-point information with time tag	M_DP_TA_1
[X]	<5> := Step position information	M_ST_NA_1
[X]	<6> := Step position information with time tag	M_ST_TA_1
[X]	<7> := Bitstring of 32 bit	M_BO_NA_1
[X]	<8> := Bitstring of 32 bit with time tag	M_BO_TA_1
[X]	<9> := Measured value, normalized value	M_ME_NA_1
[X]	<10> := Measured value, normalized value with time tag	M_ME_TA_1
[X]	<11> := Measured value, scaled value	M_ME_NB_1
[X]	<12> := Measured value, scaled value with time tag	M_ME_TB_1
[X]	<13> := Measured value, short floating point value	M_ME_NC_1
[X]	<14> := Measured value, short floating point value with time tag	M_ME_TC_1
[X]	<15> := Integrated totals	M_IT_NA_1
[X]	<16> := Integrated totals with time (*time is received, but isn't used by SCADA)	M_IT_TA_1
[X]	<17> := Event of protection equipment with time tag	M_EP_TA_1

[X]	<18> := Packed start events of protection equipment with time tag	M_EP_TB_1
[X]	<19> := Packed output circuit information of protection equipment with time tag	M_EP_TC_1
[X]	<20> := Packed single-point information with status change detection	M_PS_NA_1
[X]	<21> := Measured value, normalized value without quality descriptor	M_ME_ND_1
[X]	<30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
[X]	<31> := Double-point information with time tag CP56Time2a	M_DP_TB_1
[X]	<32> := Step position information with time tag CP56Time2a	M_ST_TB_1
[X]	<33> := Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
[X]	<34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
[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
[X]	<37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
[X]	<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

Process information in control direction

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

[X]	<45> := Single command	C_SC_NA_1
[X]	<46> := Double command	C_DC_NA_1
[X]	<47> := Regulating step command	C_RC_NA_1
[X]	<48> := Set point command, normalized value	C_SE_NA_1
[X]	<49> := Set point command, scaled value	C_SE_NB_1
[X]	<50> := Set point command, short floating point value	C_SE_NC_1
[X]	<51> := Bitstring of 32 bit	C_BO_NA_1

System information in monitor direction

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

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

System information in control direction

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

[X]	<100> := Interrogation command	C_IC_NA_1
[X]	<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
[X]	<106> := Delay acquisition command	C_CD_NA_1

Parameter in control direction

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

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

File transfer

(Station-specific parameter, mark each type ID 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)

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

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

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
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						X	X			X						X	X	X	X
<46>	C_DC_NA_1						X	X			X						X	X	X	X
<47>	C_RC_NA_1						X	X			X						X	X	X	X
<48>	C_SE_NA_1						X	X			X						X	X	X	X
<49>	C_SE_NB_1						X	X			X						X	X	X	X
<50>	C_SE_NC_1						X	X			X						X	X	X	X
<51>	C_BO_NA_1						X	X			X						X	X	X	X
<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																X	X	X	X
<103>	C_CS_NA_1			X			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						X	X									X	X	X	X
<110>	P_ME_NA_1						X	X							X		X	X	X	X
<111>	P_ME_NB_1						X	X							X		X	X	X	X
<112>	P_ME_NC_1						X	X							X		X	X	X	X
<113>	P_AC_NA_1						X	X	X	X							X	X	X	X
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1a)																			

[a)] Blank or X only.

9) Basic Application Function

Station initialization

(Station-specific parameter, mark with an "**X**" if function is used)

[X] Remote initialization

Cyclic data transmission

(Station-specific parameter, mark with an "**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 with an "**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 with an "**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 with an "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 [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_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 with an "**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
- [X] group 1
- [X] group 2
- [X] group 3
- [X] group 4
- [X] group 5
- [X] group 6
- [X] group 7
- [X] group 8
- [X] group 9
- [X] group 10
- [X] group 11
- [X] group 12
- [X] group 13
- [X] group 14
- [X] group 15
- [X] group 16

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

Clock synchronization

(Station-specific parameter, mark with an "**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
- [ ] Day of week used
- [ ] RES1, GEN (time tag substituted/ not substituted) used
- [ ] SU-bit (summertime) used

Command transmission

(Object-specific parameter, mark with an "**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 transmission
- [X] Direct set point command transmission
- [X] Select and execute command
- [X] Select and execute set point command
- [ ] C_SE ACTTERM used
- [X] No additional definition
- [X] Short-pulse duration (duration determined by a system parameter in the controlled station)
- [X] Long-pulse duration (duration determined by a system parameter in the controlled station)
- [X] Persistent output

Transmission of integrated totals

(Station- or object-specific parameter, mark with an "**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 transmission
- [X] Mode B: local freeze with counter interrogation
- [X] Mode C: freeze and transmit by counter interrogation commands
- [ ] Mode D: freeze by counter-interrogation command, frozen values reported spontaneously
- [X] Counter read
- [X] Counter freeze without reset
- [X] Counter freeze with reset
- [ ] Counter reset
- [X] General request counter
- [X] Request counter group 1
- [X] Request counter group 2
- [X] Request counter group 3
- [X] Request counter group 4

Parameter loading

(Object-specific parameter, mark with an "**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

Parameter activation

(Object-specific parameter, mark with an "**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

Test procedure

(Station-specific parameter, mark with an "**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 procedure

File transfer

(Station-specific parameter, mark with an "**X**" if function is used)

File transfer in monitor direction

☐ Transparent file

☐ 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 with an "**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

Acquisition of transmission delay

(Station-specific parameter, mark with an "**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

Annex B – Eskom Bitstring Implementation

1) IEC 60870-5-101 Protocol Implementation AGC

The implementation of AGC is only applicable to Transmission master stations.

Background

It is a prerequisite that the IEC 60870-5-101 communication protocol be implemented on the Remote Terminal Unit (RTU), gateway or Distributed Control System (DCS) to enable communication between the Eskom Master device (Eskom Master Station) and the power station.

The options available to change the output of the units at the power station are:

1) A raise/lower command sent to a single power station joint unit controller using bitstring of 32 bit command.

2) A raise/lower command sent to address individual unit controllers using bitstring of 32 bit command.

3) A setpoint command sent to a single power station joint unit controller.

The unit output of individual units at a multi-unit power station shall be raised or lowered at the same time.

The solution is to combine all the individual changes into a single command. The command used is the bitstring of 32 bit with a pair of bits allocated to each unit in sequence or the power station joint unit controller, with a 01 being a raise and a 10 being a lower. This provides the ability to raise or lower up to 16 units at the same time for the option of individual unit controllers. If no change is required, the corresponding pair of bits has the value 00.

The Eskom Master Station AGC program is implemented using the raise/lower commands for both single and multi-unit power stations. When AGC is implemented using raise/lower commands to a joint unit controller, only the first pair of bits in the 32 bit string is used. The power station joint unit controller decides how the single raise or lower signal, received from Eskom Master Station, should be dispatched among the units under its control.

For power stations that use the individual unit raise/lower commands, the *bitstring of 32 bit* command is sent to the power station Remote Terminal Equipment for decoding and from there the individual unit raise/lower commands are sent to the unit controller for implementation.

On the Eskom Master Station raise/lower commands are implemented via the C_BO_NA_1 *bitstring of 32 bit* ASDU.

Operation

When the *bitstring of 32 bit* command is used by an RTU, a pulse which is a relay output with a pulse width of 1 second shall either raise or lower the power station's or unit's capacity by the contracted amount. The unit controller shall be configured to interpret the number of megawatts per pulse and the unit setpoint is adjusted appropriately.

Where the *bitstring of 32 bit* command is received directly by a DCS, the DCS shall dispatch the raise/lower commands to the individual unit controllers or the power station joint unit controller.

Where the *bitstring of 32* bit command is received by a RTU, the RTU may interface to the DCS via hardwired pulsed relay outputs.

A maximum of 16 unit controllers are addressed using two adjacent pairs of bits in the *bitstring of 32* bit command as shown in Figure B.1.

The following criterion applies to the use of the command:

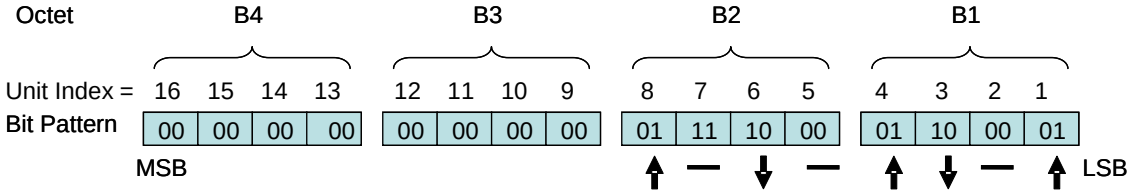

Figure B.1: Structure of *bitstring of 32bit* command

- Odd bits are used for the raise action and even bits for a lower action.
- Every bit that has a value of 1 in the bitstring of 32 bit command shall activate an output, except if both bits have a value of 0 or 1 in the bit pair. If both bits have a value of 0 in the bit pair, no raise or lower command shall be executed for that particular unit. If both bits have a value of 1 in the bit pair, then the RTU or DCS shall treat the bit pair as invalid and no raise or lower command shall be executed for that particular unit.
- If an RTU is used, in order to allow faster processing of the command, the RTU shall not require the "Select and execute command" procedure, but shall operate with the "Direct command" procedure.
- If the bitstring of 32 bit command is received directly by the DCS, then the DCS must process this bitstring of 32 bit command in isolation i.e. without any reference to any previous bitstring of 32 bit command received. For example, if the values of bits in a bit pair is identical in two consecutive bitstring of 32 bit command messages, then the DCS should process them as two separate raise or lower commands to the corresponding unit.
- The following describes the unit layout per octet:
  - Octet B1 addresses units 1 – 4 where unit 1 is the least significant bit pair in the octet.
  - Octet B2 addresses units 5 – 8 where unit 5 is the least significant bit pair in the octet.
  - Octet B3 addresses units 9 – 12 where unit 9 is the least significant bit pair in the octet.
  - Octet B4 addresses units 13 – 16 where unit 13 is the least significant bit pair in the octet.
- In terms of the Information Object Address values, an object with an Information Object Address of 43001 shall address the first 16 units and 43017 shall address the next 16 units.

2) Examples

Scenario 1: AGC addresses all units at the power station, the RTU or DCS receives the following commands and sends them to the respective units.

Example 1:

Command	Hex	Binary	Operation
1	83 01 A4 84	10 00 01 00(LSB) 10 10 01 00 00 00 00 01 10 00 00 11	Raise unit 2, lower unit 4 raise unit 6, lower unit 7, lower unit 8, raise unit 9, and lower unit 16. **Note: Invalid bit pair 13 results in no operation**
2	82 05 24 14	00 01 01 00(LSB) 00 10 01 00 00 00 01 01 10 00 00 10	Raise unit 2, raise unit 3, raise unit 6, lower unit 7, raise unit 9, raise unit 10, lower unit 13 and lower unit 16

Scenario 2: AGC sends the raise/lower command to the station joint unit controller which controls all the units at a station. The result is that the joint unit controller translates the pulse to a corresponding station MW requirement.

Example 2:

Command	Hex	Binary	Operation
1	00 03 00 01	00 00 00 01(LSB) 00 00 00 00 00 00 00 11 00 00 00 00	Raise output at station level **Invalid bit pair 9 results in no operation**
2	03 00 00 01	00 00 00 01(LSB) 00 00 00 00 00 00 00 00 00 00 00 11	Raise output at station level **Note: Invalid bit pair 13 results in no operation**
3	00 0F 00 02	00 00 00 10(LSB) 00 00 00 00 00 00 11 11 00 00 00 00	Lower output at the station level **Note: Invalid bit pairs 9 and 10 results in no operation**

3) Performance Requirements for AGC

The following performance requirements shall be met for AGC:

1) AGC commands for up to 16 units shall be accepted and processed by the RTU, Gateway or DCS such that a setpoint change on the Plant/Unit Control System is completed and the AGC setpoint feedback is received by Eskom Master Station within 2 seconds from when the command is sent from Eskom Master Station. This implies that the change should be completed before the next AGC command is sent.

2) In order to meet the aforementioned 2 second AGC cycle time requirement, the various components in the system are allocated a maximum time frame for communication and information update:

- 1 second is the maximum time allocated for communication between the RTU/Gateway/DCS and SCADA Master station, processing of information at the SCADA Master Station and telecommunication latency and is denoted as T_M; and
- 1 second is the maximum time allocated for all the communication and processing of information between the RTU/Gateway/DCS and the Plant/Unit Control System and is denoted as T_D,

as indicated in Figure B.2 below.

Notes:

1) AGC command could be either 32 bitstring command or setpoint command.

2) The following ASDUs should be used:

- ASDU 48 – 50 for setpoint command
- ASDU 51 for 32 bitstring command

3) T_M = AGC command sent from Eskom Master Station and received by RTU/Gateway/DCS + AGC setpoint feedback message leaving the RTU/Gateway/DCS and received by the Eskom Master Station + telecommunications latency.

4) TD = Processing of the AGC command message at RTU/Gateway/DCS + message sent to Plant/Unit Control System for processing + AGC setpoint feedback sent from output of plant for the associated setpoint command received from RTU/Gateway/DCS + AGC setpoint feedback processed at the RTU/Gateway/DCS to be sent to the Eskom Master Station.

5) Each of the various time components in TM and TD above may include multiple protocol messages, e.g. a minimum of 3 IEC 60870-5-101 messages transmitted from Eskom Master Station and 3 replies from the RTU/Gateway/DCS for a single setpoint command execution. Messages will then be sent from Eskom Master Station to the RTU/Gateway/DCS until the setpoint feedback is received, hence all these messages must be included in the 2 seconds.

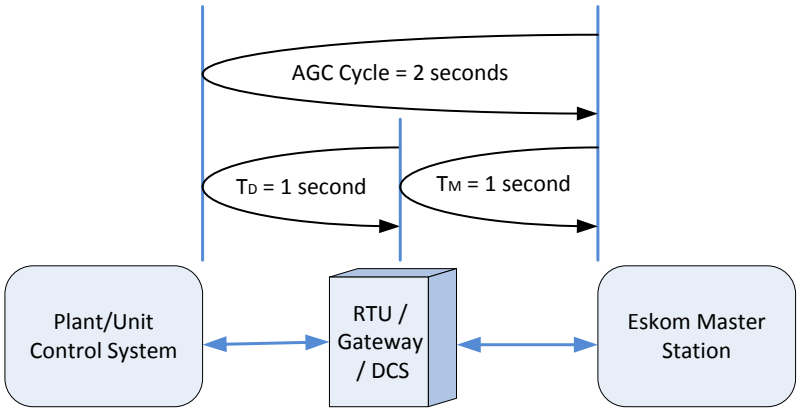

Figure B.2: AGC cycle time

Annex C – Information Object Address Values

This appendix lists the Information Object Address values for the different ASDUs and address structure used on the Eskom Master Device

1) Eskom ASDU information object values

IEC ASDU	Information Object Address Range
Single point information	1 to 10 000
Double point information	10 001 to 15 000
Step position information	15 001 to 20 000
Measured value	20 001 to 25 000
Integrated totals	25 001 to 30 000
Single command	30 001 to 35 000
Double command	35 001 to 40 000
Bitstring of 32 bit command (lamp drive outputs)	40 001 to 43 000
Bitstring of 32 bit command (AGC outputs)	43001 to 45 000
Set-point command (meter drive outputs)	45 001 to X
Set-point command (set-point outputs)	(X+1) to 65 355

Notes:

1) Bitstring of 32 bit commands for AGC are fixed to start at address 43 001

2) If no meter drives are present then set-point commands start at address 45 001.

2) Eskom Address Structure

Field	Length in octets
Type identification	1
Variable structure qualifier	1
Link address	1
Cause of transmission	1
Common address of ASDU	2
Information object address	2

Annex D – Additional Information

This appendix outlines additional information.

1) Deadband Filtering

All measured values should have deadband filtering to minimise traffic on the communication medium and must be user configurable to meet the master station operation requirements.

2) Clock Synchronisation

If the Remote Terminal Equipment is unable to be time synchronised by the local GPS due to the failure of the local GPS, then Remote Terminal Equipment must be synchronised by the Eskom Master device.

3) Classes of Data

Table 1 below indicates the assignment of ASDUs to Class 1 and Class 2 messages.

Table D.1: Assignment of ASDUs

	Type Identification
Class 1	1,2,3,4,30,31
Class 2	5,6,7,8,9,10,11,12,13,14,15,16,21,32,33,34,35,36,37,38

Annex E – PIXIT Document

The Protocol Implementation eXtra Information for Testing (PIXIT) document, states the extra information needed for testing as defined in Clause 5 of IEC TS 60870-5-601.

Table E.1: Configuration Parameter Values

Test No.	Test	Description	Reference	Required
5.2.1.61	Special Assignment of class 2 messages	Not required	IEC 60870-5-101, 6.2, 7.4.2	No
5.2.1.121	Address field of the Link	Structured	IEC 60870-5-2, 5.1.3, 6.1.3	No
5.2.1.131	Information Object Address	Structured	IEC 60870-5-101, 7.2.5	Yes

Table E.2: Verification of Link Layer

Test No.	Test	Description	Reference	Required
5.3.3.10	FT1.2 Frame Format (Single, Fixed and Variable)	Use of the Single control character or frames with fixed length should be selectable. Default is fixed length	IEC 60870-5-1, 6.2.4.2	Yes
5.3.3.61	Unbalanced Transmission Procedure	Service S1 – Send/No Reply	IEC 60870-5-2, 4.1	Yes
5.3.3.64		Primary F-CODE 0: answered with Secondary F-Code 0,1,14,15	IEC 60870-5-2, 4.2.2, 5.1.2	Yes
5.3.3.65		Primary F-CODE 1: answered with Secondary F-Code 0,1,14,15	IEC 60870-5-2, 4.2.2, 5.1.2	Yes
5.3.3.66		Primary F-CODE 3: answered with Secondary F-Code 0,1,14,15	IEC 60870-5-2, 4.2.2, 5.1.2	Yes
5.3.3.67		Primary F-CODE 4: answered with Secondary F-Code 0,1,14,15	IEC 60870-5-2, 4.2.2, 5.1.2	Yes
5.3.3.68		Primary F-CODE 8: answered with Secondary F-Code 0,1,14,15	IEC 60870-5-2, 4.2.2, 5.1.2	Yes
5.3.3.61	Unbalanced Transmission Procedure	Service S1 – Send/No Reply	IEC 60870-5-2, 4.1	Yes
5.3.3.69		Primary F-CODE 9: answered with Secondary F-Code 0,1,14,15	IEC 60870-5-2, 4.2.2, 5.1.2	Yes
5.3.3.70		Primary F-CODE 10: answered with Secondary F-Code 0,1,14,15	IEC 60870-5-2, 4.2.2, 5.1.2	Yes
5.3.3.71		Primary F-CODE 11: answered with Secondary F-Code 0,1,14,15	IEC 60870-5-2, 4.2.2, 5.1.2	Yes
5.3.3.80	Balanced Transmission Procedure	Not required		No
5.3.3.100	Time Out Interval	To = 1 second @ 9600, To = 0.5 second @ 19200		Yes
5.3.3.101		Retries = 5		Yes

Table E.3: Verification of the Data Unit Identifier

Test No.	Test	Description	Reference	Required
5.3.4.11	Variable Structure Qualifier	SQ: = 1 only for COT Spontaneous (3), Cyclic/Periodic, Requested (5), or Interrogation (20…36). Check the PICS for the supported COT values. Make sure SQ = 1 is only used for ASDU types that admit sequential packing.	IEC 60870-5-101, 7.2.2	Yes
5.3.4.21	Cause of Transmission	Originator address identifies source application of Primary station	IEC 60870-5-101, 7.2.3	No
5.3.4.26		Test bit = 1: ASDU generated during test conditions	IEC 60870-5-101, 7.2.3	Yes

Table E.4: Verification of ASDUs for Process Information in Monitor (Normal) direction

Test No.	Test	Description	Reference	Required
5.3.6.11	M_SP_NA_1 ASDU 1 Single Point Information	SIQ with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 from this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.1	Yes
5.3.6.15	SIQ	BL = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.16		SB = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.17		NT = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.34	SIQ	BL = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.35		SB = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.36		NT = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.51	M_DP_NA_1 ASDU 3 Double Point Information	DIQ with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 form this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.3	Yes
5.3.6.55		SB = 0,1	IEC 60870-5-101, 7.2.6.2	Yes
5.3.6.56		NT = 0,1	IEC 60870-5-101, 7.2.6.2	Yes
5.3.6.70	M_DP_NA_1 ASDU 4 Double Point Information with time tag			

Table E.4 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.6.74	DIQ	BL = 0,1	IEC 60870-5-101, 7.2.6.2	Yes
5.3.6.75		SB = 0,1	IEC 60870-5-101, 7.2.6.2	Yes
5.3.6.76		NT = 0,1	IEC 60870-5-101, 7.2.6.2	Yes
5.3.6.91	M_ST_NA_1 ASDU 5 Step-position Information	VTI with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 form this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.5	Yes
5.3.6.96	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.97		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.98		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.115	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.116		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.117		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.131	M_BO_NA_1 ASDU 7 Bitstring of 32 bit	BSI with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 form this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.7	Yes
5.3.6.135	BSI	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.136		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.137			IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.150	M_BO_TA_1 ASDU 8 Bitstring of 32 bit with time tag	BSI with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 from this offset (see IEC 60870-5-101, 7.2.2.1)		
5.3.6.154	BSI	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.155		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.156		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes

Table E.4 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.6.191	M_ME_TA_1 ASDU 10 Measured value, normalised value with time tag!	NVA with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 from this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.10	Yes
5.3.6.192	NVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.6	Yes
5.3.6.195		BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.196		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.197		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.211	M_ME_NB_1 ASDU 11 Measured value, scaled value	SVA with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 from this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.11	Yes
5.3.6.213	SVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.7	Yes
5.3.6.216	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.217		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.218		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.230	M_ME_TB_1 ASDU 12 Measured value, scaled value with time tag!			
5.3.6.232	SVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.7	Yes
5.3.6.235	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.236		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.237		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.251	M_ME_NC_1 ASDU 13 Measured value, short floating point number	IEEE STD 754 with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 from this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.13	Yes

Table E.4 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.6.257	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.258		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.259		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.270	M_ME_TC_1 ASDU 14 Measured value, short floating point number with time tag			
5.3.6.276	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.277		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.278		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.301	M_ME_NC_1 ASDU 15 Integrated totals	BCR with SQ = 1, with only IOA of the first element and the following Information Elements are identified by numbers incrementing continuously by +1 from this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.15	Yes
5.3.6.340	M_EP_TA_1 ASDU 17 Event of protection equipment with time-tag			
5.3.6.343	SEP	ES =0,1	IEC 60870-5-101, 7.2.6.10	Yes
5.3.6.344	SEP	RES =0	IEC 60870-5-101, 7.2.6.10	Yes
5.3.6.345	SEP	BL = 0,1	IEC 60870-5-101, 7.2.6.10	Yes
5.3.6.346	SEP	SB = 0,1	IEC 60870-5-101, 7.2.6.10	Yes
5.3.6.347	SEP	NT = 0,1	IEC 60870-5-101, 7.2.6.10	Yes
5.3.6.363	SPE	GS = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.364	SPE	SL1 = 0,1	IEC 60870-5-101, 7.2.6.11	Yes

Table E.4 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.6.340	M_EP_TA_1 ASDU 17 Event of protection equipment with time-tag			
5.3.6.366	SPE	SL3 = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.367	SPE	SIE = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.368	SPE	SRD = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.369	QDP	EI = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.370	QDP	BL = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.371	QDP	SB = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.372	QDP	NT = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.373	QDP	EI = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.421	M_MPS_NA_1 ASDU 20 Packet single-point information with status change detection	SCD with SQ = 1, with only the IOA of the first element and the following information. Elements are identified by numbers incrementing continuously by +1 from this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.20	Yes
5.3.6.423	SCD	STi = 0,1	IEC 60870-5-101, 7.2.6.40	Yes
5.3.6.424	SCD	CDi = 0,1	IEC 60870-5-101, 7.2.6.40	Yes
5.3.6.427	QDS	SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.428	QDS	NT = 0,1	IEC 60870-5-101, 7.3.1.20	Yes
5.3.6.441	M_ME_ND_1 ASDU 21 Measured value, normalised value without quality descriptor	NVA with SQ = 1, with only the IOA of the first element and the following information. Elements are identified by numbers incrementing continuously by +1 from this offset (see IEC 60870-5-101, 7.2.2.1)	IEC 60870-5-101, 7.3.1.21	Yes
5.3.6.443	NVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.6	Yes

Table E.4 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.6.450	M_SP_TB_1 ASDU 30 Single-point information with time tag CP56Time2a			
5.3.6.454	SIQ	BL = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.455		SB = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.456		NT = 0,1	IEC 60870-5-101, 7.2.6.1	Yes
5.3.6.480	M_DP_TB_1 ASDU 31 Double-point information with time tag CP56Time2a			
5.3.6.484	DIQ	BL = 0,1	IEC 60870-5-101, 7.2.6.2	Yes
5.3.6.485		SB = 0,1	IEC 60870-5-101, 7.2.6.2	Yes
5.3.6.486		NT = 0,1	IEC 60870-5-101, 7.2.6.2	Yes
5.3.6.510	M_ST_TB_1 ASDU 32 Step-position information with time-tag CP56Time2a			
5.3.6.515	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.516		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.517		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.540	M_BO_TB_1 ASDU 33 Bitstring of 32 bit with time-tag CP56Time2a			
5.3.6.544	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.545		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.546		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes

Table E.4 (*continued*)

5.3.6.571	M_ME_TD_1 ASDU 34 Measured value, normalised value with time-tag CP56Time2a			
5.3.6.572	NVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.6	Yes
5.3.6.575	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.576	QDS	SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.577	QDS	NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.600	M_ME_TE_1 ASDU 35 Measured value, scaled value with time-tag CP56Time2a			
5.3.6.602	SVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.7	Yes
5.3.6.605	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.606		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.607		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.630	M_ME_TF_1 ASDU 36 Measured value, short floating point number with time-tag CP56Time2a			
5.3.6.636	QDS	BL = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.637		SB = 0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.638		NT = 0,1	IEC 60870-5-101, 7.2.6.3	Yes

Table E.4 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.6.690	M_EP_TD_1 ASDU 38 Event of protection equipment with time-tag CP56Time2a			
5.3.6.692	SEP	ES =0,1	IEC 60870-5-101, 7.2.6.3	Yes
5.3.6.694	SEP	BL = 0,1	IEC 60870-5-101, 7.2.6.10	Yes
5.3.6.695	SEP	SB = 0,1	IEC 60870-5-101, 7.2.6.10	Yes
5.3.6.696	SEP	NT = 0,1	IEC 60870-5-101, 7.2.6.10	Yes
5.3.6.720	M_EP_TE_1 ASDU 39 Packed start events of protection equipment with time-tag CP56Time2a			No
5.3.6.722	SPE	GS = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.723	SPE	SL1 = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.724	SPE	SL2 = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.725	SPE	SL3 = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.726	SPE	SIE = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.727	SPE	SRD = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.730	QDP	BL = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.731	QDP	SB = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.732	QDP	NT = 0,1	IEC 60870-5-101, 7.2.6.4	Yes

Table E.4 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.6.734	QDP	EI = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.360	M_EP_TF_1 ASDU 40 Packed start events of protection equipment with time-tag CP56TIME2A			No
5.3.6.762	OCI	GC = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.763	OCI	CL1 = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.764	OCI	CL2 = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.765	OCI	CL3 = 0,1	IEC 60870-5-101, 7.2.6.11	Yes
5.3.6.768	QPD	BL = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.769	QPD	SB = 0,1	IEC 60870-5-101, 7.2.6.4	Yes
5.3.6.770	QPD	NT = 0,1	IEC 60870-5-101, 7.2.6.4	Yes

Table E.5: Verification of ASDUs for Process Information in Control (Normal) direction

Test No.	Test	Description	Reference	Required
5.3.7.1	C_SC_NA_1 ASDU 45 Single Command			
5.3.7.5	SCO	QU = 4 to 8, 9 to 15, 16 to 31	IEC 60870-5-101, 7.2.6.26	Reserved ranges
5.3.7.6		S/E = 0,1	IEC 60870-5-101, 7.2.6.26	Yes
5.3.7.10	C_DC_NA_1 ASDU 46 Double Command			
5.3.7.13	DCO	QU = 4 to 8, 9 to 15, 16 to 31	IEC 60870-5-101, 7.2.6.26	Reserved ranges
5.3.7.14		S/E = 0,1	IEC 60870-5-101, 7.2.6.26	Yes

Table E.5 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.7.23	RCO	QU = 4 to 8, 9 to 15, 16 to 31	IEC 60870-5-101, 7.2.6.26	Reserved ranges
5.3.7.24		S/E = 0,1	IEC 60870-5-101, 7.2.6.26	Yes
5.3.7.31	NVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.6	Yes
5.3.7.33	QOS	QL = 0, 1…63 or 64…127	IEC 60870-5-101, 7.2.6.39	Reserved ranges
5.3.7.34		S/E = 0,1	IEC 60870-5-101, 7.2.6.39	Yes
5.3.7.40	C_SE_NB_1 ASDU 49 Set point command Scaled value			
5.3.7.41	SVA	Value (with scaling factor)	IEC 60870-5-101, 7.2.6.7	Yes
5.3.7.43	QOS	QL = 0, 1…63 or 64…127	IEC 60870-5-101, 7.2.6.39	Reserved ranges
5.3.7.44		S/E = 0,1	IEC 60870-5-101, 7.2.6.39	Yes
5.3.7.50	C_SE_NC_1 ASDU 50 Set point command, short floating point value			
5.3.7.54	QOS	QL = 0, 1…63 or 64…127	IEC 60870-5-101, 7.2.6.39	Reserved ranges
5.3.7.55		S/E = 0,1	IEC 60870-5-101, 7.2.6.39	Yes
5.3.7.60	C_BO_NA_1 ASDU 51 Bitstring of 32 bits	Also refer to Appendix A		Yes

Table E.6: Verification of ASDUs for System Information in Monitor (Normal) direction

Test No.	Test	Description	Reference	Required
5.3.8.1	M_EI_NA_1 ASDU 70 End of initialisation			
5.3.8.3	QOS	UI = 0, 1, 2, 3-31 or 32-127	IEC 60870-5-101, 7.2.6.21	Reserved ranges
5.3.8.4		BS = 0,1	IEC 60870-5-101, 7.2.6.21	Yes

Table E.7: Verification of ASDUs for System Information in Control (Normal) direction

Test No.	Test	Description	Reference	Required
5.3.9.1	C_IC_NA_1 ASDU 100 Interrogation command			
5.3.9.3	QOI	QOI = 1…19 or 20…36 or 37…63 or 64…255 20 is the default	IEC 60870-5-101, 7.2.6.22	0,1…19 or 37…63 or 64…255 Reserved ranges
5.3.9.60	C_RP_NA_1 ASDU 105 Reset Process command			
5.3.9.62	QRPI	QRP = 1,2 (zero is not permitted)	IEC 60870-5-101, 7.2.6.27	Yes

Table E.8: Verification of ASDUs for Parameters in Control (Normal) direction

Test No.	Test	Description	Reference	Required
5.3.10.1	P_ME_NA_1 ASDU110 Parameter of measured value, normalised value			
5.3.10.2	NVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.6	Yes
5.3.10.4	QPM	KAP = 0-4	IEC 60870-5-101, 7.2.6.24	Yes
5.3.10.5	QPM	LPC = 0,1	IEC 60870-5-101, 7.2.6.24	Yes
5.3.10.11	P_ME_NB_1 ASDU111 Parameter of measured value, scaled value			
5.3.10.11	SVA	Value (translation considering the scaling factor)	IEC 60870-5-101, 7.2.6.7	Yes
5.3.10.13	QPM	KAP = 0-4	IEC 60870-5-101, 7.2.6.24	Yes
5.3.10.14	QPM	LPC = 0,1	IEC 60870-5-101, 7.2.6.24	Yes
5.3.10.15	QPM	POP = 0,1	IEC 60870-5-101, 7.2.6.24	Yes

Table E.8 (*continued*)

Test No.	Test	Description	Reference	Required
5.3.10.20	P_ME_NC_1 ASDU112 Parameter of measured value, scaled value			
5.3.10.24	QPM	KAP = 0-4	IEC 60870-5-101, 7.2.6.24	Yes
5.3.10.25	QPM	LPC = 0,1	IEC 60870-5-101, 7.2.6.24	Yes
5.3.10.26	QPM	POP = 0,1	IEC 60870-5-101, 7.2.6.24	Yes
5.3.10.30	P_ME_ND_1 ASDU113 Parameter of measured value, scaled value			
5.3.10.31	QPA	QPA =3(other values not permitted)	IEC 60870-5-101, 7.2.6.25	Yes

Conformance Test Procedures

Table E.9: Data Unit Conformance Test Procedure

Test No.	Test	Description	Reference	Required
5.4.13.1	TYPE IDENTIFICATION	If COT=44 is NOT supported, any undefined ASDU received by the controlled station should be mirrored with P/N=1 negative	IEC 60870-5-101, 7.3	Yes
		If COT=44 is NOT supported, any undefined ASDU received by the controlling station is ignored (or discarded)	IEC 60870-5-101, 7.3	Yes
5.4.13.5	CAUSE OF TRANSMISSION	Test bit = 1 ASDU generated during test conditions	IEC 60870-5-101, 7.2.3	No, ASDU 104 not selected
5.4.13.5	CAUSE OF TRANSMISSION	If COT=45 is NOT supported, any undefined ASDU received by the controlled station should be mirrored with P/N=1 negative	IEC 60870-5-101, 7.2.3	Yes
		If COT=45 is NOT supported, any undefined ASDU received by the controlling station is ignored (or discarded)	IEC 60870-5-101, 7.2.3	Yes

Table E.9 (*continued*)

Test No.	Test	Description	Reference	Required
5.4.13.10	COMMON ADDRESS of ASDU	If COT=46 is NOT supported, any message received by the controlled station containing an undefined CASDU should be mirrored with P/N=1	IEC 60870-5-101, 7.2.4	Yes
		If COT=46 is NOT supported, any message received by the controlling station containing an undefined CASDU is ignored (or discarded)	IEC 60870-5-101, 7.2.4	Yes
		Broadcast CASDU value (0xFF<FF>) only used with ASDU TYPES 100 (interrogation), 101 (Counter interrogation), 103 (Clock Sync) or (Reset Process)	IEC 60870-5-101, 7.2.4	Yes

Table E.10: Information Object Address Conformance Test Procedures

Test No.	Test	Description	Reference	Required
5.4.14.1	OBJECT ADDRESS	If COT=47 is NOT supported, any message received by the controlled station containing an undefined IOA should be mirrored with P/N=1 negative	IEC 60870-5-101, 7.2.5	Yes
		If COT=47 is NOT supported, any undefined ASDU received by the controlling station is ignored (or discarded)	IEC 60870-5-101, 7.2.5	Yes

Table E.11: Cyclic Data Transmission Function Conformance Test Procedure

Test No.	Test	Description	Reference	Required
5.4.19.1	Cyclic data transmission and Background Scan – sequential procedure	The Controlled station may transmit a Single point information object (configurable IOA) with COT =3 (SPONT) if buffer overflow occurs (statusON = overflow, statusOFF=no overflow). Dependent on configuration the Controlled station deletes the newest or oldest event in buffer when overflow occurs. Upon receipt of a buffer overflow message, the controlling station issues a GI command.	IEC 60870-5-101, 7.2.2.3	Yes, oldest to be deleted.

Table E.12: Data Acquisition through Read Function Conformance Test Procedure

Test No.	Test	Description	Reference	Required
5.4.20.1	Data acquisition through Read – sequential procedure:			No

Table E.13: Acquisition of Events Function Conformance Test Procedure

Test No.	Test	Description	Reference	Required
5.4.21.1	Acquisition of events – sequential procedure	Local buffer in the Controlling station to collect events that may arrive faster on the communication link than they can be processed and/or conveyed to higher layers or user processes (to prevent communication delays)		Yes, check controlling station
		The Controlled station may transmit a Single point information object (configurable IOA) with COT =3 (SPONT) if buffer overflow occurs (statusON = overflow, statusOFF=no overflow). Dependent on configuration the Controlled station deletes the newest or oldest event in buffer when overflow occurs. Upon receipt of a buffer overflow message, the controlling station issues a GI command.	IEC 60870-5-101, 7.2.2.3	Yes, oldest to be deleted first.

Table E.14: General Interrogation Function Conformance Test Procedure

Test No.	Test	Description	Reference	Required
5.4.22.10	General Interrogation – Outstation interrogation -more than one logical Remote Unit (LRU) available in the controlled station			Only if controlled station has more than one logical Remote Unit (LRU) available, otherwise covered in TS 60870-5-601 clause 5.4.22.1

Table E.15: Transmission of Integrated Totals (Telecounting) Conformance Test Procedures

Test No.	Test	Description	Reference	Required
5.4.25.10	Transmission of integrated totals – sequential procedure: Mode B – Local freeze with Counter Interrogation	The controlling station sends the counter interrogation command at the configured intervals		Yes
		The counter value is either the locally memorised increment during the past interval or the locally frozen integrated total (memorised counter) at the end of the past interval (plausibility test)		Yes
		The Sequence number of the transmitted Counter value (SQ) changes with each counter transmission interval (plausibility test)		Yes
		The values of the object(s) transferred and stored on the controlling station should represent the actual values on the controlled station.		Yes
		The tests in this Table are performed correctly by each M_IT ASDU in the PICS that supports COT 10		Yes
		The Counter Interrogation command is sent at the configured intervals		Yes
5.4.25.30	Transmission of integrated totals – sequential procedure: Mode D – Remote initiated spontaneous transmission	The freeze Counter Interrogation command is sent at the configured interval		Yes
		The Counter values are sent by the Controlled station at configured intervals		Yes

Table E.16: Parameter loading function Conformance Test Procedure

Test No.	Test	Description	Reference	Required
5.4.26.1	Parameter loading – sequential procedure: Load and activate parameter			No

Table E.17: Test procedure function Conformance Test Procedure

Test No.	Test	Description	Reference	Required
5.4.27.1	Test procedure – sequential procedure			No

Table E.18: Delay acquisition procedure function Conformance Test Procedures

Test No.	Test	Description	Reference	Required
5.4.29.1	Delay acquisition procedure – sequential procedure			Yes

Table E.19: Additional Conformance Test Procedures

Test No.	Test	Description	Reference	Required
5.4.30.20	Time Invalid	After receipt of an ASDU with time stamp marked invalid (IV=1) the controlling station immediately initiates a Clock synchronisation procedure (if supported) after the Clock synchronisation procedure has been completed as part of the Initialisation procedure.		No

Table E.20: PIXIT related Conformance Test Procedures

This can be used for specific PIXIT related test procedures. If there is no specific PIXIT related test cases, then this can be skipped

Test No.	Test	Description	Reference	Required
5.4.32.1	Function			
5.4.32.2	Function			
5.4.32.3	Function			
5.4.32.4	Function			