DNV·GL

Conformance Test Report for the IEC 61850-9-2 Sampled Values Publisher Interface in REF615

ABB oy

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Task and objective: DNV GL has performed a conformance test of the IEC 61850 9-2 Sampled Values Publisher implementation in the REF615
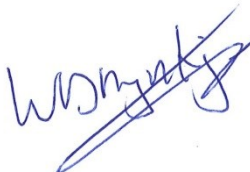
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2015-07-10	2015-07-10	2015-07-16

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☐ Secret

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Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
0	2015-07-03	First issue	N. de Bruijn	W. Nijntjes	P. Cioci
1	2015-07-10	First revision	N. de Bruijn	W. Nijntjes	P. Cioci

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1 INTRODUCTION

REF615 is a dedicated feeder protection and control relay designed for the protection, control, measurement and supervision of utility substations and industrial power systems including radial, looped and meshed distribution networks with or without distributed power generation. REF615 is a member of ABB's Relion® product family and part of its 615 protection and control product series. The 615 series relays are characterized by their compactness and withdrawable-unit design.

The scope of the test is an IED publishing IEC 61850-9-2 sampled value messages constrained by the 9-2LE guideline. For example such IED could be a merging unit. A merging unit is a physical device that converts input signals from (non) conventional CT's and/or VT's and merges the signals into a digital IEC 61850-9-2 sampled value message.

The test procedures in this document are based on the "Implementation Guideline for Digital Interface to Instrument Transformers using IEC 61850-9-2, version 2.1, July 2004" further referred to as 9-2LE.

Note: In case a 9-2LE publishing IED supports GOOSE or MMS based services to transfer binary status or control indications the applicable server conformance test procedures have to be used for the test.

1.1 Glossary

|	
DUT	Device Under Test
ICD	IED configuration description in SCL-format
IED	Intelligent Electronic Device
MICS	Model Implementation Conformance Statement
MU	Merging Unit
PICS	Protocol Implementation Conformance Statement
TICS	Technical Issues Implementation Conformance Statement
PIXIT	Protocol Implementation eXtra Information for Testing
PPS	Pulse Per Second
SCD	Substation configuration description in SCL-format
SCL	Substation Configuration Language
TISSUE	Technical issue
UCA IUG	UCA International Users Group.

1.2 Identifications

The following table gives the exact identification of tested equipment and test environment used for this conformance test.

DUT	REF615 Supported sampling rates: 80 samples per cycle Supported frequencies: 50Hz and 60Hz S/N: 1VHR91213651 SW version: 5.1 Build: 53
MANUFACTURER	ABB Oy Distribution Automation P.O. Box 699 FI-65101 Vaasa FINLAND
PICS	Protocol Implementation Conformance Statement for the IEC 61850 interface in 615 series, revision H, dated: 31 March 2015
MICS	reference to 9-2LE
TICS	reference to 9-2LE
PIXIT	Protocol Implementation extra Information for Testing (PIXIT) for the IEC 61850 9-2LE interface in 615 series, revision A, dated: 24 June 2015.
ICD or SCD	REF615_ed1.cid, configVersion = "G"
TEST INITIATOR	*MANUFACTURER*
TEST FACILITY	KEMA Nederland B.V. Protocol Competence & Test Center Utrechtseweg 310, Arnhem, The Netherlands Accredited by the UCA IUG to issue the Level A Certificates
TEST ENGINEER	Niek de Bruijn, niek.deBruijn@dnvgl.com
TEST SESSION	May-June 2015, Arnhem, The Netherlands
ANALYSER	Omicron SVScout V1.10.197 with Napatech NT4E Adapter UniCA 61850 analyzer version 5.29.02
SIGNAL GENERATOR	Omicron CMC-256(JA195S) test set
PTP TIME MASTER	Meinberg M600
MEDIA CONVERTERS	Omicron CMLIB (AM039B)

2 TEST ENVIRONMENT

The test environment consists of the following components:

– DUT = 9-2LE publisher
– Current and/or Voltage signal generator
– 9-2LE Analyzer
– PTP/PPS time master.
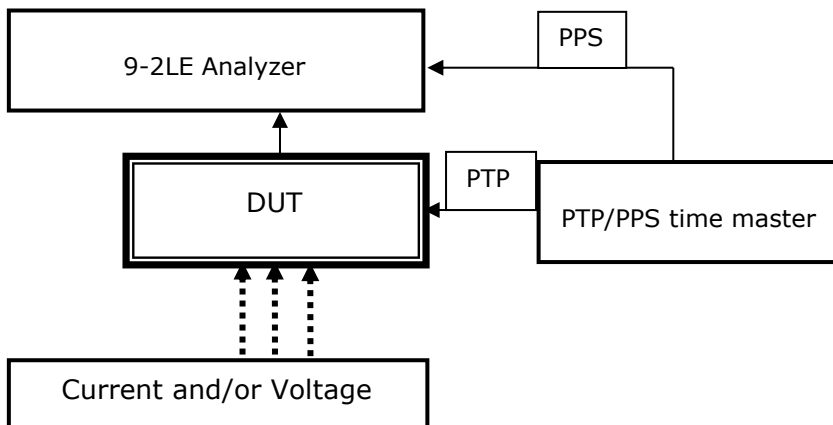
Figure 2.1 The test environment

The analyser can compare the "reference" sampled values from the signal generator with the sampled values from the DUT. The signal generator shall be accurate enough to perform the accuracy plausibility tests.

As described by the UCAIug test procedures for an IEC 61850 9-2LE conformance test for Ed.1 it is mandatory to have a PPS clock to synchronize with. However this device is not equipped with such functionality. Therefore a time master with PPS and PTP signal is used to synchronize the clocks of the Analyzer and the DUT. Because this is not as described in the official test procedures, the UCAIug cannot issue a certificate. Therefore only this report has been issued by DNV GL.

3 TEST RESULTS

Table 3.1 in this Chapter gives an overview of the conformance test results. References shown in the table columns refer to references of individual test procedures in clause 5.

The **Mandatory** column indicates the mandatory test cases with test result passed and the **Conditional** column indicates the conditional test cases with test result passed.

The **Verdict** column indicates the test result of all applicable test procedures in the test group. When one or more test procedures have test result Failed the test group receives verdict Failed.

Table 3.1   Overview of applicable test cases passed for DUT

Conformance Block	Mandatory	Conditional
Configuration	Cnf1, Cnf2, Cnf3, Cnf4, Cnf5, Cnf6, Cnf7, Cnf8	
11a Sampled Value Publishing 50 Hz, 80 samples/cycle	Svp1, Svp2, Svp3, Svp6, Svp10, Svp11, Svp15	Svp4, Svp7, Svp8, Svp12, Svp13, Svp16
11a Sampled Value Publishing 60Hz, 80 samples/cycle	Svp1, Svp2, Svp3, Svp6, Svp10, Svp11, Svp15	Svp4, Svp7, Svp8, Svp12, Svp13, Svp16

Table 3.2   Overview of applicable test cases failed, inconclusive or comments for DUT

Conformance Block	Inconclusive	Failed	Comment
11a 50 Hz, 80 samples/cycle		Svp14	See recommendations
11a 60 Hz, 80 samples/cycle		Svp14	See recommendations

4 CONCLUSION AND RECOMMENDATONS

Based on the test results described in this report, DNV GL declares the tested IEC 61850 implementation in the DUT has **shown to be non-conforming** to 9-2LE as specified in the PICS, PIXIT and ICD and configured according to the SCD.

4.1 Recommendations following from the test

The following comments and recommendations apply for the *DUT*:

- During the test it was noted that PPS support was not available, we recommend, in order being fully compliant with the IEC 61850 9-2LE standard, to implement a PPS clock synchronisation mechanism. Documentation specifies IEEE 1588 v2 is also supported.

5 TEST PROCEDURES FOR 9-2LE PUBLISHERS

5.1 Documentation

Id	Test procedure	Verdict
Doc1	Check if the manufacturer documentation and hardware / software versions of the DUT do match: a PICS b MICS (reference to 9-2LE) c PIXIT d TICS (reference to 9-2LE).	Passed
Doc2	Verify the PIXIT matches the PIXIT template from the test procedures document.	Passed

5.2 Configuration

Id	Test procedure	Verdict
Cnf1	Test if the ICD configuration file conforms to the SCL schema (IEC 61850-6).	Passed
Cnf2	Check if the SCL configuration file corresponds with the actual names, data-sets, and values exposed by the DUT on the network. For ICD: MsvID = xxxxMUnn01 or xxxxMUnn02, ConfRev=1, APPID = 0x4000 For SCD: MsvID and all SV communication parameters.	Passed
Cnf3	Check if the server "SMVSettings" capabilities in the ICD "services" section do match with the IED capabilities.	Passed
Cnf4	Verify the name and logical nodes (LLN0, LPHD, InnATCTR1, InnBTCTR2, InnCTCTR3, InnNTCTR4, UnnATVTR1, UnnBTVTR2, UnnCTVTR3, UnnNTVTR4) of the logical device "xxxxMUnn" (9-2LE table 4) in the SCL.	Passed
Cnf5	Verify the logical node LLN0 of the logical device xxxxMUnn (9-2LE table 5) in the SCL: – dataset "PhsMeas1" – sampled value control block "MSVCB01"or "MSVCB02".	Passed
Cnf6	Verify the dataset PhsMeas1 (9-2LE table 6) in the SCL.	Passed
Cnf7	Verify the common data class SAV and scale factor values (9-2LE table 7) in the SCL: 0.001 for current; 0.01 for voltage.	Passed
Cnf8	Verify the Multicast sampled value control block "MSVCB01" and/or "MSVCB02" (9-2LE table 8 and table 9) in the SCL.	Passed
Cnf9	Verify that if the device does not supply all samples, 'dummy' SAV data objects might be referenced in the data set. To detect the difference between dummy and real samples in the SCL, the ICD shall have all LN's included but the ones that are not supported have the LN Mode preconfigured to "Off".	Not applicable

5.3 Communication services

5.3.1 Abstract test cases

Test ID	Test Case	M/C
Svp1	Verify that the maximum delay time from taking the sample to sending the corresponding message is within the limit specified in IEC 60044-8 clause 5.3.2 Note 2: 3 ms (+10%/100%).	M
Svp2	Verify that physical layer is 100Base-FX full duplex with ST or MT-RJ connectors or 100Base-TX with RJ45 connector.	M
Svp3	Verify that the format of the link layer matches with 9-2LE Annex A figure 3.	M
Svp4	Verify that application layer matches with MSVCB01: APDU with 1 ASDU (9-2LE Annex A figure 4).	C1
Svp5	Verify that application layer matches with MSVCB02: APDU with 8 ASDU (9-2LE Annex A figure 4).	C1
Svp6	Verify the format of the ASDU matches with 9-2LE Annex A figure 5.	M
Svp7	Verify that the calculated neutral samples have the derived quality bit set.	C2
Svp8	Verify that the MSVCB01 samples are transmitted with 80 messages per cycle.	C1
Svp9	Verify that the MSVCB02 samples are transmitted with 32 (256/8) messages per cycle.	C1
Svp10	Verify that SmpCnt will be incremented each time a new sampling value is taken. The counter shall be set to zero if the sampling is synchronised by clock signal (SmpSynch = TRUE) and the synchronising signal occurs. The value zero shall be given to the data set where the sampling of the primary current coincides with the sync pulse.	M
Svp11	Verify that the sampled values match with the analog signals.	M
Svp12	Verify that the voltage scaling parameters are configured as specified in the PIXIT and correctly applied.	C3
Svp13	Verify that the current scaling parameters are configured as specified in the PIXIT and correctly applied.	C3
Svp14	Verify that the DUT is synchronised with PPS signal. Verify that in case the PPS signal is lost, the SmpSynch in the SV message shall be set to FALSE. "SmpCnt" shall wrap as if a synchronization pulse would be present.	M
Svp15	Verify that after restoring the power the DUT shall publish valid 9-2 messages within specified time (PIXIT).	M
Svp16	Verify that in TEST mode the quality bit TEST is set for each sample (PIXIT).	C4
Svp17	Signals that are not measured or calculated shall have the corresponding Quality bit = Invalid.	C5

Conditions	
C1 =	at least 80 or 256 sample rate shall be supported
C2 =	mandatory in case neutral values are calculated
C3 =	mandatory in case the DUT is connected to a conventional CT/VT
C4 =	mandatory in case TEST mode is supported
C5 =	mandatory in case DUT does measure less than 3 currents and 3 voltages or the DUT supports Quality = Invalid.

5.3.2 Detailed test procedures

Svp1	Verify that the maximum delay time from taking the sample to sending the corresponding message is within the limit	Passed
9-2LE clause 5 IEC 60044-8 clause 5.3.2 note 2[1] PIXIT		
Expected result 2 DUT samples the signals as configured 3 DUT sends sampled value messages. The measured delay time shall be less than 3 ms (+10% / -100%). The measured delay time is defined as the fraction of second of the capture time of the message with SmpCnt=0 4 Maximum delay does not exceed value specified in PIXIT.		
Test description 1 Configure the DUT with the correct parameters 2 Generate 50 Hz current and/or voltage signals 3 Capture the sampled values messages for 1 minute 4 Repeat step 1 to 3 five times 5 Repeat step 1 to 4 for 60 Hz and other sampling rates.		
Comment Note: the test case is passed when the measured delay time is below the specified limit. The measured delays are: − 50 Hz and 80 samples = min 1.679 ms max 1.689 ms (PIXIT 1.7 milliseconds) − 60 Hz and 80 samples = min 1.412 ms max 1.418 ms (PIXIT 1.7 milliseconds)		

Svp2	Verify that physical layer is 100Base-FX full duplex with ST, LC or MT-RJ connectors or 100Base-TX with RJ45 connector	Passed
9-2LE clause 6.2.1		
Expected result 3 DUT sends sampled value messages on the configured connector 6 DUT sends sampled value messages on the configured connector.		
Test description 1 Configure the DUT using the copper connection 2 Generate current and/or voltage signals 3 Capture the sampled values messages for 1 minute 4 Configure the DUT using the fiber connection 5 Generate current and/or voltage signals 6 Capture the sampled values messages for 1 minute.		
Comment DUT has 100Base-TX full duplex with RJ connectors .		

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[1]   IEC 60044-8 clause 5.3.2: NOTE 2 If the merging unit is intended to be used with synchronization pulses, the rated delay time is 3 ms (+10% − 100%) for all data rates, since it is not relevant for phase error.

Svp3	Verify the format of the link layer	Passed
9-2LE Annex A figure 3, clause 6.2.2		
Expected result		

3   DUT sends sampled value messages with the following format of the link layer:
   –   destination MAC address   = 01-0C-CD-04-xx-xx
   –   TPID   = 0x8100
   –   VLAN priority as configured (default = 4)
   –   VLAN ID as configured (default = 0x000)
   –   Ether type   = 0x88BA
   –   APPID   = 0x4000
   –   reserved 1   = 0x0000
   – reserved 2 = 0x0000.		

Test description		
1 Configure the DUT 2 Generate current and/or voltage signals 3 Capture the sampled values messages for 1 minute.		
Comment		

Svp4	Verify that application layer matches with MSVCB01: APDU with 1 ASDU	Passed
9-2LE Annex A figure 4, clause 7.1.4		
Expected result		

3   DUT sends sampled value messages with 1 ASDU
   –   noAsdu = 1
   –   svID = xxxxMUnn01
   –   smpCount = 0..3999 (50Hz) or 0..4799 (60Hz)
   –   confRev = 1
   –   smpSynch = TRUE in case PPS is connected
   –   sequence of data
   – refresh time and sample rate are not present.		

Test description		
1 Configure the DUT 2 Generate current and/or voltage signals 3 Capture the sampled values messages for 1 minute.		
Comment		
During the test, instead of a PPS clock, a PTP clock is used. Since this device does not support PPS.		

Svp6	Verify the format of the ASDU dataset	Passed

9-2LE Annex A figure 5

Expected result

3	DUT sends sampled value messages with the correct format of the ASDUs
	− 4 phase Currents
	− 4 phase Voltages
	− Not supported values are 0 and have the corresponding invalid quality bit set.

Test description

1	Configure the DUT with the correct sample rate
2	Generate current and/or voltage signals
3	Capture the sampled values messages for 1 minute.

Comment

Svp7	Verify that the calculated neutral samples have the derived quality bit set	Passed

9-2LE clause 6.2.3

Expected result

3	DUT sends sampled value messages with the correct format of the ASDUs
	− Calculated neutral values have the derived quality bit (0x2000) set.

Test description

1	Configure the DUT with the correct sample rate
2	Generate current and/or voltage signals
3	Capture the sampled values messages for 1 minute

Comment

Svp8	Verify that the MSVCB01 samples are transmitted with 80 messages per cycle	Passed

9-2LE clause 7.1.4

Expected result

2	DUT samples the signals as configured
3	In one minute DUT sends 240000±1 sampled value messages for 50 Hz and 288000±1 messages for 60 Hz.

Test description

1	Configure the DUT with the correct parameters
2	Generate 50 Hz current and/or voltage signals
3	Capture the sampled values messages for 1 minute
4	Repeat step 1 to 3 five times
5	Repeat step 1 to 4 for 60 Hz.

Comment

Svp10	Verify that SmpCnt will be incremented and reset	Passed
9-2LE clause 7.2.1		

Expected result

3 DUT sends sampled value messages.

  – SmpCnt is incremented at each sample (ASDU)

  – SmpCnt value zero shall be given to the data set where the sampling of the primary current coincides with the sync pulse (plausibility check)

5 If the merging unit does not receive a synchronization signal SmpCnt shall wrap as if a synchronization pulse would be present.

Test description

1 Configure the DUT with the correct parameters

2 Generate 50 Hz current and/or voltage signals

3 Capture the sampled values messages for 1 minute

4 Disconnect the PPS

5 Capture the sampled values messages for 1 minute

6 Repeat step 1 to 5 for 60 Hz.

Comment

The SmpCnt zero at synch pulse is a plausibility check not an accuracy test.

During the test, instead of a PPS clock, a PTP clock is used. Since this device does not support PPS.

Svp11	Verify that the sampled values match with the analog signals	Passed

9-2LE Annex C and Annex D

Expected result

3   Voltages
- If VN is calculated, check that VN is equal to VA, VB, VC when applying 1 phase voltage
- When applying a symmetrical 3 phase voltage system the calculated VN is close to zero
- When applying the same voltage to VA, VB, VC, the magnitude and polarity are the same and VN is 3 times the magnitude of a phase voltage

     Currents
- If IN is calculated, check that IN is equal to IA, IB, IC when applying 1 phase current
- When applying a symmetrical 3 phase current system the calculated IN is close to zero
- When applying "line-to-line" current, the magnitude is the same and the polarity has the opposite value, IN is close to zero.

Test description

1   Configure the DUT with the correct parameters 50 Hz

2   Generate the following 50 Hz current and/or voltage signals for 3 phase signal generator:
- 10 seconds symmetrical 3 phase
- 10 seconds per phase: A -> B -> C

     OR for one phase test generator:
- 10 seconds inject same voltage to A, B and C
- 10 seconds inject "line-to-line" current into 2 phases A-B
- 10 seconds inject "line-to-line" current into 2 phases B-C
- 10 seconds inject "line-to-line" current into 2 phases C-A
- 10 seconds per phase: A -> B -> C

3   Capture the sampled values messages

4   Repeat step 1 to 3 for 60 Hz.

Comment

This is a plausibility check not an accuracy test.

Svp12	Verify that the voltage scaling parameters are configured as specified in the PIXIT and correctly applied	Passed

9-2LE Annex C and Annex D PIXIT

Expected result

3   Voltages
- The magnitude of sampled values for VA, VB, VC, (VN) match applied voltage.
- The configured scaling parameters (VT ratios) are correctly taken into account.

Test description

1   Configure the DUT with the correct parameters 50 Hz

2   Generate the following 50 Hz voltage signals
- 15 seconds all 3 phases
- 15 seconds per phase: A -> B -> C

3   Capture the sampled values messages

4   Repeat step 1 to 3 for 60 Hz.

Comment

This is a plausibility check not an accuracy test.

Svp13	Verify that the current scaling parameters are configured as specified in the PIXIT and correctly applied	Passed
9-2LE Annex C and Annex D PIXIT		
Expected result		
3	- The magnitude of sampled values for IA, IB, IC, (IN) match applied current. - The configured scaling parameters (CT ratios) are correctly taken into account.	
Test description		
1	Configure the DUT with the correct parameters 50 Hz	
2	Generate the following 50 Hz current signals	
	− 15 seconds all 3 phases	
	− 15 seconds per phase: A -> B -> C	
3	Capture the 9-2 sampled values messages	
4	Repeat step 1 to 3 for 60 Hz.	
Comment		
This is a plausibility check not an accuracy test.		

Svp14	Verify that the DUT is synchronised with PPS signal	Failed
9-2LE clause 7.2.1 PIXIT		
Expected result		
3	When PPS is connected DUT sends sampled value messages with SmpSynch = TRUE. When PPS is disconnected and when DUT has left the hold-over mode it sends messages with SmpSynch = FALSE.	
Test description		
1	Configure the DUT with the correct parameters	
2	Generate 50 Hz current and/or voltage signals	
3	Capture the sampled values messages, disconnect the PPS after 10 seconds and connect it again after 1.5 times the specified holdover time	
4	Repeat step 1 to 3 for 60 Hz.	
Comment		
For this test PPS was not used, since the device does not support this. We have used a PTP clock to set up the time synchronization mechanism. When disconnecting the time master from the DUT, the SmpSynch will be set to false and after 2-3 seconds the DUT becomes the time master itself and set the SmpSynch to true.		

Svp15	Verify that after restoring the power the DUT shall publish valid 9-2 messages within specified time (PIXIT).	Passed
9-2LE clause 7.2.1 PIXIT		
Expected result		
3	DUT sends valid sampled value messages within the PIXIT specified time after restoring the power.	
Test description		
1	Configure the DUT with the correct parameters	
2	Generate 50 Hz current and/or voltage signals, after 10 seconds disconnect and restore the power supply	
3	Capture the sampled values messages until valid samples are transmitted	
4	Repeat step 1 to 3 for 60 Hz.	
Comment		

Svp16	Verify that in TEST mode the quality bit TEST is set for each sample (PIXIT)	Passed
9-2LE clause 7.2.1 PIXIT		
Expected result		
3	DUT sends sampled value messages with quality bit TEST (0x0800) for each sample.	
Test description		
1	Configure the DUT with the correct parameters and enable TEST mode	
2	Generate 50 Hz current and/or voltage signals	
3	Capture the sampled values messages for 1 minute	
4	Repeat step 1 to 3 for 60 Hz.	
Comment		

Svp17	Signals that are not measured or calculated shall have the corresponding Quality bit = Invalid (PIXIT)	Passed
9-2LE clause 7.1.3 PIXIT		
Expected result		
3	Signals that are not measured or calculated or as specified in the PIXIT shall have the corresponding Quality bit Invalid (0x0001).	
Test description		
1	Configure the DUT as specified in the PIXIT	
2	Generate 50 Hz current and/or voltage signals	
3	Capture the sampled values messages for 1 minute	
4	Repeat step 1 to 3 for 60 Hz.	
Comment		

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