Base Load Power Hub (BLPH)

THIRD PARTY COMMUNICATION TEST PROCEDURE

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

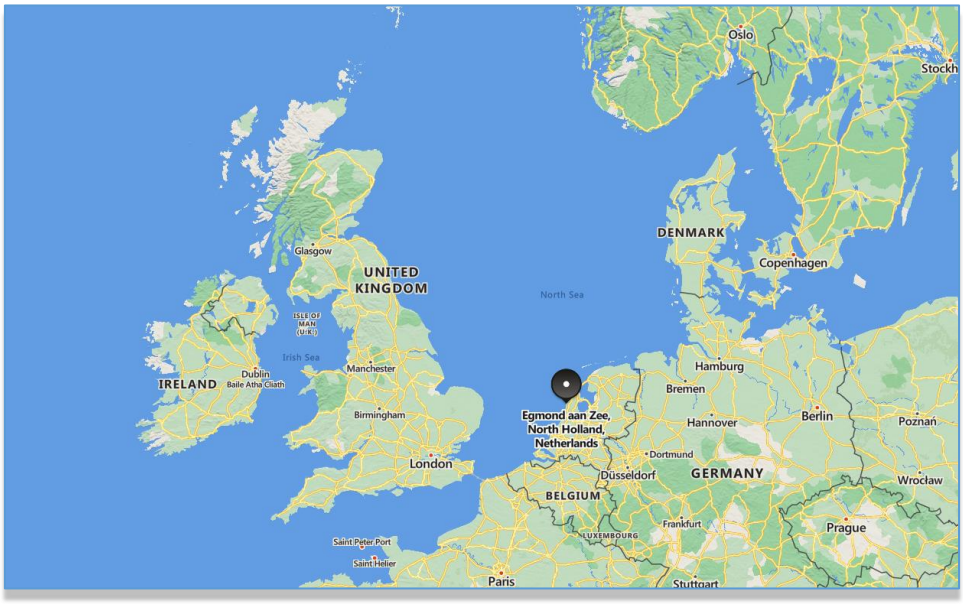


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

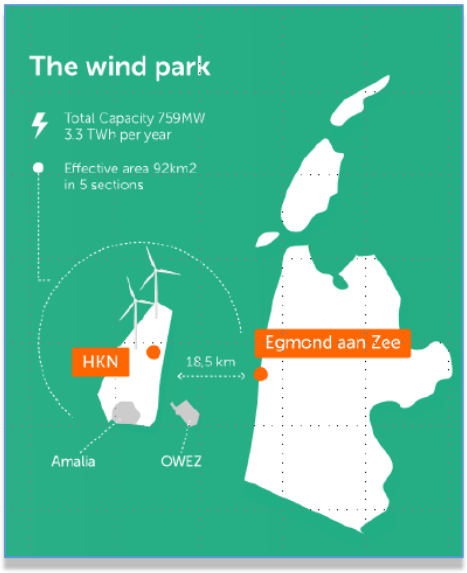


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

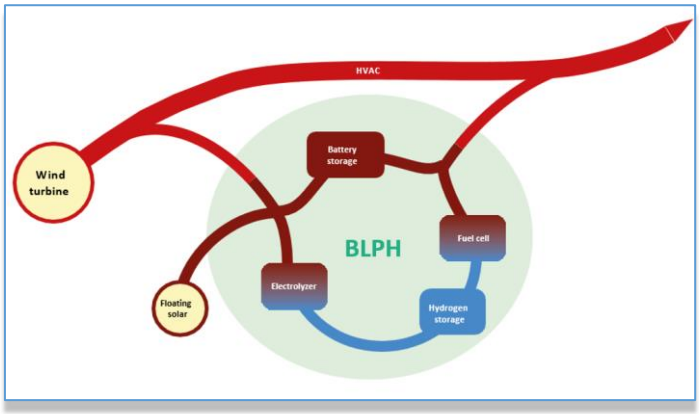


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 DOCUMENT SCOPE

The purpose of this package communication test procedure document is to define the check and test activities to be performed, in order to test communication of subsystem packages with Yokogawa PAS.

3 CONTRACTOR REFERENCE DOCUMENTS

MAIN CONTRACTOR Project Documents :

#	**Company Doc. No.**	**TITLE**
C01		
C02		
C03		
C04		
C05		
C06		
C07		
C08		
C09		
C10		
C12		
C13		
C14		
C15		
C17		
C18		
C19		
C20		
C21		
C22		
C23		
C24		
C25		
C26		

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4 VENDOR REFERENCE DOCUMENTS

MAIN VENDOR Project Documents:

#	Company Doc. No.	TITLE
V01		
V02		
V03		
V04		
V05		
V06		
V07		
V08		
V09		
V10		
V11		
V12		
V13		
V14		
V15		
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V24		
V25		
V26		
V27		

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#	Company Doc. No.	TITLE
V28		
V29		
V30		
V31		
V32		
V33		
V34		
V35		
V36		
V37		
V38		
V39		
V40		
V41		
V42		

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5 TEST PURPOSE

This Test Procedure is organized in a collection of Inspection Data Sheets that cover the test to be executed in customer or subsystem vendor premises.

The tests covered in this document are related only to serial communication between Yokogawa PAS (Process Automation System, including EMCS) and 3rd party systems.

6 TEST PREREQUISITES PCS

In order to perform the test, Yokogawa will use a demo system consisting of the subsequent components:

- Engineering Workstation (with CENTUM VP software) and monitor.
- AFV30D DCS rack with single CPU.
- Single or redundant communication card (ALE111 for Modbus TCP, A2PL131 for Profinet).

If the test will be performed at subsystem vendor premises, Yokogawa is expecting to have availability of :

- 240V 50Hz power supply.
- CAT5E or CAT6 network cables.
- Network apparatus (e.g. switches), if deemed necessary for the specific test.

Moreover, availability of documents concerning the serial link to be tested is a necessary prerequisite, in order to proceed with the actual test. The minimum required information is :

- Interface protocol to be used.
- Communication parameters (IP address, subnet mask, device parameters, device tag when applicable, communication speed when applicable).
- Communication maps, specifying for each signal to be tested :
    - Tag
    - Address
    - Description
    - Data type
    - Data access (read/write)
    - Range
    - Scale
    - Offset
    - Engineering Unit (if applicable)

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7 TEST PREREQUISITES EMCS

The test must check the connection and the data exchange between the EMCS and the BLPH packages and WindFarm server.

To perform the test, Yokogawa will use a system equivalent to the final system consisting of an industrial PC and the required protocol clients: MODBUS TCP, OPC-UA, PROFINET, IEC-61850.

If the test will be performed at subsystem vendor premises, Yokogawa is expecting to have availability of :

- 240V 50Hz power supply.
- CAT5E or CAT6 network cables.
- Network apparatus (e.g. switches), if deemed necessary for the specific test.

Availability of documents concerning the communication interface is a necessary prerequisite, in order to proceed with the actual test. The minimum required information is :

- Interface protocol to be used.
- Communication parameters (IP address, subnet mask, device parameters, device tag when applicable, communication speed when applicable).
- Communication maps, specifying for each signal to be tested :
    - Tag
    - Address
    - Description
    - Data type
    - Data access (read/write)
    - Range
    - Scale
    - Offset
    - Engineering Unit (if applicable)

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8 SERIAL LINK VALIDATION

This chapter describes the tests that will be executed during the "Serial Link Communication tests".

To perform the complete test, the subsystem Vendor's presence (and relevant hardware) is required.

The following tests shall be performed for each Serial Link Communication.

The protocols considered will be Modbus TCP, Profinet, and IEC61850.

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TEST Form 2.1				
Vendor REFERENCE :				
PROJECT :		**System :**	PAS	Rev. 0
Item Description:	Configuration capabilities file to be verified (applicable to Profinet and IEC61850)			
PRELIMINARY	The Capabilities file of the subsystem vendor should be available. It is recommended to make the file available before the actual test, for preliminary checks and configuration.			
SCOPE	Availability of correct capabilities file (i.e. GSDML file) should be verified.			
REF. DOCUMENTS	Relevant vendor document indicating the file name and version.			
PROCEDURE	The import of the correct capabilities file should be verified in PAS engineering station			

EXPECTED RESULT	The file is correct, and the revision is the same indicated by the subsystem vendor.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

TEST Form 2.2				
Vendor REFERENCE :				
PROJECT :		**System :**	PAS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between PAS and subsystem.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides.			

EXPECTED RESULT	Observe that there is no communication fault on PCS and on subsystem. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

TEST Form 2.3				
Vendor REFERENCE :				
PROJECT :		**System :**	PAS	Rev. 0
Item Description:	Soft Link Digital Input/Output test (if any)			
PRELIMINARY	The test should be performed with subsystem vendor assistance.			
SCOPE	Verify the communication for all digital signals between PAS and subsystem on Engineering Workstation interface. Verify that it is possible to read and write signals as specified in Signal List: • "read" signals will be generated/forced by 3rd party and checked on Yokogawa test equipment side; • "write" signals will be generated/forced by Yokogawa and checked on 3rd party's side.			
REF. DOCUMENTS	Relevant Signal List Relevant Control Narrative			
PROCEDURE	With the subsystem vendor's assistance, verify that each subsystem digital signal corresponds to the same PAS digital signal.			

EXPECTED RESULT	No mismatch occurs between subsystem and PAS signals.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

TEST Form 2.4				
Vendor REFERENCE :				
PROJECT :		**System :**	PAS	Rev. 0
Item Description:	Soft Link analog Input/Output test (if any)			
PRELIMINARY	The test should be performed with subsystem Vendor assistance.			
SCOPE	Verify the communication for all analog signals between PAS and subsystem on Engineering Workstation interface. Verify that it possible to read and write signals as specified in Signal List: • "read" signals will be generated/forced by 3rd party and checked on Yokogawa test equipment side; • "write" signals will be generated/forced by Yokogawa and checked on 3rd party's side.			
REF. DOCUMENTS	Relevant Signal List Relevant Control Narrative			
PROCEDURE	With the subsystem vendor's assistance, verify that each subsystem analog signal corresponds to the same PAS analog signal.			

EXPECTED RESULT	No mismatch occurs between subsystem and PAS signals.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

TEST Form 2.5				
Vendor REFERENCE :				
PROJECT :		**System :**	PAS	Rev. 0
Item Description:	Diagnostic routines, System alarms check			
PRELIMINARY	The PAS Engineering Workstation shall be available. The presence of subsystem Vendor is necessary to perform this test.			
SCOPE	Verify the correct detection of any fault of system under test.			
REF. DOCUMENTS	Yokogawa Instruction Manuals Vendor manuals			
PROCEDURE	Verify that in case of any fault/disconnection related to the communication with the package, the Yokogawa PAS generates an alarm that is available in PAS system alarm list. This will be verified on Engineering Workstation interface.			

EXPECTED RESULT	Each failure will be correctly identified and alarmed in the System Alarm view.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

TEST Form 2.6				
Vendor REFERENCE :				
PROJECT :		**System :**	PAS	Rev. 0
Item Description:	Redundancy test (applicable only for Floating Solar Farm)			
PRELIMINARY	The PAS engineering test station shall be available. The presence of Subsystem Vendor is necessary to perform this test.			
SCOPE	Verify the correct functionality of the system in case one of the redundant communication components fails.			
REF. DOCUMENTS	-			
PROCEDURE	1. Power off any redundant communication component any verify that the communication is still up. 2. Remove the Ethernet cable from Primary PAS card and observe that there is no failure in communication.			

EXPECTED RESULT	The redundancy functionality is achieved if there is no failure.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS	The test will pass if the above functionality is achieved.			
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

9 TEST EMCS COMMUNICATION WITH BESS PACKAGE

TEST Form 3.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and BESS Package through PROFINET protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the package.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on BESS. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐	FAIL ☐		
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

10 TEST EMCS COMMUNICATION WITH FUEL CELL PACKAGE

TEST Form 4.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and FUEL CELL Package through MODBUS TCP protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the package.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on FUEL CELL. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

11 TEST EMCS COMMUNICATION WITH SOLAR FARM PACKAGE

TEST Form 5.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and Solar Farm Package through MODBUS TCP protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the package.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on Solar Farm. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

12 TEST EMCS COMMUNICATION WITH ELECTROLYZER PACKAGE

TEST Form 6.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and Electrolyzer Package through PROFINET protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the package.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on Electrolyzer. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

13 TEST EMCS COMMUNICATION WITH WIND FARM PACKAGE

TEST Form 7.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and Wind Farm Package through OPC-UA protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the package.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on Wind Farm. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

14 TEST EMCS COMMUNICATION WITH BLPH-GIS

TEST Form 8.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and GIS through IEC-61850 protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the package.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on GIS. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

15 TEST EMCS COMMUNICATION WITH MV SWITCHGEAR SG-100D1

TEST Form 9.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and MV SWITCHGEAR SG-100D1 through IEC-61850 protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the package.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on MV SWITCHGEAR SG-100D1. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

16 TEST EMCS COMMUNICATION WITH LV SWITCHGEAR SG-200N1

TEST Form 10.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and LV SWITCHGEAR SG-200N1 through IEC-61850 protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the device.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on LV SWITCHGEAR SG-200N1. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

17 TEST EMCS COMMUNICATION WITH SOLAR LV SWITCHGEAR SG-200D2

TEST Form 11.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and SOLAR LV SWITCHGEAR SG-200D2 through MODBUS-TCP protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the device.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on SOLAR LV SWITCHGEAR SG-200D2. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐	FAIL ☐		
COMMENTS				
TEST DATE :				
CLOSED DATE :				
	Vendors			
	Signature	Signature	Signature	Signature

18 TEST EMCS COMMUNICATION WITH AVR OF TRANSFORMER TR-100AD

TEST Form 12.1				
Vendor REFERENCE :				
PROJECT :		**System :**	EMCS	Rev. 0
Item Description:	Communication and configuration check			
PRELIMINARY	To perform this test, it is necessary that the Vendor's subsystem with the hardware necessary for communication is present; otherwise, the test cannot proceed.			
SCOPE	Verify the correct connectivity between EMCS and AVR OF TRANSFORMER TR-100AD through MODBUS-TCP protocol.			
REF. DOCUMENTS	Relevant Signal List			
PROCEDURE	After subsystem soft link connection is established, verify that the connections are Healthy and permanent for both sides. Read the signals that are readable and check if the operations return a value. Write the commands and check if feedback is returned by the device.			

EXPECTED RESULT	Observe that there is no communication fault on EMCS and on AVR OF TRANSFORMER TE-100AD. For both systems, diagnostics information indicates no errors.			
TEST RESULTS	PASS ☐ FAIL ☐			
COMMENTS				
TEST DATE :				
CLOSED DATE :				

19 PENDING POINT LIST

Pending Points List (Punch List)				
Vendor REF :				**PP n°:** P .
PROJECT :		**SYSTEM :**		

Pending Point Number	Description	Issued Date	Closed Date

	Yokogawa Signature	Signature	Signature	Signature	

20 PENDING POINT FORM

Pending Points Form		
		sheet of
Vendor REFERENCE :		
PROJECT :		
PENDING POINT NUMBER :		
TEST DESCRIPTION :		
SYSTEM :		
ISSUED DATE :		
DESCRIPTION :		
SOLUTION :		

COMMENTS :				
TEST DATE :				
CLOSED DATE :				
Vendors	**Yokogawa**			
Signature	Signature	Signature	Signature	Signature