Power Potential

DER Test Specification v1.2.3

November 2018

Contents

1. Introduction

The Power Potential project (previously called the Transmission and Distribution Interface 2.0 project) is a joint effort between National Grid Electricity System Operator (NG ESO) and UK Power Networks (UKPN) to find an innovative solution to technical constraints experienced at the transmission level.

The project is focused in the South-East area of England and there are four existing Grid Supply Points (GSP) in scope for the project: Bolney, Ninfield, Sellindge and Canterbury North. The transmission network, and the areas within the distribution network at this location are at the limit of capacity for transferring generation away from the area. This means for particular faults or conditions on the transmission network, voltage levels at certain points could reach values that can violate statutory voltage limits. This constraint is preventing additional generation from being able to connect to the South-East transmission or distribution networks. To enable more generation to connect, large-scale network investment is traditionally required. The Power Potential project aims to find an innovative solution to help manage transmission constraints by providing power services to the NG ESO from Distributed Energy Resources (DERs) connected to UK Power Networks' distribution network. This will ultimately facilitate faster and cheaper alternative DER connections and will reduce the operating costs currently being incurred in managing the existing limitations in this area.

The project aims to create a regional reactive power market for the first time in UK which will help defer network reinforcement needs in the transmission system. DER can also bid for active power services in the Power Potential project. The project has the following key deliverables:

1. A commercial framework using market forces to create new services provided from DER to National Grid ESO via UK Power Networks.

2. A technical and market solution known as Distributed Energy Resources Management System (DERMS) to support technical and commercial optimisation and dispatch. It includes gathering bids from DER and presenting an optimised view of the services to NG ESO split by GSP. The DERMS will be installed in the UKPN's control room.

Figure 1 presents the operation of major components from the Power Potential control system between National Grid ESO, UK Power Networks and DER.

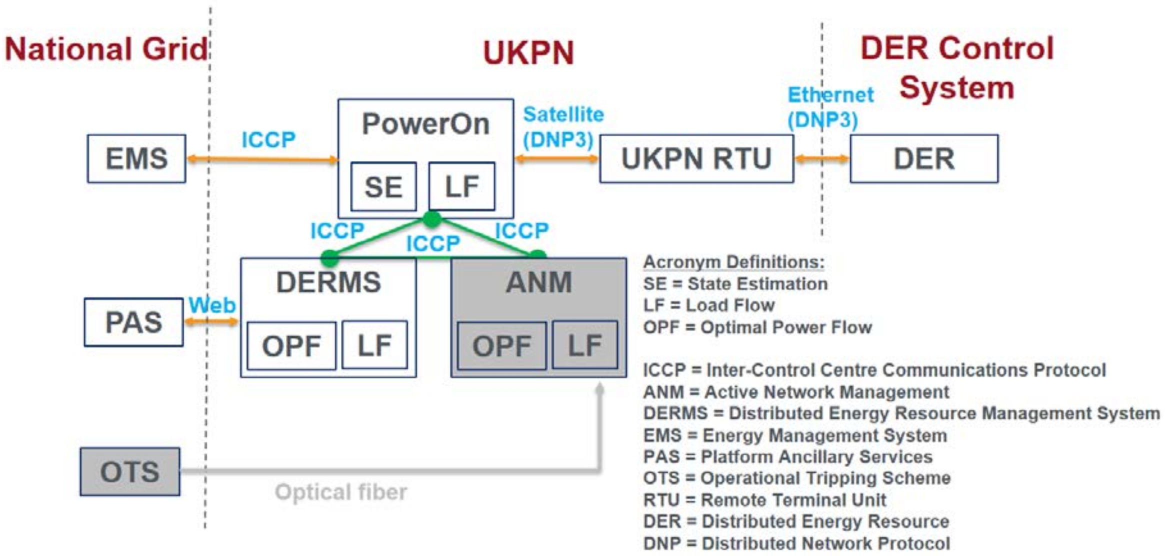


Figure 1 - Power Potential main communication paths between National Grid ESO, UK Power Networks and DER

2. Purpose of this document

This document presents the DER Test Specification details for the DERMS deployment, specifically the interface testing between UKPN Remote Terminal Unit (RTU) and DER. The test scope includes real time data exchange between UKPN RTU and DER (non-functional), as well as DER capability/performance test (functional). The test specification, as set out in this document, includes the following components:

1. DER control system
2. UKPN RTU

The DER Test Specification defines a suite of tests used to ensure that all functions as described in the *DER Technical Requirements* document are met. The test specifications provide an overview of the test procedure and details the individual tests performed at each stage of testing. A detailed test procedure will be provided in a separate document *"DER Commissioning Test Procedure"*. The test procedure consists of tests that are associated with on-site testing only.

The complexity of the deployed DERMS control system (i.e. the number of measurement points, thresholds and generators) and the resulting multitude of possible states mean that the tests outlined in this specification are designed to be representative in that, while all functions are tested, they do not necessarily cover every possible combination of conditions for each system component.

This document will capture the following for each of the test cases:

3. Requirements and description of test case
4. Input data required for the test
5. Steps to conduct the test (outline only, detailed steps will be in the DER Commissioning Test Procedure document)
6. Expected output/results

The DER Test Specification herein does not include:

7. The market system, commercial framework design and other DER user interface related tests for DERMS
8. DERMS to DER aggregator interface

3. Test Strategy and Documents

UKPN has defined a test strategy for the overall Power Potential project. As part of this strategy, this document includes two stages for the DER commissioning including lab integration and on-site testing. It is to be noted that the test for time synchronisation between UKPN RTU and DER controller will be performed as part of site-commissioning test.

a. Lab Testing Environment

The purpose of this environment is to bench test the integration between the different systems in the Power Potential solution. The integrated system will be performed at the UKPN control centre test environment as shown in **Figure 2**. The UKPN test lab will have facility for integration with the site devices, which includes a UKPN RTU and a DER control system. It is strongly advised (but not a requirement for trial participation) that the DER test engineer will bring an actual DER controller (similar to the one available at their site) for UKPN lab testing. If a DER control system is not a feasible option then a DNP3 slave simulator with all the DER IO points mapped, can be used.

The UKPN lab test environment is a preferred architecture for testing the UKPN RTU integration with the DER controller as full integration can be tested prior to on-site testing cutover. The tests that can be carried out in this environment are detailed in section 4.

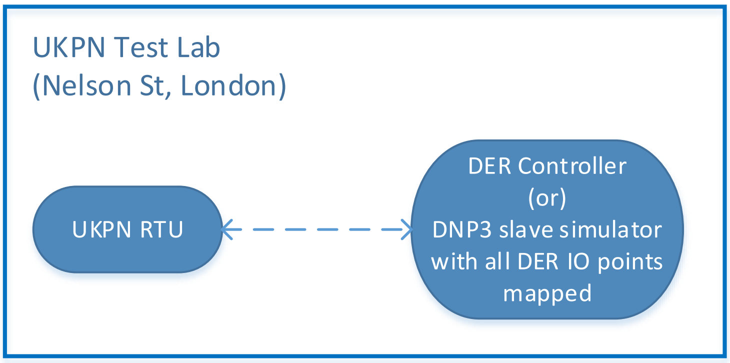


Figure 1 – Lab testing environment

b. On-site Testing Environment

This is the operational testing environment where all the functional and site commissioning tests will be performed. This environment, as shown in **Figure 3**, includes the site RTU and the customer DER control system as well. The tests which can be carried out in this environment are detailed in section 4 and section 5:

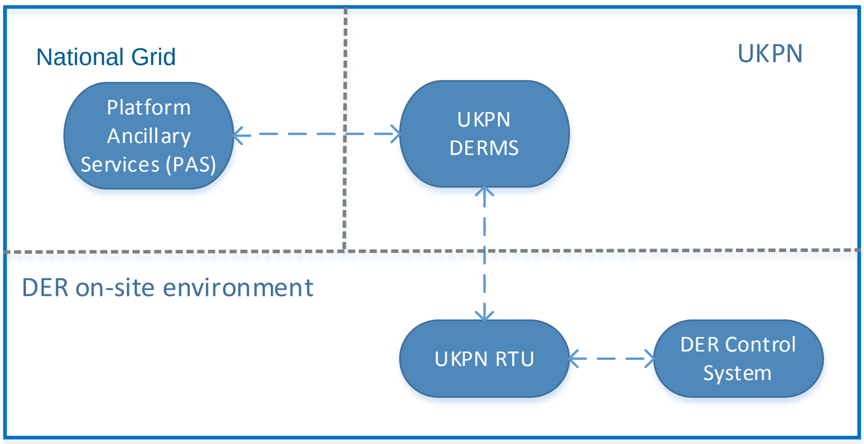


Figure 2 – On-site testing environment

4. Integration Tests

This section covers the test cases associated to the UKPN RTU to DER control system integration. This is realised using DNP3 protocol where UKPN RTU acts as the master and DER control system acts as the slave. Tests are to be carried in both lab integration (not compulsory) and on-site (compulsory) environments.

4.1 RTU – DER Installation

Test Case Identifier	RTU_DER_1
Description	This test is to confirm if the RTU to DER integration gets back to its normal status after an initialisation routine. This can happen during a power loss situation or an RTU restart scenario.
Pre-Requisites	1. RTU and DER are configured as per the engineering specifications and all the Inputs/Outputs (IO) data are mapped. 2. DNP3 communication link is established between RTU and DER and there is a healthy poll established. 3. RTU Human Machine Interface (HMI) is available to view all the IO points exchanged between RTU and DER. 4. Alternately if RTU HMI is not available a Distributed Network Protocol (DNP) traffic monitor like Wireshark can be used.
Inputs/Outputs (IO)	All IO points as defined in *DER Interface Schedule* document are configured.
Test Steps	1. Make sure RTU and DER are communicating and the RTU local HMI is showing all IO points in good quality. 2. Power off the RTU. 3. Power on the RTU, send any binary output command and send any analogue output command. 4. Turn power off to the DER control system. 5. Turn power on to the DER control system, send any binary output command and send any analogue output command from RTU HMI.
Expected Outputs	5. All the IO points are displayed in RTU HMI with good quality after power cycling of RTU and DER. 6. DER can respond to the binary/analogue output command after power cycling of RTU and DER.
Test Environments	7. Lab and on-site

4.2 RTU – DER Digital Input Map

Test Case Identifier	RTU_DER_2
Description	This test is to confirm if the RTU gets all the digital inputs correctly from the DER control system. These inputs basically inform the UKPN RTU on whether the various conditions requested by UKPN for DER control were successfully received and executed by DER control system.
Pre-Requisites	8. RTU and DER are configured as per the engineering specifications and all the I/O data are mapped. 9. DNP3 communication link is established between RTU and DER and there is a healthy poll established. 10. RTU HMI is available to view all the IO points exchanged between RTU and DER. 11. Alternately if RTU HMI is not available a DNP traffic monitor like Wireshark can be used. 12. DER control system should be able to force the signals that are mapped as binary inputs in UKPN RTU.
Inputs	*All binary inputs listed below:* 13. Readback that 'Active' power upper limit is activated, this will be used to detect abnormal behaviour between UKPN RTU and DER. 14. Readback that 'Active' power lower limit is activated, this will be used to detect abnormal behaviour between UKPN RTU and DER. 15. Readback that 'Reactive' power upper[1] limit is activated, this confirmation will be used to detect abnormal behaviour between UKPN RTU and DER. 16. Readback that 'Reactive' power lower[1] limit is activated, this confirmation will be used to detect abnormal behaviour between UKPN RTU and DER. 17. Readback that 'Voltage' upper limit is activated, this confirmation will be used to detect abnormal behaviour between UKPN RTU and DER. 18. Readback that 'Voltage' lower limit is activated, this confirmation will be used to detect abnormal behaviour between UKPN RTU and DER. *19.* Readback that 'Power Factor' upper[1] limit is activated, this confirmation will be used to detect abnormal behaviour between UKPN RTU and DER *20.* Readback that 'Power Factor' lower[1] limit is activated, this confirmation will be used to detect abnormal behaviour between UKPN RTU and DER.
Test Steps	1. Make sure UKPN RTU and DER are communicating and the RTU local HMI is showing all binary input points in good quality. 2. Force all the 8 inputs listed above to "0" state in DER control system, verify if the RTU HMI shows the correct status. 3. Force each input to "1" state separately in DER control system, verify if the RTU HMI shows the correct status. 4. Verify if the alarm state is displaying correctly (if configured for local HMI).
Expected Outputs	21. All the Inputs are displayed in HMI with good quality. 22. All the inputs are mapped correctly and respond correctly to the state of change.
Test Environment	23. Lab and on-site

[1] Positive reactive power sign refers to lagging (i.e. upper limit is lagging PF) and negative to leading (lower limit is leading PF)

4.3 RTU – DER Digital Output Map

Test Case Identifier	RTU_DER_3
Description	This test is to confirm if the RTU can send binary output commands to DER control system. The commands drive the DER to different conditions of operation that is desired by the UKPN DERMS system. Also, these commands include signals that tell the DER about compliance to the active and reactive power services.
Pre-Requisites	24. RTU and DER are configured as per the engineering specifications and all the input /output data are mapped. 25. DNP3 communication link is established between RTU and DER and there is a healthy poll established. 26. RTU HMI is available to send binary output commands for all points exchanged between RTU and DER. 27. Alternately if RTU HMI is not available there should be a way to send binary commands through the configuration/diagnostic tool of the RTU.
Inputs/Outputs	*All binary outputs listed below:* 28. 'Active' power setpoint is activated, DER must comply with 'Active' power upper limit and operate at the "Active Power Setpoint". 29. 'Active' power setpoint is activated, DER must comply with 'Active' power lower limit and operate at the "Active Power Setpoint". 30. 'Reactive' power setpoint is activated, DER must comply with 'Reactive' power upper limit and operate at the "Reactive Power Setpoint". 31. 'Reactive' power setpoint is activated, DER must comply with 'Reactive' power lower limit and operate at the "Reactive Power Setpoint". 32. 'Voltage' setpoint is activated, DER must comply with "Voltage upper limit" and operate at the "Voltage Setpoint". 33. 'Voltage' setpoint is activated, DER must comply with "Voltage lower limit" and operate at the "Voltage Setpoint". 34. 'Power Factor' setpoint is activated, DER must comply with "Power Factor upper limit" and operate at the "Power factor Setpoint". 35. 'Power Factor' setpoint is activated, DER must comply with "Power Factor lower limit" and operate at the "Power Factor Setpoint".
Test Steps	1. Make sure RTU and DER are communicating and the RTU local HMI is showing all binary output points in good quality. 2. Send an on/latch on command separately for each of the 8 binary outputs shown above. 3. For each output verify if the DER control system received the signals and responds to the command. 4. Send an off/latch off command separately for each of the 8 binary outputs shown above. 5. For each output verify if the DER control system received the signals and responds to the command.
Expected Outputs	36. All the outputs are correctly mapped between UKPN RTU and DER. 37. DER control system responds correctly to all the commands.
Test Environments	38. Lab and on-site (Note in on-site testing we may need to coordinate with the customer to make sure all commands do not cause any operational safety issues)

4.4 RTU – DER Analogue Input Map

Test Case Identifier	RTU_DER_4
Description	This test is to confirm if the RTU gets all the analogue inputs correctly from DER control system. These inputs basically inform the UKPN RTU on whether the various setpoints requested by UKPN for DER control were successfully received and executed by DER control system.
Pre-Requisites	39. RTU and DER are configured as per the engineering specifications and all the input /output data are mapped. 40. DNP3 communication link is established between RTU and DER and there is a healthy poll established. 41. RTU HMI is available to view all analogue input points exchanged between the RTU and DER. 42. Alternately, if RTU HMI is not available a DNP traffic monitor like Wireshark can be used. 43. DER control system should be able to force the signals that are mapped as analogue inputs in UKPN RTU. For analogue inputs that are configured as Object 40, we may need to send the analogue output commands to drive different values and this test case can be combined with the analogue output test case.
Inputs	*All analogue inputs listed below:* 44. Readback of the received 'Active' power upper limit from the DER to UKPN RTU. This is required to check integrity of the DER control system and the comms link between UKPN RTU and DER. 45. Readback of the received 'Active' power lower limit from the DER to UKPN RTU. This is required to check integrity of the DER control system and the comms link between UKPN RTU and DER. 46. Readback of the received 'Reactive' power upper limit from the DER to UKPN RTU. This is required to check integrity of the DER control system and the comms link between UKPN RTU and DER. 47. Readback of the received 'Reactive' power lower limit from the DER to UKPN RTU. This is required to check integrity of the DER control system and the comms link between UKPN RTU and DER. 48. Readback of the received 'Voltage' upper limit from the DER to UKPN RTU. This is required to check integrity of the DER control system and the comms link between UKPN RTU and DER. 49. Readback of the received 'Voltage' lower limit from the DER to UKPN RTU. This is required to check integrity of the DER control system and the comms link between UKPN RTU and DER. 50. Readback of the received 'Power Factor' upper limit from the DER to UKPN RTU. This is required to check integrity of the DER control system and the comms link between UKPN RTU and DER. 51. Readback of the received 'Power Factor' lower limit from the DER to UKPN RTU. This is required to check integrity of the DER control system and the comms link between UKPN RTU and DER.
Test Steps	1. Make sure RTU and DER are communicating and the RTU local HMI is showing all analogue input points in good quality. 2. Force all the 8 Analogue inputs listed above to 0% in DER control system, verify if the RTU HMI shows the correct value including the scaling in engineering units desired. 3. Force each input to 50% of full scale in DER control system, verify if the RTU HMI shows the correct value including the scaling in engineering units desired.

	4. Force each input to 100% of full scale in DER control system, verify if the RTU HMI shows the correct value including the scaling in engineering units desired. 5. Force each input to 0% of full scale in DER control system, verify if the RTU HMI shows the correct value including the scaling in engineering units desired. 6. Verify if the alarm state is displaying correctly if configured for Local HMI. Note: If analogue Object 40 are used as readback for setpoints, then we must send analogue output commands for those points from the UKPN RTU.
Expected Outputs	52. All the inputs are displayed in HMI with good quality. 53. All the inputs are mapped correctly and respond to the value in DER control system. 54. All inputs are scaled correctly as per the technical requirement.
Test Environments	55. Lab and on-site

4.5 RTU – DER Analogue Output Map

Test Case Identifier	RTU_DER_5
Description	This test is to confirm if the RTU can send analogue output commands to DER control systems. These commands are basically operational setpoints that are desired by the UKPN DERMS system. These commands are very important for the P/Q services.
Pre-Requisites	56. RTU and DER are configured as per the engineering specifications and all the input /output data are mapped. 57. DNP3 communication link is established between RTU and DER and there is a healthy poll established. 58. RTU HMI is available to send analogue output commands for all points exchanged between RTU and DER. 59. Alternately if RTU HMI is not available there should be a way to send analogue commands through the configuration/diagnostic tool of the RTU.
Inputs/Outputs	*All analogue outputs listed below:* 60. 'Voltage' lower limit that the DER must comply with when "Voltage lower limit enable" is HIGH (1). 61. 'Power Factor' upper limit that the DER must comply with when "Power Factor upper limit enable" is HIGH (1). 62. 'Power Factor' lower limit that the DER must comply with when "Power Factor lower limit enable" is HIGH (1). 63. Measured 'Active' power at the point of connection. 64. Measured 'Reactive' power at the point of connection. 65. Measured 'Voltage' at the point of connection. 66. Measured 'Power Factor' at the point of connection. 67. This is the optimal value requested to the DER for 'Active' power. 68. This is the optimal value requested to the DER for 'Reactive' power. 69. This is the optimal value requested to the DER for 'Power Factor'. 70. This is the optimal value requested to the DER for 'Voltage'.
Test Steps	1. Make sure RTU and DER are communicating and the RTU local HMI is showing all analogue output points in good quality. 2. Send a 50% command separately for each of the 12 analogue outputs shown above. 3. For each output verify if the DER control system received the signals and responds to the command. 4. Send a 100% command separately for each of the 12 analogue outputs shown above. 5. For each output verify if the DER control system received the signals and responds to the command. 6. Send a 0% command separately for each of the 12 analogue outputs shown above. 7. For each output verify if the DER control system received the signals and responds to the command.
Expected Outputs	71. All the outputs are correctly mapped between RTU and DER. 72. DER control system responds correctly to all the commands. 73. All the scaling of output commands is correct.

Test Environments	74. Lab and on-site (Note in on-site testing we may need to coordinate with customer to make sure all commands do not cause any operational safety issues)

5. DER Capability/Performance Tests

The tests in these sections are meant for testing the DER capability/performance. These tests are done at site once DER and RTU integration is complete in the lab environment (laboratory pre-commissioning testing is advisory but not adequate for commissioning). The customer may have performed similar tests with DER and its control system and those test sheets can be used as a reference. The reactive power capability tests are required for DER to participate in the Reactive Power service (all DER), and the active power capability tests are required for DER wishing to participate in the Active Power service (as indicated by the DER).

5.1 Reactive Power Capability Tests

Test Case Identifier	DER_Capability_Reactive_Power_1
Description	The capability is usually measured at the point of connection to the network and applies to the DER rather than component parts. The reactive capability testing is normally arranged with the ‘UKPN control centre’ at a mutually agreed time. The test will be carried out under instruction from the UKPN control engineer and should be monitored and recorded at both the ‘UKPN control centre’ and by the DER owner.
Pre-Requisites	75. RTU and DER control system are fully integrated and testing completed. 76. Local HMI are available for changing the different control conditions and getting the feedback. 77. DER is set at unity Power Factor and max generation. 78. Ensure suitable configuration of RTU logic with following parameters: 78.1. Tolerances for detecting breaches 78.2. Set timers to detect breaches 78.3. Reset timers to clear breaches 78.4. Failsafe actions for each breach (P upper, P lower, Q upper, etc.) 78.5. Is orphan detection required? 78.6. Is decouple detection required?
Inputs/Outputs	*The outputs are listed below:* 79. Maximum DER Reactive power limit reached (Lag). 80. Maximum DER Reactive power limit reached (Lead).
Test Steps	1. Put the DER in local mode using local HMI. 2. Enable the DER in ‘Active’ power and set the upper, lower and ‘Active’ power at the maximum possible active power output from NMS HMI. 3. From local HMI verify that DER is operating under at 100% value with ‘Active’ power enabled. 4. From local HMI put the DER in ‘Voltage Control’ mode. 5. Adjust the voltage setpoint such that the ‘Reactive’ power is driven to max lag value. 6. Maintain status quo for 5 minutes.

	7. Adjust the voltage setpoint such that the ‘Reactive’ power is driven to max lead value. 8. Maintain status quo for 5 minutes. 9. Switch back to original voltage set-point. 10. Enable the DER in ‘Active’ power setpoint and set the upper, lower and ‘Active’ power at the minimum possible setpoint from NMS HMI. 11. From local HMI verify that DER is operating under remote NMS mode and at the minimum possible ‘Active’ power setpoint and limits enabled. 12. From Local HMI verify that ‘Reactive Power’ is driven to max lag value. 13. Maintain the status quo for 5 minutes. 14. Adjust the voltage setpoint such that the ‘Reactive’ power is driven to the max lead value. 15. Maintain the status quo for 5 minutes. 16. Switch back to original voltage set-point. 17. From local HMI put the DER in ‘Power Factor’ mode (this does not apply to those DER which are operating in voltage control mode as part of their original contractual agreement).
Expected Outputs	Verify the following: 81. DER can generate the max allowable leading and lagging ‘Reactive’ power at maximum and minimum “Active Power Setpoint” possible for the generator at the time. 82. Verify the ‘Voltage Reference’ and system voltage at point of connection and see if there is any violation (e.g. ± 6%).
Test Environments	83. On-site (Note in on-site testing we may need to coordinate with customer to make sure all commands do not cause any operational safety issues)

5.2 Active Power Capability Tests

Test case identifier	DER_capability_active_power_1
Description	The capability is usually measured at the point of connection to the network and applies to the DER rather than component parts. The 'Active' power testing is normally arranged with the 'UKPN control centre' at a mutually agreed time. The test will be carried out under instruction from the UKPN control engineer and should be monitored and recorded at both the 'UKPN control centre' and by the DER owner. This test will demonstrate the capability of the DER to curtail 100% and to export 100% as instructed by the UKPN master systems.
Pre-Requisites	84. RTU and DER control system are fully integrated and testing completed. 85. Local HMI are available for changing the different control conditions and getting the feedback. 86. Ensure suitable configuration of RTU Logic with following parameters: 86.1. Tolerances for detecting breaches 86.2. Set timers to detect breaches 86.3. Reset timers to clear breaches 86.4. Failsafe actions for each breach (P upper, P lower, Q upper, etc.) 86.5. Is Orphan detection required? 86.6. Is decouple detection required?
Inputs/Outputs	*The outputs are listed below:* 87. Maximum DER real power limit reached. 88. Minimum DER real power limit reached.
Test Steps	1. Put the DER in local mode. 2. Enable the DER in Active Power limits and set the upper, lower and Active Power setpoint at 100% from NMS HMI. 3. From local HMI verify that DER is operating under remote NMS mode and at 100% value and with Active Power setpoint and limits enabled 4. Maintain status quo for 5 minutes. 5. Enable the DER in Active Power limits and set the upper, lower and Active Power setpoints at 0% from Local HMI. 6. From local HMI verify that DER is operating under remote NMS mode and at 0% value and with Active Power setpoint and limits enabled. 7. Maintain status quo for 5 minutes. 8. Switch back to original Active power set-point. 9. From local HMI put the DER in 'Active Power' mode.
Expected Outputs	Verify the following: 89. DER responds to "Active Power Setpoints" 90. Note the time response from setpoint change to the final value 91. Note the reactive power and PF 92. Note the connection point voltages
Test Environments	93. On-site (Note in on-site testing we may need to coordinate with customer to make sure all commands do not cause any operational safety issues)

5.3 Active Power – Speed of Response

Test case identifier	DER_capability_active_power_2
Description	These tests will examine the DER speed of response capability to achieving real and reactive power service instructions issued to the DER control system. The DER test results are expected to match (where relevant) with the DER Technical Characteristics Submission Spreadsheet.
Pre-Requisites	94. RTU and DER control system are fully integrated and testing completed. 95. Local HMI are available for changing the different control conditions and getting the feedback. 96. Put the DER at around 60% 'Active' power, or other active power value agreed with the DER consistent with capability offered in its framework agreement and current operating conditions, and at unity Power Factor. 97. Ensure suitable configuration of RTU Logic with following parameters: 97.1. Tolerances for detecting breaches 97.2. Set timers to detect breaches 97.3. Reset timers to clear breaches 97.4. Failsafe actions for each breach (P upper, P lower, Q upper, etc.) 97.5. Is Orphan detection required? 97.6. Is decouple detection required?
Inputs/Outputs	*The outputs are listed below:* 98. The DER Real Power setpoint reached (MW/sec) according to customer's Technical Characteristics Submission Spreadsheet (see **Figure 4**). 99. The DER Voltage Power setpoint reached (sec) according to customer's Technical Characteristics Submission Spreadsheet.
Test Steps	1. Put the DER in local mode using local HMI. 2. Enable the DER in 'Active' power setpoint and limits. 3. From Local HMI verify that DER is operating with 'Active' power setpoint and limits enabled. 4. Make a set point change of say +5 %. 5. Wait for the DER response to settle. 6. From Local HMI verify that DER is operating with 'Active' power setpoint and limits enabled. 7. Make a set point change of say -5 %. 8. Wait for the DER response to settle.
Expected Outputs	Verify the following: *(The following data must be recorded and submitted to UKPN)* 100. kW – 'Active' power at the applicable measurement point. 101. kvar – 'Reactive' power at the applicable measurement point. 102. Time response of the DER control system. 103. Initial reaction time to make an 'Active' power response to a change in setpoint. 104. Total time taken to get a settled response.
Test Environments	105. On-site (Note in on-site testing we may need to coordinate with customer to make sure all commands do not cause any operational safety issues)

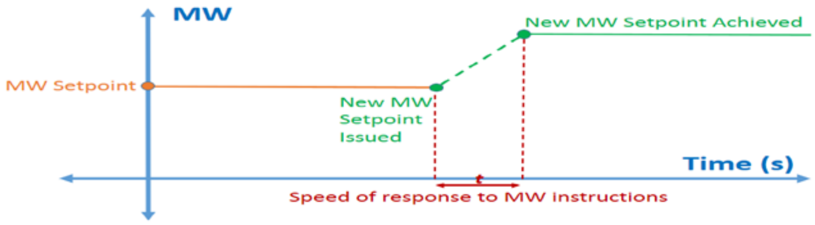
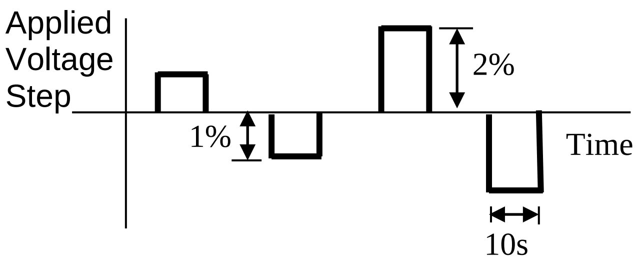


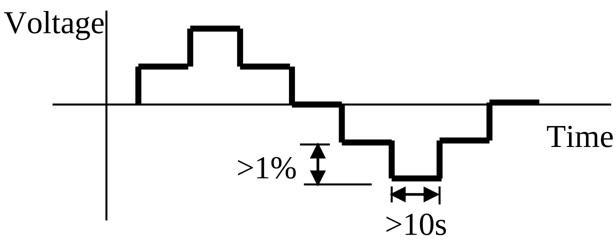
Figure 3 - MW response test

5.4 Voltage Capability Tests

Test Case Identifier	DER_Capability_Voltage_1
Description	These tests are to verify that the DER is equipped with a continuously-acting automatic voltage control that meets the requirements explained in the DER Technical Requirements document. The tests require the application of a voltage step to the DER reference voltage target. 
Pre-Requisites	106. RTU and DER control system are fully integrated and testing completed. 107. Local HMI are available for changing the different control conditions and getting the feedback. 108. Put the DER at around 60% ‘Active’ power, or other active power value agreed with the DER consistent with capability offered in its framework agreement and current operating conditions, and at unity Power Factor. 109. Ensure suitable configuration of RTU Logic with following parameters: 109.1. Tolerances for detecting breaches 109.2. Set timers to detect breaches 109.3. Reset timers to clear breaches 109.4. Failsafe actions for each breach (P upper, P lower, Q upper, etc.) 109.5. Is Orphan detection required? 109.6. Is decouple detection required?
Inputs/Outputs	*The outputs are listed below:* 110. These tests will examine the response of DER to external voltage step changes caused on the distribution network. 111. Dynamic voltage response of DER: achieving 90% of the steady state reactive power change calculated from declared voltage slope within 2 seconds.
Test Steps	1. Put the DER in local mode using local HMI. 2. Put the DER in ‘Voltage’ mode. 3. From local HMI verify that DER is operating in ‘Voltage’ mode. 4. Alter the voltage setpoint to + 1%. 5. Wait for the response to settle (e.g.10seconds). 6. Alter the voltage setpoint to -1%. 7. Wait for the response to settle. 8. Alter the voltage setpoint to + 2%.

	9. Wait for the response to settle. 10. Alter the voltage setpoint to - 2%. 11. Wait for the response to settle.
Expected Outputs	Verify the following: 112. kW – ‘Active’ power at the applicable measurement point 113. kvar – ‘Reactive’ power at the applicable measurement point 114. ‘Voltage’ at controlled busbar, usually the Point of Connection 115. ‘Voltage Setpoint’ or ‘Voltage Reference’ 116. Power Factor (if relevant) 117. Voltage slope
Test Environments	118. On-site (Note in on-site testing we may need to coordinate with customer to make sure all commands do not cause any operational safety issues)

5.5 Voltage Capability Tests – Tap Changer

Test Case Identifier	Der_Capability_Voltage_2
Description	These tests are to verify that the DER is equipped with a continuously-acting automatic voltage control that meets the requirements explained in the DER Technical Requirements document. The tests require the application of a voltage step to the DER through tapping of an external upstream tap changer. It is suggested that the tests are conducted by applying a series of positive and negative steps at least 10 seconds apart to allow steady state to be established. This is illustrated in figure below:  Where steps can be initiated using UKPN transformer tap changers, the DER will need to respond to voltage changes in the UKPN system. It will be required for the associated Automatic Voltage Control (AVC) scheme to be switched from auto to manual for the duration of the test.
Pre-Requisites	119. RTU and DER control system are fully integrated and testing completed. 120. Local HMI are available for changing the different control conditions and getting the feedback. 121. Put the DER at around 60% ‘Active’ power, or other active power value agreed with the DER consistent with capability offered in its framework agreement and current operating conditions and at unity Power Factor. 122. Ensure suitable configuration of RTU Logic with following parameters: 122.1. Tolerances for detecting breaches 122.2. Set timers to detect breaches 122.3. Reset timers to clear breaches 122.4. Failsafe actions for each breach (P upper, P lower, Q upper, etc.) 122.5. Is Orphan detection required? 122.6. Is decouple detection required?
Inputs/Outputs	*The outputs are listed below:* 123. These tests will examine the response of DERMS and DER to external voltage step changes caused on the distribution network. 124. Dynamic voltage response of DER: achieving 90% of the possible change from full lead (importing reactive power) to full lag (exporting reactive power) within 2 seconds.
Test Steps	1. Put the DER in local mode using local HMI. 2. Put the DER in ‘Voltage’ mode.

	3. From local HMI verify that DER is operating under 'Voltage' mode. 4. Coordinate with UKPN control centre and tap up /tap down the nearest upstream tap changer transformer in manual mode (local/remote tap change controller should be manual). 5. Wait for the DER response to settle after a tap up or tap down operation.
Expected Outputs	Verify the following: *(The following data must be recorded and submitted to UKPN)* 125. kW – 'Active' power at the applicable measurement point 126. kvar – 'Reactive' power at the applicable measurement point 127. 'Voltage' at controlled busbar, usually the Point of Connection 128. 'Voltage Setpoint' or 'Voltage Reference' 129. Voltage slope
Test Environments	130. On-site (Note in on-site testing we may need to coordinate with customer to make sure all commands do not cause any operational safety issues)

5.6 Reactive Voltage Capability Tests – Voltage Setpoint

Test Case Identifier	DER_Capability_Voltage_3
Description	These tests are to verify that the DER is equipped with a continuously-acting automatic voltage control that meets the requirements for the reactive power service defined in this document. The tests require the application of a voltage step to the DER reference voltage target. A new voltage reference setpoint will be issued to the DER control system and UKPN will measure how long it took for the DER control system to receive the new instruction and how long it takes for the new voltage setpoint to be achieved at the DER point of connection.
Pre-Requisites	131. RTU and DER control system are fully integrated and testing completed. 132. Local HMI are available for changing the different control conditions and getting the feedback. 133. Put the DER at around 60% 'Active' power, or other active power value agreed with the DER consistent with capability offered in its framework agreement and current operating conditions and at unity Power Factor. 134. Ensure suitable configuration of RTU Logic with following parameters: 134.1. Tolerances for detecting breaches 134.2. Set timers to detect breaches 134.3. Reset timers to clear breaches 134.4. Failsafe actions for each breach (P upper, P lower, Q upper, etc.) 134.5. Is Orphan detection required? 134.6. Is decouple detection required?
Inputs/Outputs	*The outputs are listed below:* 135. Voltage setpoint achieved at DER PoC and in desired speed (see **Figure 5**). 136. Dynamic voltage response of DER: achieving 90% of the possible change from full lead (importing reactive power) to full lag (exporting reactive power) within 2 seconds.
Test Steps	1. Put the DER in local mode using local HMI. 2. Put the DER in 'Voltage' mode. 3. From local HMI verify that DER is operating under 'Voltage' mode. 4. Make a set point change of say +1 %. 5. Wait for the DER response to settle. 6. From local HMI verify that DER is operating under 'Voltage' mode. 7. Make a set point change of say -1 %. 8. Wait for the DER response to settle.
Expected Outputs	Verify the following: *(The following data must be recorded and submitted to UKPN)* 137. kW – 'Active' power at the applicable measurement point 138. kvar – 'Reactive' power at the applicable measurement point 139. Voltage at controlled busbar, usually the PoC 140. 'Voltage Setpoint' or 'Voltage Reference' 141. Time response of the DER control system

	142. Initial reaction time to make a 'Reactive' power response to a change in setpoint 143. Total time taken to get a settled response
Test Environments	144. On-site (Note in on-site testing we may need to coordinate with customer to make sure all commands do not cause any operational safety issues)

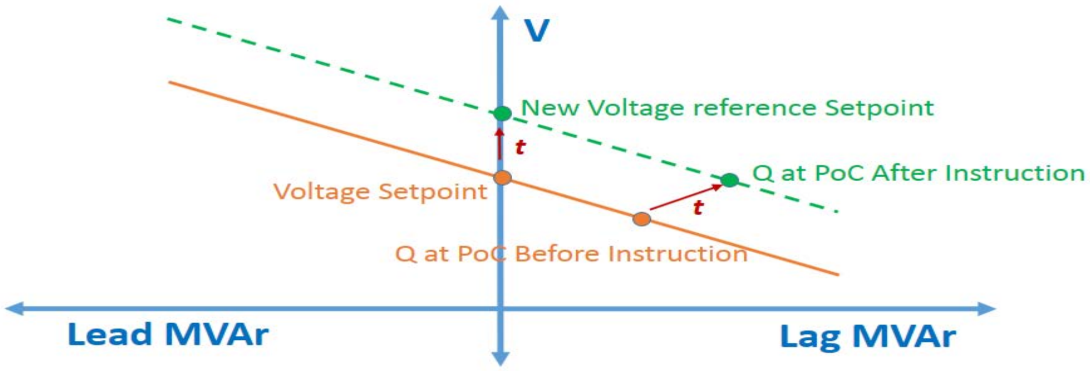


Figure 4 – Voltage response test

6. Definitions, Acronyms and Abbreviations

Term	Definition
ANM	Active Network Management
DER	Distributed Energy Resources
DER control system	The native control system used by the DER customer to operate and control the DER plan that interfaces with the UK Power Networks equipment
DERMS	Distributed Energy Resources Management System The centralised software based control system within UK Power Networks that dispatches DER to provide active and/or reactive power services to National Grid ESO as part of the Power Potential project
DNP3	Distributed Network Protocol Communication protocol widely used with the utilities industry and used by UK Power Networks for its SCADA system
DNO	Distribution Network Operator
GSM	Global System for Mobile Communication
HMI	Human Machine Interface (screen for operation)
LAN	Local Area Network
Object 40	Output analogue DNP3 signal from UK Power Networks RTU
PAS	Platform for Ancillary Services (National Grid system)
PowerON	The end-to-end Network Management System that UK Power Networks is using at control centre level to manage its distribution network
POC	Point of Connection The interface between the UK Power Networks’ equipment (main fuse, energy meter) and the consumer’s equipment (supply panel)
PP	Power Potential
Ramp rate	The ramp-up and ramp-down rate refers to the rate-of-change of site/DER power export
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition Centralised computer-based systems that monitor and control the electricity distribution network
UKPN	UK Power Networks
NMM	Network Model Manager
IEMS	Integrated Energy Management System

7. List of Referenced Documents

Document Title	Document Reference
DER Technical Requirements	https://www.nationalgrideso.com/innovation/projects/power-potential
DER Interface Schedule	https://www.nationalgrideso.com/innovation/projects/power-potential
DER Commissioning Test Procedure	Under Preparation
Power Potential Test Strategy	PP-Test Strategy v0.10.doc (Internal UK Power Networks)

8. Appendices

The document below can be found in the UK Power Networks G81 design specification library

Appendix	Document Name
A	EDS 05-9600a RTU Logic for ANM schemes diagram

9. Document control

Version	Date	Author(s)	Reviewers	Summary of Change
1.0	02/11/2018	Dr Ali R Ahmadi Dr Sima Davarzani	Tim Manandhar Dr Rita Shaw	Creation of document
1.1	07/11/2018			Grammatical changes
1.2	12/11/2018		Kellie Dillon Dr Rita Shaw	Clarity to DER customers
1.2.1	13/11/2018		Kellie Dillon Dr Rita Shaw	Correct references from section 1 to 4, Watchdog signal removed, DNP3 poll remains.
1.2.2	22/11/2018		Dr Sima Davarzani Dr Rita Shaw	Minor changes
1.2.3	28/11/2018	Clare Maguire	Dr Rita Shaw	Change cover page

UK Power Networks, Energy House, Carrier Business Park
Hazelwick Ave,Three Bridges, Crawley, West Sussex, RH10 1EX

www.ukpowernetworks.co.uk

National Grid ESO, Faraday House, Warwick Technology Park,
Gallows Hill, Warwick, CV34 6DA

nationalgrideso.com