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TEST PROCEDURE**

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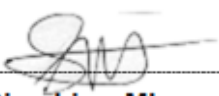
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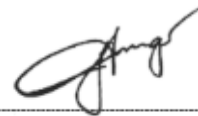


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1. Introduction

This document contains procedures for verification of the DNP3 RTU protocol implementation in Network Manager System.

2. Supporting clauses

2.1 Scope

This document covers the testing that is based on the (.ini) parameter files for the support of the DNP3 Protocol as defined in the NM drivers (x85 – DNP over IP and x86 – DNP3 Serial). The Protocol implementation on the test devices like RTUs that are used during testing shall support and parse the messages issued by the Master. The master station shall also parse messages from the RTUs.

2.1.1 Purpose

The purpose of this specification is to define all significant Use Cases related to functionality and performance for the DNP3 RTU protocol implementation in the Network Manager system.

2.1.2 Applicability

This document shall apply throughout Eskom Distribution.

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] ISO 9001, Quality Management Systems.
- [2] 1KSE 000 206D227 - Test Procedure DNP 3.0 Master
- [3] IEEE 1815 (2012), IEEE Standard for Electric Power Systems Communication – Distributed Network Protocol, IEEE
- [4] DNP3 IED Certification Procedure Subset Level 2, DNP3 User Group
- [5] 240-59089329, Eskom's DNP3 Implementation Standard, S Mbanga
- [6] 240-76628305, SPECIFICATION FOR POLE-MOUNTED AUTORECLOSERS, PART 2: TELECONTROL REQUIREMENTS
- [7] FD_PCU400_DNP3_IP_RTU_Master_Protocol – ABB document
- [8] 3AJK000007-175 Rev. C October, 2014 - Release_Notes_PCU400

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Back-End or Application	The processor which hosts the Master Station SCADA application.
ASE2000	DNP3 Protocol analyser tool that can be used as master, RTU or in monitor mode. It can also be used to view files that have been captured after the operation in the above-mentioned modes.
Feline	A software application capable of analysing layer one timing on asynchronous digital communication lines.
Fieldcomm	DNP3 Protocol analyser tool that can be used as master or in monitor mode. It can also be used to view files that have been captured after the operation in the two mentioned modes.
In Service	When a specific communication line polling application is granted access to include a Remote Terminal Unit in its cyclic polling sequence the Remote Terminal Unit is considered In Service.
Inoperable	Inoperable indicates that the communication path to the Remote Terminal Unit was not intact at the time of a poll request. Thus, inoperable refers to the state of the communication path to the Remote Terminal Unit based on the success of the last automated or manually initiated poll.
Integrity Poll	A specific type of poll sequence used to retrieve the status of inputs and outputs that are configured on the Remote Terminal Unit.
Layer 1 (ISO)	Refers to the physical layer within the communication line as defined in the Open Systems Interconnection (OSI) model.
Operable	Operable indicates that the communication path to the Remote Terminal Unit was intact at the time of a poll request. Thus, operable refers to the state of the communication path to the Remote Terminal Unit based on the success of the last automated or manually initiated poll.
Out of service	When a specific communication line polling application is denied access to include a Remote Terminal Unit in its cyclic polling sequence the Remote Terminal Unit is considered Out of Service.
PCU	The application processor that the DNP protocol is implemented in. The Process Control Unit (PCU) is responsible for mapping data and command messages from the DNP RTU protocol to the RCS.
simSCADA+ V3	A virtual RTU simulation software application.
Test Poll	A specific type of poll sequence to test the state of the communication path to the Remote Terminal Unit when there has been no application layer message communication between the RTU and the PCU for the parameter set period.

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
AS	Application Servers
DCD	Data Carrier Detect
DNP3	Distributed Network Protocol
LAN	Local Area Network
NM	Network Manager
PCU	Process Communication Unit
RTS	Request To Send
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SoE	Sequence of Events
VDU	Video Display Unit

2.5 Roles and responsibilities

The Telecontrol and SCADA Study committee oversees the testing and implementation of the protocol drivers. The SCADA environment is responsible to monitor the performance of the drivers after acceptance testing. Should bugs be picked after acceptance testing, the SCADA environment shall raise those with the test team and coordinators of the testing. The coordinator raises these events/bugs with the supplier and engagements with the test team are held to resolve the issues.

2.6 Process for monitoring

Compliance to expected operations is monitored by the SCADA custodians.

2.7 Related/supporting documents

Not applicable.

3. Requirements

3.1 Overview of the functions

The Network Manager (NM) central system consists of a redundant pair of computers called Application Servers (AS). All control and data acquisition processes are implemented in subsystem Remote Communication Server System (RCS), which is a part of AS. The current NM 10 system has the same system setup but not in physical form, as it is a virtual computers setup.

The RCS System handles the communication between the AS and the RTUs through the Process Communication Unit (PCU), which are connected as a redundant system. Both the AS and PCU are each normally connected to two local area networks (LAN's, see Figure 1) (project specific).

The PCU implements the connections to the Remote Terminal Units (RTU) on the communication lines. The DNP protocol is implemented in the PCU. The PCU is responsible for mapping data and command messages from the DNP RTU.

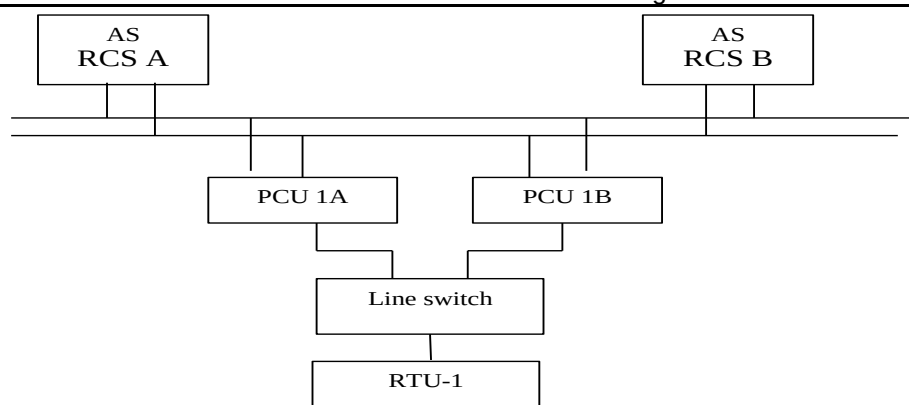


Figure 1: Physical connection

3.2 Test Schedule

3.2.1 RTU Restart

Test Objective			
To verify that a RTU is presented correctly in VDU pictures after it is started. Furthermore, it should be verified that process data from the RTU is presented as updated. This test shall be performed for both Time synchronisation (TsynBroadcast) parameter being enabled and disabled. The recommended setting is time synchronisation broadcast enabled for unsolicited lines due to effective utilization of bandwidth.			
Test	Step description	Expected result	Passed Test
	Ensure the TsynBroadcast = 1, enabled Switch off the RTU and wait for it to go offline and select on different VDUs the single line diagram (the page that presents RTUs), the event list and the alarm list of the control system.	The RTU is in service, but not operable.	
1.	Acknowledge all alarms in the power system and the control system.	All alarms acknowledge all alarms	
2.	Select on a VDU the single line diagram of the station DNP.	All measurands and indications are presented as not updated.	
3.	Switch the power on for the RTU DNP-RTU.	Control system single line: Green at DNP-RTU DNP-RTU information picture: Inoperable: No Control system event list: DNP-RTU Operable Control system alarm list: The DNP-RTU alarm disappears. The protocol analyser capture file must show: the RTU going through the start-up sequence as follows: - RTU sends an Unsolicited null, - master writes IIN 7, - Then Master writes date and time - Master sends an integrity Poll and then Enable unsolicited reporting.	

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Test	Step description	Expected result	Passed Test
4.	TsynBroadcast = 0, disabled Switch off the RTU and wait for it to go offline and select on different VDUs the single line diagram (the page that presents RTUs), the event list and the alarm list of the control system.		
5.	Repeat tests performed in steps 1-3, in steps 6-8.		
6.	Acknowledge all alarms in the power system and the control system.	All alarms acknowledge all alarms	
7.	Select on a VDU the single line diagram of the station DNP.	All measurands and indications are presented as not updated.	
8.	Switch the power on for the RTU DNP-RTU.	Control system single line: Green at DNP-RTU DNP-RTU information picture: Inoperable: No Control system event list: DNP-RTU Operable Control system alarm list: The DNP-RTU alarm disappears. The protocol analyser capture file must show: the RTU going through the start-up sequence as follows: • RTU sends an Unsolicited null, • master writes IIN 7, • Then Master writes date and time • Master sends an integrity Poll and then Enable unsolicited reporting.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

3.2.2 Indication, Single

Test Objective			
To verify that process data (indication) from the RTU is presented as updated with the right value after it has been changed. To also observe that the messages on the protocol analyser are processed as desired.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture of the indication DNPIND S1, i.e. and single bit mapped point, e.g. ARC Mode, SEF ON/OFF. Trip and close Isolate	The indication is presented as updated with status value ON/CLOSE or OFF/OPEN.	

Test	Step description	Expected result	Passed Test
2.	Select on different VDUs the event list of the power system and change the indication status value for the RTU to ON/CLOSE or OFF/OPEN. This must be the opposite of the status in test 1	The indication is shown in the information picture as ON/CLOSE or OFF/OPEN In the event list there appears an entry for the indication status change. Also observe on the DNP 3 capture that DNP 3 point ID of the changed point is changing from 0/1 to 1/0 accordingly.	
3.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

3.2.3 Double bit indication

Test Objective			
To verify that process data (indication) from the RTU is presented as updated with the right value after it has been changed. To also observe that the messages on the protocol analyser are processed as desired showing two bits representing the status of the double bit point. The new object 3 variation 1 indicating double bits to also be tested.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture of the indication DNPIND D5, i.e. a double bit mapped point, e.g. Breaker Indication Closed/Tripped .	The indication is presented as updated with status value ON/CLOSE or OFF/OPEN.	
2.	Select on different VDUs the event list of the power system and change the indication status value for the RTU to ON/CLOSE or OFF/OPEN. This must be the opposite of the status in test 1	The indication is shown in the information picture as ON/CLOSE or OFF/OPEN In the event list there appears an entry for the indication status change. Also observe on the DNP 3 capture that DNP 3 point ID of the changed point is changing from 0/1 to 1/0 accordingly.	
3.	Select the information picture of the indication DNPIND D5, i.e. a double bit mapped point, e.g. Breaker Indication Closed/Tripped. A point must be configured for OBJ3V1.	The indication is presented as updated with status value ON/CLOSE or OFF/OPEN. Also observe on the protocol analyser tool that the objects and variations are for double bit points.	
4.	Select on different VDUs the event list of the power system and change the indication status value for the RTU to ON/CLOSE or OFF/OPEN. This must be the opposite of the status in test 3, A point must be configured for OBJ3V1	The indication is shown in the information picture as ON/CLOSE or OFF/OPEN In the event list there appears an entry for the indication status change. Also observe on the DNP 3 capture that DNP 3 point ID of the changed point is changing from 0/1 to 1/0 accordingly.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

3.2.4 Indication change, Single

Test Objective			
To verify that the time stamped process data (indication) from the RTU is presented as updated with the right value after it has been changed. To also observe that the messages on the protocol analyser are processed as desired when sent as Unsolicited events with time.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture of the indication DNPIND S2, i.e. a single bit mapped point, e.g. ARC Mode, SEF ON/OFF, Trip/Close Isolate. (Change a point on the RTU)	The indication is presented as updated with status value ON/CLOSE or OFF/OPEN.	
2.	Select on different VDUs the event list of the power system and change the indication status value for the RTU to ON/CLOSE or OFF/OPEN. This must be the opposite of the status in test 1	The indication is shown in the information picture as ON/CLOSE or OFF/OPEN In the event list there appears an entry for the indication status change. Also observe on the DNP 3 capture that DNP 3 point ID of the changed point is changing from 0/1 to 1/0 accordingly.	
3.	Select the SOE window VDU	In the Sequence of event list there appears an entry for the indication status change.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

3.2.5 Indication change, Double

Test Objective			
To verify that the time stamped process data (indication) from the RTU is presented as updated with the right value after it has been changed. To also observe that the messages on the protocol analyser are processed as desired when sent as Unsolicited events with time. The new object and variation for double bits, OBJ 4 var 1 to be tested.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture of the indication DNPIND D1, i.e. a double bit mapped point, e.g. Breaker Indication Closed/Tripped .	The indication is presented as updated with status value ON/CLOSE or OFF/OPEN for the double bit point.	
2.	Select on different VDUs the event list of the power system and change the indication status value for the RTU to ON/CLOSE or OFF/OPEN. This must be the opposite of the status in test 1 (using the Event Test, test environment)	The indication is shown in the information picture as ON/CLOSE or OFF/OPEN In the event list there appears an entry for the indication status change. Also observe on the DNP 3 capture that DNP 3 point IDs of the changed points are changing from 0/1 to 1/0 accordingly.	

Test	Step description	Expected result	Passed Test
3.	Select the SOE window VDU (Picture Types/Sequence of events list)	In the Sequence of event list there appears an entry for the indication status change.	
4.	Select the information picture of the indication DNPIND D5, i.e. a double bit mapped point, e.g. Breaker Indication Closed/Tripped .- A point configured for OBJ4V1	The indication is presented as updated with status value ON/CLOSE or OFF/OPEN. Also observe on the protocol analyser tool that the objects and variations are for double bit points.	
5.	Select on different VDUs the event list of the power system and change the indication status value for the RTU to ON/CLOSE or OFF/OPEN. This must be the opposite of the status in test 4- A point configured for OBJ3V1	The indication is shown in the information picture as ON/CLOSE or OFF/OPEN In the event list there appears an entry for the indication status change. Also observe on the DNP 3 capture that DNP 3 point ID of the changed point is changing from 0/1 to 1/0 accordingly.	
Name of Tester:		DATE:	Test Passed without exceptions?
Comments:			

3.2.6 Ignore older Indications with time.

Test Objective			
To verify that time stamped indications received from the RTU older than recently received are discarded.			
Test	Step description	Expected result	Passed Test
1.	Generate time stamped indications in the RTU.	The messages are presented in the SoE list in the NM system.	
2.	Change the time on the RTU backwards (This can be done with the RTU configurator software) and generate time stamped indications in the RTU with the same time or earlier time as in the previous message. Ensure that the time difference is longer than the IgnoreOldIndSoE value set. Recommended IgnoreOldIndSoE= 3000.	The PCU discards any time stamped indication with an older time compared to the last received and stored time. A notification is sent to the NM control system event list.	
3.			
4.			
5.			
6.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

3.2.7 Measured value change (Analogue)

Test Objective			
To verify that process data (measured value) from the RTU is presented as updated with the right value after it has been changed.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture of the measured value DNPMEA A2, i.e. analogue value like current, voltage or MVARs.	The measured value is presented as updated with a valid value.	
2.	Change the measured value for the RTU to another valid value. Remember that the value must be changed more than the dead-band. (e.g. Change MVARs, Amps, Voltage of Test RTU, through mA injection or forcing the value via software)	The measured value is shown with the correct value in the information picture. Observe that the Analogue change message is sent to the PCU via the capture on the protocol simulator software Object 32 Variation 2 (Analog Input change- without time)	
3.	Select the information picture of the measured value that is setup for floating points, i.e. analogue value like Temperature, voltage or MVARs. On NM this point must be set as RSP Format 1, Short Floating Point	The measured value is presented as updated with a valid value.	
4.	Change the measured value for the RTU to another valid value. Remember that the value must be changed more than the dead-band.	The measured value is shown with the correct value in the information picture. Observe that the Analogue change message is sent to the PCU via the capture on the protocol simulator software Object 32 Variation 7 (Analog Input Event— Single-prec flt-pt without time)	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

3.2.8 Measured value outside range

Test Objective											
To verify that measurands are marked as Invalid if the input value is out of the transducer range.											
Test	Step description	Expected result	Passed Test								
1.	Select on VDUs the single line diagram of the station DNP.										
2.	Select in a new window the information picture for the measurand DNPMEA A2 i.e. analogue value like current, voltage or MVARs.										
3.	Simulate a value outside the signal range on the RTU input of the selected measurand. This can be simulated using the SimScada and the over range flag or Injecting a range more than what the transducer is calibrated for i.e. injecting more than 20mA with a milliamp injector on a point rated for 20mA.	Check the result in the information picture. <table border="0"> <tr> <td>Input</td> <td>Value</td> <td>Colour</td> <td>Invalid (Inform. pict.)</td> </tr> <tr> <td>Outside not changed</td> <td>Magenta</td> <td>Yes</td> <td></td> </tr> </table> On the DNP 3 capture file the message is reported as 32767 with the IIN flag for Over range asserted.	Input	Value	Colour	Invalid (Inform. pict.)	Outside not changed	Magenta	Yes		
Input	Value	Colour	Invalid (Inform. pict.)								
Outside not changed	Magenta	Yes									
4.	Injecting a value in a range more than what the transducer is calibrated for i.e. injecting more than 20mA with a milliamp injector on a point rated for 20mA.	<table border="0"> <tr> <td>Input</td> <td>Value</td> <td>Colour</td> <td>Invalid (Inform. pict.)</td> </tr> <tr> <td>OK</td> <td>correct value</td> <td>Green</td> <td>No</td> </tr> </table> On the DNP 3 capture file the message is reported as 32767 with the IIN flag for Over range asserted. Outside Transducer Limit : Yes	Input	Value	Colour	Invalid (Inform. pict.)	OK	correct value	Green	No	
Input	Value	Colour	Invalid (Inform. pict.)								
OK	correct value	Green	No								
5.											
6.											
Name of Tester:		Date:	Test Passed without exceptions?								
Comments:											

3.2.9 Analogue control (Setpoint)

Test Objective			
To verify that the setpoints function as desired			
Test	Step description	Expected result	Passed Test
1.	Select the information picture of the measured value for the setpoint	The measured value is presented as updated with a valid value.	
2.	Change the measured value for the RTU to another valid value by issuing a ramp up or down.	The analogue control value is shown with the correct value in the information picture. Observe that the Analogue output message is sent from the PCU via the capture on the protocol simulator software Object 41 Variation 2 containing the set value. The echo message from the RTU (SimScada) is received with status 0.	
3.	Observe that the values that are sent out are as desired.	The values must align with the settings on the database for raw and engineering.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

4. Process command

4.1 Pulse on: Select Before Operate Command

Test Objective			
To verify that a command to a select-before-operate digital output point is performed correctly.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture for the command DNPCMD P1, select a command that has been configured for select before operate.		
2.	Select the command and execute it.	In the Line Listener Display you can see the telegram sequence of select is performed and afterwards the operate command. In the protocol analyser software, you can see the telegram sequence of select is performed and afterwards the operate command. Object 12 Variation 1 with function codes 3 (Select) and 4 (Operate) also showing Pulse ON (Trip/Close).	
3.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

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4.2 Pulse on: Direct operate

Test Objective			
To verify that a command to a Direct operate output point is performed correctly.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture for the command DNPREG 1, point configured for direct operate. (Breaker Trip/Close)		
2.	Select the command and execute it.	In the Line Listener Display you can see that a raise or lower is executed. In the protocol analyser software you can see the telegram sequence of select is performed and afterwards the operate. Object 12 Variation 1 with function code 5 (Direct Operate) also showing Pulse ON (Trip/Close).	
3.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

4.3 Latch ON/OFF: Direct operate

Test Objective			
To verify that a command to a latched output point is performed correctly.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture for the command DNPCMD P3. Configured as latch on/off (Null): Direct operate.		
2.	Select the command and execute it.	In the Line Listener Display you can see that a latched command is executed. In the protocol analyser software you can see the telegram sequence of a direct operate command. Object 12 Variation 1 with function code 5 (Direct Operate) also showing Latch ON/Off (null).	
3.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

4.4 Retransmission of a command

Test Objective			
To verify that a command is not retransmitted.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture for the command DNPCMD P3.		
2.	Disconnect the RTU line when the line is idle (no telegrams are sent to/from the RTU)		
3.	Select the command and execute it. (You can use a Pulse On (Trip) and Pulse On (Close).	In the Line Listener Display you can see that no retransmission of the command is performed. An error notification (Negative Acknowledgement) is shown in the Power system event list. In the protocol analyser software, you can see the telegram sequence of a direct operate command. Object 12 Variation 1 with function code 5 (Direct Operate) also showing Latch ON/Off (Null). Observe that there will be no retransmission of the same command after the timeout period.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

4.5 Command errors

Test Objective			
To verify that error codes for failed commands are reported to the NM system.			
Test	Step description	Expected result	Passed Test
1.	Use the ASE 2000 test set to generate the following responses to a command one by one	Check that error messages are reported for each of the error codes. Test for 4 = The control sent to the ARC point to generate the control not supported flag and the NM event list to show the message control not supported. Test for 6 = The ARC on control sent to the point set as inverted to result in the same effect as sending an ARC off. Due to the last control being sent as ARC off to the unit the result will be as if the same command has been send to a unit that is already in the desired state.	
2.	0 = Command accepted;		
3.	1 = Select/Operate timeout		

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Test	Step description	Expected result	Passed Test
4.	2; = Operate;		
5.	3 = Formatting error without select;		
6.	4 = Control operation not supported;		
	5 = Point already active;		
	6 = Control point not allowed		
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5. RTU Communication

5.1 RTU communication Failure

Test Objective			
To verify that a communication failure is presented correctly in VDU pictures and audible alarm. Furthermore, it should be verified that process data from the lost RTU is presented as not updated, and that the communication is reestablished when the failure is eliminated.			
Test	Step description	Expected result	Passed Test
1.	Acknowledge all alarms in the power system and the control system. Reset the audible alarms.		
2.	Select on a VDU the single line diagram of the station DNP.	All measurands and indications are presented as updated and without unacknowledged alarm.	
3.	Select on different VDUs the single line diagram (the page that presents RTUs), the event list and the alarm list of the control system.	The alarm indicator is grey and fixed and the alarm window is empty. There are no RTUs in alarm status.	
4.	Select the information picture of the DNP-RTU in a separate picture window and Simulate a communication failure by disconnecting the communication cable from DNP-RTU. (Take the unit out of service and in service while the cable is disconnected to fail it or wait for the scheduled integrity poll interval)	After a delay of some seconds: The alarm indicator in the system window is red and flashing. Control system single line: (Offline)Flashing * at DNP-RTU (see comment) DNP-RTU information picture: Operable: No Control system event list: DNP-RTU Inoperable Control system alarm list: *DNP-RTU Inoperable	

Test	Step description	Expected result	Passed Test
5.	Acknowledge the alarm for DNP-RTU.	Control system alarm list: DNP-RTU Inoperable	
6.	Restore the communication line to the DNP-RTU by connecting the communication cable. (Take the unit out of service and in service while the cable is disconnected to fail it or wait for the scheduled integrity poll interval)	After a delay of some seconds: Control system single line: green dot at DNP-RTU (see comment) DNP-RTU information picture: Operable: Yes Control system event list: DNP-RTU Operable Control system alarm list: DNP-RTU alarm off In the station single line diagram all measurands and indications from the disconnected RTU are marked as updated. Observe on the protocol analyser that after the test poll RTU message is sent to the unit, there will be an integrity poll message sent to the RTU unit that results in the unit being operable (Online).	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.2 RTU Stopped

Test Objective			
To verify that a failure in a RTU is presented correctly in VDU pictures and audible alarm. Furthermore, it should be verified that process data from the RTU is presented as not updated and that the presentation is re-established when the RTU is taken In Service.			
Test	Step description	Expected result	Passed Test
1.	Acknowledge all alarms in the power system and the control system. Reset the audible alarms.		
2.	Select on a VDU the single line diagram of the station DNP.	All measurands and indications are presented as updated and without unacknowledged alarm	
3.	Select on different VDUs the single line diagram (the page that presents RTUs), the event list and the alarm list of the control system.	The alarm indicator is grey and fixed and the alarm window is empty. There are no RTUs in alarm status.	

Test	Step description	Expected result	Passed Test
4.	Simulate a failure in the DNP-RTU by switching off its power supply.	Observe in the Protocol analyser that the Master tries to send the Integrity poll message class1,2,3 & 0 to the unit 1 + number of max retries times. After a delay of some seconds: The audible alarm for control system alarm is started. The alarm indicator in the system window is red and flashing. Control system single line: Flashing * at DNP-RTU DNP-RTU information picture: Inoperable: Yes Control system event list: DNP-RTU Inoperable Control system alarm list: *DNP-RTU Inoperable In the station single line diagram all measurands and indications from the disconnected RTU are marked as invalid (colour = magenta).	
5.	Switch the power on for DNP-RTU.	Observe in the protocol monitor software that the RTU sends the unsolicited null message when it restarts and messages as per restart test follow as per 4.2.1. After a delay of some seconds: Control system single line: green dot at DNP-RTU (see comment) DNP-RTU information picture: Operable: Yes Control system event list: DNP-RTU Operable Control system alarm list: DNP-RTU alarm off In the station single line diagram all measurands and indications from the disconnected RTU are marked as updated. Observe on the protocol analyser that after the test poll RTU message is sent to the unit, there will be an integrity poll message sent to the RTU unit that results in the unit being operable (Online).	
6.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.3 RTU out of service

Test Objective			
To verify that a RTU is presented correctly in VDU pictures when it is taken Out of Service. Furthermore, it should be verified that process data from the RTU is presented as not updated and that the presentation is re-established when the RTU is taken In Service.			
Test	Step description	Expected result	Passed Test
1.	Acknowledge all alarms in the power system and the control system, then Select on a VDU the single line diagram of the station DNP.	All measurands and indications are presented as updated and without unacknowledged alarm.	
2.	Select on different VDUs the single line diagram (the page that presents RTUs), the event list and the alarm list of the control system.	The alarm indicator is grey and fixed and the alarm window is empty. There are no RTUs in alarm status.	
3.	Select the information picture of the DNP-RTU in a separate picture window and then take the RTU Out of Service by the function command (MB3 menu) in the RTU information picture.	DNP-RTU information picture: Operable: No (see comment) In service No Control system event list: DNP-RTU Out of service M SYS No alarm presentation In the station single line diagram all measurands and indications from the RTU, which is out of service, are marked as invalid.	
4.	Take the DNP-RTU In Service by function command (MB3 menu) in the info picture.	Observe in the protocol capture file that the integrity poll message is issued to the RTU, followed by enable unsolicited message(For unsolicited line). For solicited line the first message will be disable unsolicited followed by integrity poll message. In the DNP-RTU information picture: In Service Yes Operable Yes Active Yes Control system event list: DNP-RTU In service M SYS In the station single line diagram all measurands and indications from the selected RTU are marked as updated.	
5.			
6.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.4 Status check or integrity poll

Test Objective			
To verify that indications are updated after a request for status check. To also test that the integrity scan parameter (IntegrityInterval= "00:01 00:05:00") operates as per the set values. Test will be conducted at different values. 5 min, 7 min and 10 mins			
Test	Step description	Expected result	Passed Test
1.	Select in a new window the information picture for the any indication and Simulate the input value OFF in the RTU input of the indication using an RTU or SIMSCADA.	Information picture: OFF In the protocol analyser a message showing the point status as being off will be sent.	
2.	Enter by means of AQL the value ON in the indication <ACTUAL STATUS(INDICATION)> = 1	No change.	
3.	Request the function Refresh from the menu View of the picture window.	Information picture: ON	
4.	Request a status check of the station DNP	Observe on the protocol analyser that an integrity poll message is send with a request from the RTU showing all the Static data. The indication : OFF	
5.	Set the parameter for IntegrityInterval= "00:01 00:03:00"	Leave the line without initiating any manual commands and observe that the integrity messages are sent every 5 minutes	
6.	Set the parameter for IntegrityInterval= "00:01 00:07:00"	Leave the line without initiating any manual commands and observe that the integrity messages are sent every 7 minutes	
7.	Set the parameter for IntegrityInterval= "00:01 00:10:00"	Leave the line without initiating any manual commands and observe that the integrity messages are sent every 10 minutes	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.5 RTU Class Assignment

Test Objective			
To verify the function of class assignment.			
Test	Step description	Expected result	Passed Test
1.	Make sure some points are blocked	The point goes Magenta if not in alarm state	
2.	Specify "No Assignment" for the RTU. (Set class assign parameter ClassAssign = 0 in the ini file for the RTU)		

Test	Step description	Expected result	Passed Test
3.	Take the RTU Out and then in-service.	In the protocol monitor listener check that no class data (OBJ 60) messages are sent from the PCU to the RTU.	
4.	Specify "Only blocked/Deblocked points".(Set class assign parameter ClassAssign = 2 in the ini file for the RTU)		
5.	Take the RTU Out and then in-service.	In the protocol line listener check that no class data (OBJ 60) messages are sent from the PCU to the RTU.	
6.	Specify " All defined points are assigned ".(Set class assign parameter ClassAssign = 1 in the ini file for the RTU)		
7.	Take the RTU Out and then in-service.	In the line protocol line listener check that class data (Obj 60) messages are sent for all points with a defined class. Points that are blocked shall be assigned to class 0 even if the belong to another class. (See Comment)	
Name of Tester:		Date:	Test Passed without exceptions?
Comments: When a point is blocked in the alarm state it does not turn Magenta, it retains its alarm state When the class assignment is to be used on start-up it must be set inside the line start-up parameter. It was observed that the assign class happens after the Enable unsolicited when using ClassAssign = 1. To assign class during start-up add the parameters aAC2341 and oCO234 in the linestart parameter settings. It was agreed that the AssignClass =2 is the parameter to set as the units have class assignment via the configurator tools.			

5.6 Point blocking and de-blocking

Test Objective			
To verify that it is possible to block and de-block a point (ClassAssign = 1 or 2 in the ini file)			
Test	Step description	Expected result	Passed Test
1.	Select the information picture for the indication (ARC ON/OFF, Breaker, etc) in NETWORK MANAGER and Simulate an ON value in the RTU (Simulated the Breaker position on the D20 or any test RTU).	Value goes to ON in NM Observe that the change is also send via the protocol analyser.	
2.	Block the value, by selecting Data Acquisition blocked.	The point is displayed as magenta Check that the PCU transmits Class data message to move the point to class 0 when blocking. This message will be captured on the DNP3 Simulation software.	
3.	Simulate an OFF value in the RTU (Simulated the breaker position on the D20 or any other Test RTU).	The value should be blocked (magenta) and still ON in NM.5 Observe that there is no status change sent via the protocol analyser monitoring tool as the point is set to Class 0.	

Test	Step description	Expected result	Passed Test
4.	Unblock the value, by selecting untick data acquisition block.	When the RTU is Deblocked the PCU again sends a class data message to the RTU to move the point to its specified class. The value send will be based on the class selected in the database. Current tests showed a Class 1 message being sent out to the specific test. The value goes stayed the same state (green).	
5.	Take the unit out and in service to force an integrity scan.	The changed state is updated and the colour is green.	
6.	Repeat steps 1 to 3 and swoop 5 and 4	The backend to show the updated state	
7.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.7 Time synchronization

Test Objective			
To verify that a time synchronization message is sent to the RTU. Time Synchronisation Interval – TSynclInterval parameter.			
Test	Step description	Expected result	Passed Test
1.	Set the parameter TSynclInterval = "00:00 00:02:00"	Observe that the write date and time message is sent to the RTU every 2 minutes	
2.	Set the parameter TSynclInterval = "00:00 00:05:00"	Observe that the write date and time message is sent to the RTU every 5 minutes	
3.	Set the parameter TSynclInterval = "00:00 00:07:00"	Observe that the write date and time message is sent to the RTU every 7 minutes	
4.	Set the parameter TSynclInterval = "00:00 00:10:00"	Observe that the write date and time message is sent to the RTU every 10 minutes	
5.	Set the parameter TSynclInterval = "00:00 01:10:00". Advisable to be left for overnight capturing.	Observe that the write date and time message is sent to the RTU every 70 minutes	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.8 Non- existing point on scan

Test Objective			
To verify that the PCU can handle a non-existing point from the RTU			
Test	Step description	Expected result	Passed Test
1.	Change the indication input in the DNP-RTU to a number that does not exist in the Network Manager system. If the RTU is mapped with 50 points in NM (Control system Event list), change the database on the RTU to be more than 50 and change a point outside the range. (Depending on the parameter setting)	Observe in the protocol analyser monitoring tool that the change indication is generated from the RTU. The PCU ignores the indication but issues a warning via the PCU VDU terminal than an unknown database point was received on the communication line.	
2.	Change the database back to match what is mapped in NM and change a point within the range.	Observe in the protocol analyser monitoring tool that the change indication is generated from the RTU with a DNP 3 ID inside the range. The PCU processes the indication and generate all associated alarms and events for the point.	
Name of Tester:			Test Passed without exceptions?
Comments: There is a new parameter SENDUNDEFPOINTONRSP = 0 Don't sent error for both solicited and unsolicited = 1 point err send for solicited response = 2 point err send for unsolicited response = 3 point err send for both solicited and unsolicited response This can only be simulated when set to 1, 2 or 3.			

5.9 RTS on and RTS off Delay

Test Objective			
To verify that the PCU waits before sending data if the RTS on delay is set for a particular RTU.			
Test	Step description	Expected result	Passed Test
1.	Set the RTS on delay parameter to LldRtsOnDelay = "500" LldRtsoffDelay = "200" and with and with the Layer 1 (Feline or equivalent) analyser in record mode and poll one of the RTUs on the test line.	Observe in the protocol analyser monitoring tool that the integrity poll is sent. The Layer 1 analyser shows the PCU waits for 500mS after the assertion of its RTS line before the first byte of data is sent. The Layer 1 analyser shows the PCU waits for 200mS after the last byte of data is sent before de-asserting the RTS line.	
2.	Set the RTS on and on delay parameters to LldRtsOnDelay = "100" LldRtsoffDelay = "50" and with and with the Layer 1 (Feline) analyser in record mode and poll one of the RTUs on the test line.	Observe in the protocol analyser monitoring tool that the integrity poll is sent. The Layer 1 analyser shows the PCU waits for 100mS after the assertion of its RTS line before the first byte of data is sent. The Layer 1 analyser shows the PCU waits for 50mS after the last byte of data is sent before de-asserting the RTS line.	

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Test	Step description	Expected result	Passed Test
3.	Set the RTS on and off delay parameters to LldRtsOnDelay = "750", LldRtsoffDelay = "100" and with the Layer 1 (Feline) analyser in record mode and poll one of the RTUs on the test line.	Observe in the protocol analyser monitoring tool that the integrity poll is sent. The Layer 1 analyser shows the PCU waits for 750mS after the assertion of its RTS line before the first byte of data is sent. The Layer 1 analyser shows the PCU waits for 100mS after the last byte of data is sent before de-asserting the RTS line.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.10 Minimum Separation Time

Test Objective			
To verify that the PCU waits the after receiving data before the next request if the minimum separation time is set.			
Test	Step description	Expected result	Passed Test
1.	Set the minimum separation time parameter to MinSepTime = 100 and with the Layer 1 analyser in record mode change the state of a digital indication input on one of the RTUs on the test line.	The Layer 1 analyser shows the PCU waits 100ms after receipt of the RTU data transmission before it issues an acknowledgement to the RTU on the test line.	
2.	Set the minimum separation time parameter to MinSepTime = 500 and with the Layer 1 analyser in record mode change the state of a digital indication input on one of the RTUs on the test line.	The Layer 1 analyser shows the PCU waits 500ms after receipt of the RTU data transmission before it issues an acknowledgement to the RTU on the test line.	
3.	Set the minimum separation time parameter to MinSepTime = 10000 and with the Layer 1 analyser in record mode change the state of a digital indication input on one of the RTUs on the test line.	The Layer 1 analyser shows the PCU waits 10 second after receipt of the RTU data transmission before it issues an acknowledgement to the RTU on the test line.	
4.	Set the minimum separation time parameter to MinSepTime = 5000 and with the Layer 1 analyser in record mode change the state of a digital indication input on one of the RTUs on the test line.	The Layer 1 analyser shows the PCU waits 5 seconds after receipt of the RTU data transmission before it issues an acknowledgement to the RTU on the test line.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.11 DCD Back-off Time (PTT Monitoring)

Test Objective			
To verify that the PCU Supervise DCD and waits at least DCD Back-off time.			
Test	Step description	Expected result	Passed Test
1.	Set the DCD back-off time parameter to DcdBackoff = 100 and with the Layer 1 analyser in record mode change the state of a digital indication input on one of the RTUs on the test line. (Ensure the RTU used has a post PTT time set to 200ms).	The Layer 1 analyser shows the FES waited 100mS after receipt of the RTU data transmission and with the DCD still raised issues an acknowledgement to the RTU on the test line.	
2.	Set the DCD back-off time parameter to DcdBackoff = 1000 and with the Layer 1 analyser in record mode change the state of a digital indication input on one of the RTUs on the test line. (Ensure the RTU used has a post PTT time set to 100ms).	The Layer 1 analyser shows the FES waited 1000mS after receipt of the RTU data transmission and with the DCD still raised issues an acknowledgement to the RTU on the test line.	
3.	Set the DCD back-off time parameter to DcdBackoff = 2000 and with the Layer 1 analyser in record mode change the state of a digital indication input on one of the RTUs on the test line. (Ensure the RTU used has a post PTT time set to 50ms).	The Layer 1 analyser shows the FES waited 2 seconds after receipt of the RTU data transmission and with the DCD still raised issues an acknowledgement to the RTU on the test line.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.12 Communication failure on command

Test Objective			
To verify that a command to a select-before-operate digital output point fails if the command is interrupted.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture for the command DNPCMD P1 with a point configured for select before operate.		
2.	Select the command and execute it. Remove the cable to the RTU before the command has finished for a second and then return the cable immediately.	The response to the command in Network Manager is an error message - To check the name of the error message displayed.	
3.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.13 Communication error counters

Test Objective			
To verify that communication errors (short interrupts) are counted and reported and that the error counter can be reset by operator.			
Test	Step description	Expected result	Passed Test
1.	Select the information picture for DNP-RTU and note the value of the error counter.		
2.	Simulate a short communication failure by disconnecting the communication cable to the RTU for short while (some seconds).	Observe that the error counter for the RTU is increased.	
3.	Reset the error counter by pushing the appropriate button.	Observe that the error counter is reset to 0.	
4.			
5.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.14 Communication errors

Test Objective			
To verify that error on the communication line is handled properly up to and including RTU inoperable.			
Test	Step description	Expected result	Passed Test
1.	Simulate a communication disturbance by making a telegram faulty (changing the CRC) on the communication line.		
2.	Let the PCU make app. 3 retries (Depending on the setting of the MaxRetry parameter setting).	Observe the retries on the protocol analyser monitor tool.	
3.	Remove the error	RTU Recovers	
4.	Repeat Step 1 and 2 and wait until the RTU becomes inoperable.	Observe the retries on the protocol analyser monitor tool. The RTU becomes inoperable	
5.	Remove the error from the line.	Monitor the protocol messages being sent by the PCU via the protocol analyser monitor tool. The RTU becomes operable.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.15 Failure in Front End (PCU)

Test Objective			
To verify that a failure in the online front-end system results in a front-end switchover and alarms.			
Test	Step description	Expected result	Passed Test
1.	Select the single line diagram for the station DNP.		
2.	Simulate the input value ON in the RTU for the indication DNPIND S1 and acknowledge all alarms in the power system and control system. Sent a control to the breaker and got the status back (Test d20 TFRF HV BRKR)	The point change is sent to the PCU and updated in the event and alarm list. Check on the protocol analyser monitor tool that the point is sent.	
3.	Simulate a failure in the online PCU (for example PCU B) by switching off its power supply or shutting down the driver application.	The alarm indicator in the system window is red and flashing. Message in control system event list: PCU B not operable. (Inoperable) Message in control system alarm list: PCU B not operable. (Inoperable) (yellow) Message in the alarm window: PCU B not operable.(Inoperable) The presentation in the station diagram is not changed.	
4.	Simulate the input value OFF on the RTU for the indication DNPIND S1 (Send a control)	The breaker position is updated in the station diagram.	
5.	Restore the power supply to the PCU or restart the application.	After a delay of 1-2 minutes: Message in control system event list: PCU B operable. Message in control system alarm list: message disappeared.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.16 RTU line failure

Test Objective			
To verify that if all RTUs in one RTU line do not respond, PCU switch over for that RTU line will occur.			
Test	Step description	Expected result	Passed Test
1.	Acknowledge all alarms in the power and the control system.		
2.	Select the information picture for Line Unit X that is being monitored. X is an arbitrary value for the line.	Line Unit X is online on side A (PCU A) A and B side line faulty: no.	
3.	Disconnect the LAN cable of Line Unit X on PCU B.	After 10 seconds : (Put the unit out and in service, wait until all the retries are exhausted) Control system event list: Line Unit Xb faulty(Inoperable). " Line Unit Xb standby " Line Unit Xa online Control system alarm list: Line Unit Xb faulty(Inoperable) Info picture Line Unit 1: A side online, B side standby " B side line faulty: yes " A side line faulty: no	
4.	Acknowledge all alarms in the control system.	The Line Unit 65 alarm disappears.	
5.	Connect the LAN cable of Line Unit 65 on PCU B.	Control system event list: Line Unit 65a ok Info picture Line Unit 65: A side online, B side standby " B side line faulty: no " A side line faulty: no	
6.			
7.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.17 Restart of PCUs

Test Objective			
To verify that process data from RTU is presented as not updated during PCU (pair) restart.			
Test	Step description	Expected result	Passed Test
1.	Acknowledge all alarms in the power and the control system.		
2.	Select on a VDU the single line diagram of the station DNP, the single line diagram and the event and alarm lists for the control system.	All measurands and indications are presented as updated and without unacknowledged alarm.	
3.	Stop the PCU pair (PCU A and B) by switching off the power supply.	The alarm indicator in the system window is red and flashing. Single line diagram of AMHERST: all measurands and indications are presented as not updated. Single line diagram of control syst.: all RTUs which are connected to this PCU pair (RTU xy) are marked as inoperable. Control system event list: PCU A not operable " PCU B Inoperable " RTU xy Inoperable Control system alarm list: *PCU A not operable " *PCU B Inoperable " *RTU xy Inoperable	
4.	Restart the PCU pair by switching on the power supply.	After a delay of 1-2 minutes: The alarm indicator in the system window is red and flashing. Single line diagram of DNP: all measurands and indications are presented as updated. Single line diagram of control syst.: all RTUs which are connected to this PCU pair (RTU xy) are marked as operable. Control system event list: PCU A operable " PCU B operable " RTU xy operable Control system alarm list: *RTU xy operable " PCU alarms disappear.	
5.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.18 PCU RTU restart messages after receiving message from inoperable RTU

Test Objective			
To verify that the restart RTU sequence messages are sent if an unsolicited message is received from an inoperable marked RTU.			
Test	Step description	Expected result	Passed Test
1.	Disconnect an unsolicited RTU from the line		
2.	Wait for the RTU to become inoperable	Observe on the protocol analyser that the messages from the PCU are sent to the RTU with the retries exhausted before the RTU goes Inoperable.	
3.	Generate an unsolicited message from the RTU	Observe on the protocol analyser that the unsolicited message is sent and an acknowledgement is sent to the RTU as the CON=1 in the unsolicited message. After that the PCU sends an integrity poll followed by enable unsolicited reporting message to the RTU. On NM the RTU is set as operable	
4.			
5.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.19 Test Poll handling

Test Objective			
To verify that communication within the test poll interval avoids that a test poll message is sent to an RTU. TestInterval = Is the test Interval at which a test poll (reset link) message is sent to an RTU if there is no communication between the Master and the RTU for the duration set as TestInterval. If there is communication either initiated by the Master or an unsolicited message, the timer is reset.			
Test	Step description	Expected result	Passed Test
1.	Take a note of the test poll interval. TestInterval = "00:01"	If there is no communication between the RTU and the PCU for 1 minute a test poll message is sent to the RTU.	
2.	Make sure that the Integrity Poll interval and the Time synch intervals are set for an hour (2 mins for time synch). No messages should be generated from the RTU	Observe that test poll messages are sent every 2 minutes.	
3.	Generate a command to the RTU before a test poll message is due or change a binary state, say 1,5 minutes after the previous test poll	Observe in the protocol analyser monitor tool that the test poll message is not sent a minute after the control.	

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Test	Step description	Expected result	Passed Test
4.	Make sure there is no communication for at least 6 minutes after issue of the control or binary change	Observe that a test poll message will be sent to the RTU 2 minutes relative to the time after the control was sent, showing that the timer is reset every time there is communication between the RTU and the PCU.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.20 Nack Response (IIN Error bits)

Test Objective			
To verify that error codes from the RTU are reported to the NM system. Use the test set to generate the responses one by one.			
Test	Step description	Expected result	Passed Test
1.	Use the test set to generate the response, 8 = Function code not implemented	Check that error message is reported in NM, also check that the IIN is reported in the protocol analyser tool.	
2.	Use the test set to generate the response, 9 = Requested object(s) unknown	Check that error message is reported in NM, also check that the IIN is reported in the protocol analyser tool.	
3.	Use the test set to generate the response, 10 = Parameter in qualifier, range or data is not valid	Check that error message is reported in NM, also check that the IIN is reported in the protocol analyser tool.	
4.	Use the test set to generate the response, 11 = Buffer(s) overflow	Check that error message is reported in NM, also check that the IIN is reported in the protocol analyser tool.	
5.	Use the test set to generate the response, 12 = Request already executing	Check that error message is reported in NM, also check that the IIN is reported in the protocol analyser tool.	
6.	Use the test set to generate the response, 13 = Configuration is corrupt	Check that error message is reported in NM(Power System event list), also check that the IIN is reported in the protocol analyser tool.	
7.	Use the test set to generate the response, 4 = Time required(RTU not synchronised)	Check that error message is reported in NM(Power System event list), also check that the IIN is reported in the protocol analyser tool.	
8.	Use the test set to generate the response, 7 = Restart	Check that error message is reported in NM(Power System event list), also check that the IIN is reported in the protocol analyser tool.	
9.	Device Trouble = 6		
10.	Local/ Remote = 5		
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

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5.21 Integrity Scan Interval

Test Objective			
To verify that the integrity scan on absolute time intervals with a separation between each RTU is handled correct.			
Test	Step description	Expected result	Passed Test
1.	Set-up a scenario with RTUs with a start time, interval and separation time. MinSepTime = 1000, IntegrityInterval= "00:01 00:05:00"		
2.	Restart the PCU X86 application driver to make sure that the new settings are implemented. Wait for a complete cycle to let all RTUs be scanned.	Observer the start-up sequence in protocol analyser monitor tool. Check that the PCU starts to scan the RTUs according to the set-up. The scan messages shall follow the absolute time in combination with the parameters. The integrity poll will be conducted every 5 minutes, following the same sequence.	
3.	Set-up a scenario with RTUs with a start time, interval and separation time. MinSepTime = 2000, IntegrityInterval= "00:01 00:03:00"		
4.	Restart the PCU X86 application driver to make sure that the new settings are implemented. Wait for a complete cycle to let all RTUs be scanned.	Observer the start-up sequence in protocol analyser monitor tool. Check that the PCU starts to scan the RTUs according to the set-up. The scan messages shall follow the absolute time in combination with the parameters. The integrity poll will be conducted every 3 minutes, following the same sequence.	
5.	Set-up a scenario with RTUs with a start time, interval and separation time. MinSepTime = 2000, IntegrityInterval= "60"		
6.	Restart the PCU X86 application driver to make sure that the new settings are implemented. Wait for a complete cycle to let all RTUs be scanned.	Observer the start-up sequence in protocol analyser monitor tool. Check that the PCU starts to scan the RTUs according to the set-up. The scan messages shall follow the absolute time in combination with the parameters. The integrity poll will be conducted every hour, following the same sequence.	
7.	Set-up a scenario with RTUs with a start time, interval and separation time. MinSepTime = 2000, IntegrityInterval= "180"		

Test	Step description	Expected result	Passed Test
8	Restart the PCU X86 application driver to make sure that the new settings are implemented. Wait for a complete cycle to let all RTUs be scanned.	Observer the start-up sequence in protocol analyser monitor tool. Check that the PCU starts to scan the RTUs according to the set-up. The scan messages shall follow the absolute time in combination with the parameters. The integrity poll will be conducted every 3 hours, following the same sequence.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.22 RTU Polling modes

Test Objective			
To verify that the polling is done correctly for the different polling modes used by the project.			
Test	Step description	Expected result	Passed Test
1.	Start an RTU with the selected polling mode. This is determined by the RtuPoll parameter and the macros that are used.		
2.	Check the start-up sequence.	Observe in the protocol analyser monitoring tool that the start-up sequence is for the selected mode.	
3.	Wait for the PCU to switch over to the Idle mode.	Observe in the protocol analyser monitoring tool that the idle sequence is for the selected mode.	
4.	Make a status check / integrity request to the RTU.	Observe in the protocol analyser monitoring tool that the full sequence is for the selected mode.	
5.	Make an RTU out and in service test to check that the RTU start is performed	Observe in the protocol analyser monitoring tool that the start sequence is for the selected mode.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.23 Broadcast disable unsolicited start-up message handling in unsolicited lines**Test Objective**

To verify that the broadcast disable unsolicited message is handled correctly during an unsolicited line restart. Disabling of unsolicited messages at startup = DisUnsolicitedAtStart-up. Ensure the MonoLogTout = 8000ms.

Test	Step description	Expected result	Passed Test
1.	Setup the parameter DisUnsolicitedAtStart-up = "1, 2" in the ini file.		
2.	Restart the X86 driver and check the start-up sequence.	Observe in the protocol analyser monitoring tool that the start-up sequence is using the broadcast message. The first message of the start-up sequence will be the disable unsolicited broadcast message with address 65535. This message will be sent twice without any response coming back from the RTUs. The next message will be the integrity poll to the first RTU to the nth RTU on the line. This will be followed by the Enable unsolicited sent to each RTU individually.	
3.	Setup the parameter DisUnsolicitedAtStart-up = "1, 3" in the ini file.		
4.	Restart the X86 driver and check the start-up sequence.	Observe in the protocol analyser monitoring tool that the start-up sequence is using the broadcast message. The first message of the start-up sequence will be the disable unsolicited broadcast message with address 65535. This message will be sent three times without any response coming back from the RTUs. The next message will be the integrity poll to the first RTU to the nth RTU on the line. This will be followed by the Enable unsolicited sent to each RTU individually.	
5.	Setup the parameter DisUnsolicitedAtStart-up = "0, 2" in the ini file.		
6.	Restart the X86 driver and check the start-up sequence.	Observe in the protocol analyser monitoring tool that the start-up sequence does not use the broadcast message. The first message will be the integrity poll to the first RTU to the nth RTU on the line. This will be followed by the Enable unsolicited sent to each RTU individually.	
7.			
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

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5.24 Broadcast Time

Test Objective			
To verify that the broadcast time parameter operates accordingly. Set TSyncBroadcast = 1 , Ensure the MonoLogTout = 8000ms.			
Test	Step description	Expected result	Passed Test
1.	Set the parameter TSyncInterval = "120"	Observe that the write date and time broadcast message is sent to address 65533 every 1 minutes	
2.	Set the parameter TSyncInterval = "00:00 00:01:00"	Observe that the write date and time broadcast message is sent to address 65533 every 1 minutes	
3.	Set the parameter TSyncInterval = "00:00 00:07:00"	Observe that the write date and time broadcast message is sent to address 65535 every 7 minutes	
4.	Set the parameter TSyncInterval = "00:00 00:10:00"	Observe that the write date and time broadcast message is sent to address 65535 every 10 minutes	
5.	Set the parameter TSyncInterval = "00:00 01:00:00"	Observe that the write date and time broadcast message is sent to address 65533 every 60 minutes	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.25 Followup Scan at start-up

Test Objective			
To verify that the quick start parameter operates accordingly.			
Test	Step description	Expected result	Passed Test
1.	In the ini file for unsolicited set the parameter FollowupScanAtStart-up = 1 AnsTimeOutFollowupScan = 10000 ObjCommandFollowup = "5:60:2"		
2.	Restart the X86 driver / Take the line out and in service.	Observe in the protocol analyser tool that during the line restart the PCU goes through the poll macros defined in LineStart.	
3.	Send a control to the RTU before the Enable unsolicited.	Observe in the protocol analyser tool that the control is issued and immediately followed by a class 1 read message	
4.	After the Enable unsolicited message send another control	Observe that there is no class 1 read message issued	

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Test	Step description	Expected result	Passed Test
5.	In the ini file for solicited set the parameter FollowupScanAtStart-up = 0 AnsTimeOutFollowupScan = 10000 ObjCommandFollowup = "5:60:2"		
6.	Restart the X86 driver / Take the line out and in service	Observe in the protocol analyser tool that during the line restart the PCU goes through the poll macros defined in LineStart.	
7.	Send a control to the RTU before the end of the line start message	Observe in the protocol analyser tool that during the control is issued and immediately followed by a class 1 read message	
	After the Enable Unsolicited end of the line start send another control	Observe that there is a class 1 read message issued	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

5.26 ObjcommandFollowup and AnsTimeOutFollowupScan

Test Objective			
To test the functionality of the ObjcommandFollowup and AnsTimeOutFollowupScan when it comes to controls sent during unsolicited line start-up and solicited lines. Syntax for parameter setup Objcommandfollowup = "FC:GRP:VAR[:STPT][:ENDPT][:Time] AnsTimeOutFollowupScan = time (seconds) After receipt of the mirror image response from the RTU the master will send a read message as per the syntax set. After the timeout value as per AnsTimeOutFollowupScan, the PCU will move to the next unit in line. In cases where the STPT and ENDPT parameters are set, the data will be read only for that range If the time parameter is set, the Objcommandfollowup will be executed for the duration set. The number of times the message is sent is the function of the response time from the RTU and the overall Time set in Objcommandfollowup. E.g. If the AnsTimeOutFollowupScan = 100ms and the RTUs respond exactly at 100ms with the overall time set at 1000ms in the Objcommandfollowup then the number of times the message is sent will be $(1000/100) = 10$. In cases where the RTU responds even faster than the 100ms, say 50ms, then there will be $(1000/50) = 20$.			
Test	Step description	Expected result	Passed Test
1.	In the ini file for solicited set the parameter FollowupScanAtStart-up = 0 AnsTimeOutFollowupScan = 1000 ObjCommandFollowup = "5:60:2:-1:-1:500"		
2.	Restart the X86 driver or if it was restarted earlier after making the change this can be simulated by taking the line out and into scan		

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Test	Step description	Expected result	Passed Test
3.	Issue a control on one of the RTU points	Observe in the protocol analyser tool that the control is sent out, followed by the image response from the RTU. After the receipt of the response the PCU sends the read data as per the FC, Grp and variation as set in the obj. If the response is received before the time in Obj command, the master will send class 1 read messages for the duration of the AnsTimeOutFollowupScan	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

6. DNP IP parameter testing

The construct of the actual DNP 3 application layer messages is the same; simple stacked on top of the Internet Protocol (IP) suite. This section outlines the operational tests that are specific to DNP3 over IP and the related parameters. The PCU400 DNP Master (X85) acts as a protocol converter between the DNP3 protocol and the ABB Internal RTU independent protocol RSP, using TCP/IP mode of communication.

The following connections for the X85 driver will be tested.

- TCP/IP Client (LAN/WAN)
- UDP/IP
- Point to Point and Multi-Drop

6.1 TCP/IP operation testing

TCP/IP testing will focus on the parameters that are associated with the functionality of the TCP/IP setup. The following parameters will be tested:

- SSL (Secure Socket Layer) - TCP transport layer cryptographic protocol that provides security for communications over networks. The protocol allows client/server applications to communicate in a way that is designed to prevent eavesdropping, tampering, or message forgery.

6.2 TCP/IP Parameter

Test Objective			
To test the functionality of the LLdType parameters for DNP IP by setting the parameters to various values and observe functionality. For monitoring purposes, a switch needs to be utilized with a mirror port for monitoring.			
Test	Step description	Expected result	Passed Test
1.	In the ini file for solicited set the parameter sslrequired = 1 //for L45 & L46 sslkeyfilename = "server.pem" //for L45 sslpassword = "passphrase" //for L45 LldType = 46 (TCP/IP) TcpIPAdr : xxxxx (IP address of the RTU) Dnp_source_address : yyyy (Ip Address of the Master ; PCU)		

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Test	Step description	Expected result	Passed Test
2.	Restart the X85 driver or if it was restarted earlier after making the change this can be simulated by taking the line out and into scan	Observe in the protocol analyser tool that the Master restarts as expected for a TCP/IP devices on the line. The DNP 3 datagram should show that the SSL is required , with the addresses as set in the ini file.	
3.	In the ini file for solicited set the parameter sslrequired = 0 //for L45 & L46 sslkeyfilename = "server.pem" //for L45 sslpassword = "passphrase" //for L45 LldType = 46 (TCP/IP) TcpIPAdr : xxxxx (IP address of the RTU) Dnp_source_address : yyyy (Ip Address of the Master ; PCU)		
4.	Restart the X85 driver or if it was restarted earlier after making the change this can be simulated by taking the line out and into scan	Observe in the protocol analyser tool that the Master restarts as expected for a TCP/IP device on the line. The DNP 3 datagram should show that the SSL is not required (as SSL is set to 0), with the addresses as set in the ini file.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

6.3 UDP Parameter

Test Objective			
To test the functionality of the LLdType parameter for DNP using UDP by setting the parameter to various values and observe functionality.			
Test	Step description	Expected result	Passed Test
1.	In the ini file for solicited set the parameter sslrequired = 1 //for L45 & L46 sslkeyfilename = "server.pem" //for L45 sslpassword = "passphrase" //for L45 LldType = 46 (TCP/IP) UdpIpTxAdr : Default "127.0.0.1" (Localhost) UdpIpRxAAdr: Default "0.0.0.0" (Receive from all IP adress) UdpIpTxPort : Socket port no for UDP transmit LLDPORT used as Receiving portno Valid for [rtu_n] section, n = RTU # Default: 6661		

Test	Step description	Expected result	Passed Test
2.	Restart the X85 driver or if it was restarted earlier after making the change this can be simulated by taking the line out and into scan	Observe in the protocol analyser tool that the Master restarts as expected for a TCP/IP devices on the line. The DNP 3 datagram should show that the SSL is required , with the addresses as set in the ini file.	
3.	In the ini file for solicited set the parameter sslrequired = 0 //for L45 & L46 sslkeyfilename = "server.pem" //for L45 sslpassword = "passphrase" //for L45 LldType = 46 (TCP/IP) TcpIPAdr : xxxxx (IP address of the RTU) Dnp_source_address : yyyy (Ip Address of the Master ; PCU)		
4.	Restart the X85 driver or if it was restarted earlier after making the change this can be simulated by taking the line out and into scan	Observe in the protocol analyser tool that the Master restarts as expected for a TCP/IP device on the line. The DNP 3 datagram should show that the SSL is not required (as SSI is set to 0) , with the addresses as set in the ini file.	
Name of Tester:		Date:	Test Passed without exceptions?
Comments:			

7. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Thuli Tladi	Manager – Smart Grids - Telecommunications
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8. Revisions

Date	Rev	Compiler	Remarks
Jan 2025	2	S Mbanga	Editing the document and minor corrections. • Addition of OBJ3 V1 For Double bit testing • Addition of OBJ4 V 1 For Double bit Change testing • Addition of floating point testing under analogue change, OBJ 32 v7. • Deletion of duplicate section for test RTS On and RTS Off testing.
March 2017	1	S Mbanga	First issue Updating the document and transfer to the new template Conversion of the supplier document

9. Development team

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

- Simphiwe Mbanga
- Thendo Ramulondi
- Niel Myburgh
- Emmanuel Luwaca

10. Acknowledgement

Not applicable.