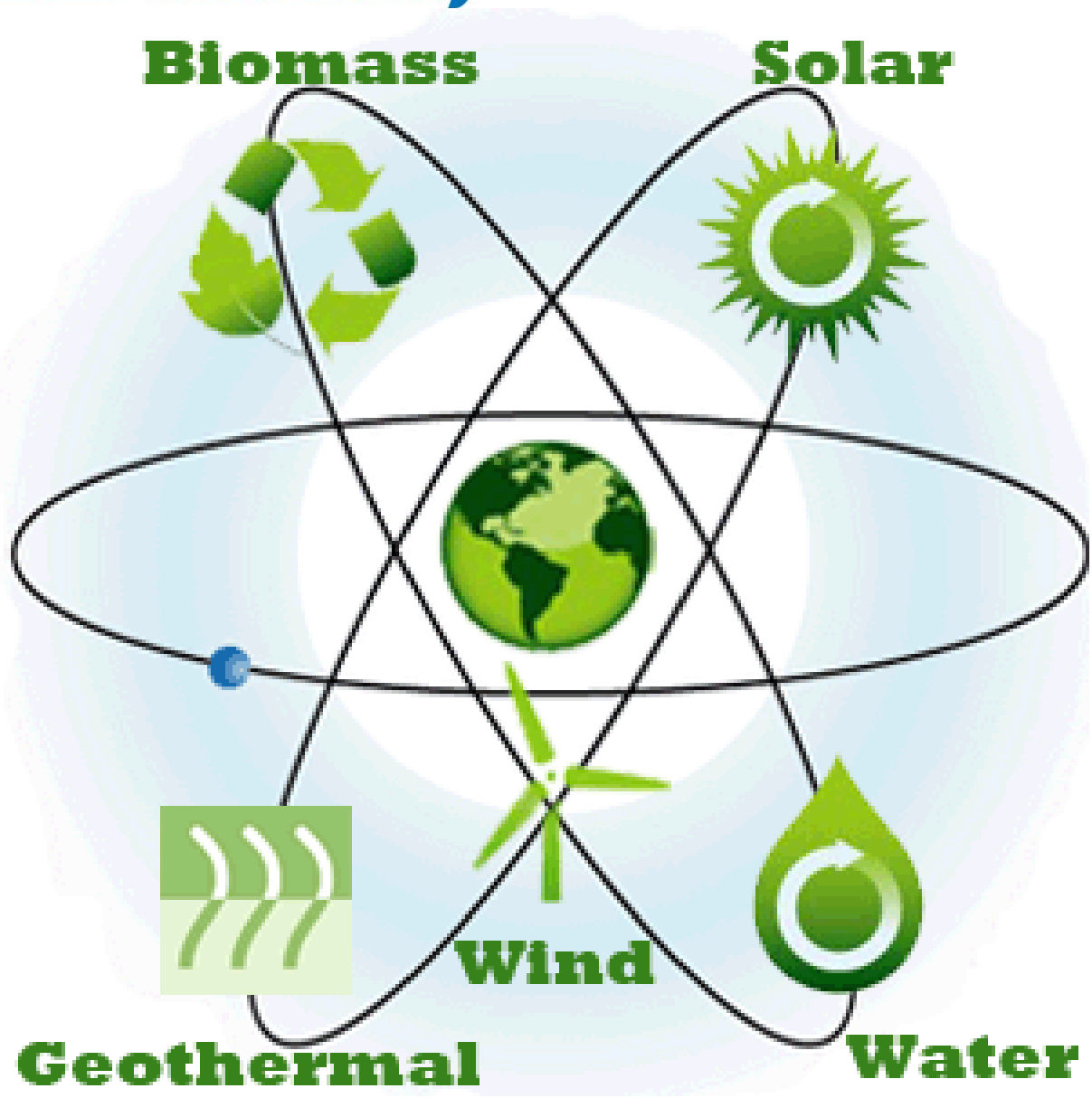

Setting Schedule for Generators less than 5 MW Exporting onto the NIE System

Issue 4.4 Jan 13

DOCUMENT CHANGE CONTROL SHEET

Document Control					
Document Version	**Description**	**Originated**	**Approved**	**Date**	**Notes**
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4.3	DRAFT	S Alexander		06/12/12	Comms ammendment
4.4	DRAFT	S Alexander		07/01/13	Name change

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NIE Ltd

Foreword

Northern Ireland Electricity is responsible for the planning, development, construction and maintenance of the transmission and distribution network in Northern Ireland, and for the operation of the distribution network.

The electricity grid comprises a number of interconnected networks of overhead line and underground cables, which are used for the transfer of electricity to customers via a number of substations. There are approximately 2,100km of transmission network (275 kV & 110 kV), of which some 80km are underground, and approximately 42,900km of the distribution system (33 kV, 11 kV & 6.6 kV), of which some 13,100km are underground.

One of our main responsibilities is to ensure the communities which we serve have a safe and reliable supply of electricity, and that we do everything we can to restore supplies as safely and quickly as possible following interruptions.

NIE holds a license “to transmit electricity for the purpose of giving a supply” to demand customers or generators.

NIE manage and optimise power flows in real time on the distribution network from the Distribution Control Centre (DCC) in Craigavon. Outages (planned and unplanned) are also managed within DCC.

Introduction

This setting schedule is produced to clarify the requirements and process to be followed by a person or party wishing to connect a generator with a capacity greater than 100KW but less than 5MW to the NIE system.

It explains a process to manage crucial interactions and data exchange. The process also involves plant testing and reporting to demonstrate compliance with NIE requirements and the Distribution Code. Where the applicant's Connection Agreement specifically requires additional conditions or tests a schedule shall be agreed between the parties – i.e. the generator and NIE

This schedule made up of two parts

- **Technical Requirements for Generators less than 5 MW Exporting to the NIE Distribution System**

- **Compliance, Test and Exporting Requirements for Generators less than 5 MW Exporting to the NIE Distribution System**

These will provide the applicant clarity with regard to the technical requirements, Distribution Code compliance testing and reporting when connecting to the Distribution Network. Other tests or requirements deemed necessary shall be specified within the connection agreement

They are also intended to inform the applicant of the necessary process, however reference should be made to the Distribution Code, the Connection Agreement and the Connection Agreement application process for a complete set of provisions relating to connection of generation.

Technical Requirements for Generators less than 5 MW Exporting to the NIE Distribution System

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1.0 Remote Telemetry Units and Control

1.1 Introduction

There is a requirement under the NI D Code May 2010 for a SCADA facility in respect of certain generation that is connected to the Distribution network. For large scale generation such as wind farms NIE generally provides for SCADA by the installation of its own Remote Telemetry Unit (RTU). The RTU is the physical interface between the Distribution Control Centre and generation connected to the distribution system plant to be monitored and controlled. This document sets out NIE's approach to small scale generation less than 5 MW.

Where a small scale generator is connected on the HV side to the 33kV system then NIE will provide SCADA by the installation of its own RTU.

Where a small scale generator is connected on the HV side to the 11kV or 6.6kV system then NIE is prepared to allow the developer to provide the RTU. It is considered that this will allow a developer to specify and procure RTU equipment in conjunction with their generator controller.

1.2 Human Machine Interface (HMI)

The RTU shall support a HMI which will be used for configuration, commissioning, testing and maintenance. This is normally a software package installed on a laptop PC.
The following general functions shall be performed:

1. – interrogate RTU fault conditions
2. – load RTU application programs
3. – interrogate the RTU database
4. – simulate alarm conditions and supervisory controls
5. – receive and transmit messages to the control centre

Note:- it is not NIE's intention that it would seek to have access to the RTU via a HMI.

1.3 RTU Power Supplies

A nominal 24 volt d.c. supply of suitable capacity is required and be capable of supporting the following:

1. – plant interposing relays
2. – indication and alarm inputs
3. – communications equipment where applicable (12V)

The 24 volt d.c. supplies to the RTU and associated equipment shall be made via a fused distribution panel.

On loss of mains supply a 10 minute battery backup is required to confirm loss of mains over SCADA

1.4 RTU Facilities

The RTU will be monitoring single digital inputs, double digital inputs, analogue inputs (4-20mA) and will be controlling double digital outputs, single digital outputs and analogue outputs (4-20mA). Details of the full facilities required are given in Appendix A.

The facilities required at each RTU are:

1. – status inputs (indications and alarms)
2. – controls, single & double
3. – analogues, inputs & outputs
4. – communication ports

1.5 Status inputs

Digital inputs shall be derived from clean, voltage free, contacts and can be either fleeting or persistent. Fleeting contacts of less than 10 milliseconds should be rejected by the RTU. Each individual status input should be configurable on a per channel basis from 10 milliseconds up to 60 seconds.

Circuit breaker (CB) monitoring requires complimentary pairs of contacts so that the intermediate status (DBI) can be monitored, 00 or 11. These Double Digital Inputs (DDIs) should be configurable for consecutive digital channels in the RTU and the DBI status should be configurable so that a delay can be applied before a DBI status is returned to the control centre. A delay of approximately 100 milliseconds would be satisfactory.

1.6 Controls

Plant equipment will be controlled from the RTU by operating an interposing relay. The design of the RTU shall prevent a control mal-operation in the event of any single component failure or loss of power to any device. The RTU shall support “3 stage control” operation i.e. select, checkback and execute routine. If an execute command isn’t received by the RTU within a defined time period the command shall be aborted by the RTU by de-energising the select relay. The execute command shall cause the interposing plant relay to be energised for a configurable period of between 0.5 and 5 seconds (typically 1 second). The RTU shall ensure that only one select or one interposing relay can be selected during any one control operation. The RTU shall control the interposing plant relays by switching both the positive and negative poles of the 24 volt d.c. supply. A Dummy CB remote control facility shall be provided at the

RTU. This will allow the control centre to test the communications and the control functionality of the RTU without risk of operating plant.

A manual Control Inhibit switch shall be provided at the RTU which will isolate both positive and negative poles of the remote control 24 volt d.c. supply. Indication of the Control Inhibit switch position will be returned to the control centre.

1.7 Analogues

Analogue inputs will be in the range 4 milliamps - 20 milliamps. Accuracy should be +/- 1% or better. The RTU scan rate of analogues and any deadband that is applied or can be configured should be detailed by the developer. Typically reporting once per rolling hour and report by exception on excursion outside of a configurable deadband of between 1% and 10%.

Analogue outputs will supply a constant value of between 4 milliamps - 20 milliamps as instructed from the control centre. The developer should indicate what happens to these analogue outputs in the event of communications or power failure and upon restoration of communications and/or power.

1.8 Communication Ports

Developers should indicate the number of communications ports available and the functions of each port for the RTU offered. At least two ports should be provided. One of the port should be able to utilise communication by polled radio and the other GPRS The communication back to the control centre is currently via polled radio. The communications protocol for radio modems is presently IEC60870-5-101 operating at a data rate of 9600 bits per second (bps) and is via a RS232 presentation. Alternatively NIE may use GPRS as the communications medium for distribution connected generators.

The developer will be required to demonstrate that the RTU offered will operate satisfactorily while communicating with the control centre SCADA system via iHost for GPRS solutions or our ABB SCADA for polled radio solutions
.
The generator controller should utilise Modbus or some similar protocol agreed by NIE and the RTU should be capable of handling this protocol.

1.9 Equipment Practice and Specification

The developer should detail the specifications of all equipment offered to include but not exclusive to; electrical and RF isolation; environmental including IP rating of any cabinet; digital and analogue input/output isolation.

The cabinet within which the RTU is housed should be suitable for an electrically noisy environment with a single earthing point terminal.

Should the site require a polled radio solution the following cabinet specification is required.

1.10 Radio and Cabinet Specification

Humidity 95% at 40 degrees C
Temperature Range -30 to +60 degrees C (full performance)
-40 to 70 degrees C (operational)

Weight 1.6 Kilograms

Case Die-cast Aluminium.

Dimensions

Width 143 mm (minimum)
Height 57 mm (minimum)
Depth 184 mm including antenna connector. The antenna design and location will be recommended following site survey

Primary Power
Voltage 13.8V Nominal (10.5 to 16 Vdc) to be provided by the developer
TX Supply current 2.5 amps
RX Supply current Operational 150ma
Standby 25ma

Power connector 2 pin polarized locking connector
Fuse 4 Amp Polyfuse Self-Resetting Internal
Remove primary power to reset.

Reverse Polarity Protection Diode across primary input.

Aluminium Aerial Pole. 6mtr long x 50mm with a 5mm wall thickness**.**

2.0 SCADA Signals

The signals listed in this section will be tested point to point from the developer's terminal box to the NIE RTU and through to the NIE DCC. The signals if ranged 4-20mA should be simulated from the terminal box and if using Modbus protocol tested as close to the transducers as possible.

Analogue Input Signals (to Control Centre) from Developer					
Signal Description	**Description**	**Range**	**Units**	**Scale**	**Display Units**
kW	Indication of the Real Power output at Generation connection point	4 - 20	mA	TBA	KW
KVAr	Indication of the Reactive Power Flow at the Generation connection point	4 - 20	mA	TBA	KVAr
Voltage 3Ø HV	Indication of the HV Voltage	4 - 20	mA	TBA	kV
Voltage Set Point	Confirmation of voltage set point signal	4 - 20	mA	TBA	pu
Power Factor Set Point	Confirmation of power factor set point signal	4 - 20	mA	-18- 0-+18	Degree
Power Factor Actual	Actual Power factor measured	4 - 20	mA	-18- 0-+18	Degree

The signals listed in this section will be tested point to point from the developer's terminal box to the RTU and through to the NIE DCC.
These signals will report by exception within a dead band range of 1% - 10% determined by NIE.

If Modbus or other agreed communication protocol is used to / from the RTU protocol then the range / units / scale to be agreed with NIE SCADA
4-20mA analogue signals - Scale to be agreed with NIE SCADA

TBA – Scale to be agreed with NIE SCADA

Analogue Output Signals (from Control Centre) to Developer					
Signal Description	**Description**	**Range**	**Units**	**Scale**	**Display Units**
Voltage Set Point	Voltage set point instruction	4 - 20	mA	TBA	pu
Power Factor Set Point	Power Factor set point instruction	4 - 20	mA	-18 – 0 - +18	Degree

If Modbus or other agreed communication protocol is used to / from the RTU protocol then the range / units / scale to be agreed with NIE SCADA
I4-20mA analogue signals - Scale to be agreed with NIE SCADA

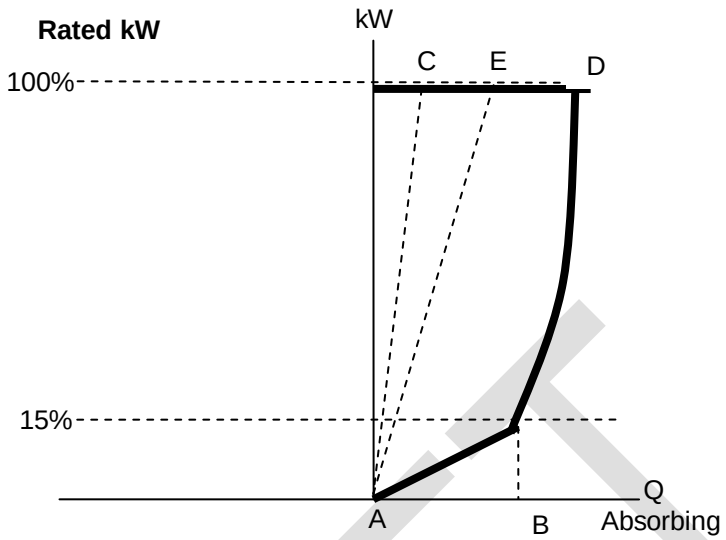
Digital Input Signals (to Control Centre) from Developer		
Signal Description	**Description**	**Signal**
Common	24V dc	
PF Control Selected	PF Control Selected	24V dc
Voltage Control Selected	Voltage Control Selected	24V dc
Voltage Control Auto Change Over[1]	Indication that the control mode has auto changed to voltage control	24V dc
CB1 Open	Circuit breaker open (controlling the circuit at the connection point)	24V dc
CB1 Closed	Circuit breaker closed (controlling the circuit at the connection point)	24V dc
Island Detected Trip	Alarm that the G59 protection has operated	24V dc
Dummy circuit breaker Open	Comms and SCADA test facility	24V dc
Dummy circuit breaker Closed		24V dc
Control Switch Off	Manual Control Inhibit (local control - no set point adjustment or controls available)	24V dc
AC Main Fail	Loss of ac supply (standby battery with 10min capacity now in operation)	24V dc

[1]Automatic changeover to voltage control mode will occur if voltage at the connection point moves beyond the limits of a deadband agreed between NIE and the developer.

Digital Output signals (from Control Centre) to Developer				
Signal Description	**Description**	**Permanent Common Signal**	**1sec pulse Open Signal**	**1sec pulse Close Signal**
Voltage Control Select Common Power Factor Control Select	To operate in voltage control mode To operate in power factor control mode	 0V 	 24V dc	24V dc
CB1 Close [1] Common CB1 Open [1]	Close the Circuit Breaker at the connection point Open the Circuit Breaker at the connection point	 0V 	 24V dc	24V dc
Common CB Lockout ON	To reset the lockout relay	0V 	 24V dc	
Close Dummy CB	Close the Dummy Circuit Breaker			24V dc
Common		0V		
Open Dummy CB	Open the Dummy Circuit Breaker		24V dc	

Modbus or other agreed communication protocol may be used between RTU and control system. These signals to be tested as close to origin as possible.

3.0 Reactive Capability for Induction Machines



Reactive Power Performance Chart

The figure above sets out the reactive power capability at the point of connection to the LV network.

Point A is the minimum absorbing reactive power capability
at 15% Rated KW output (voltage and power factor control)

Point B defines the maximum reactive power capability at 15% rated kW output (voltage control)

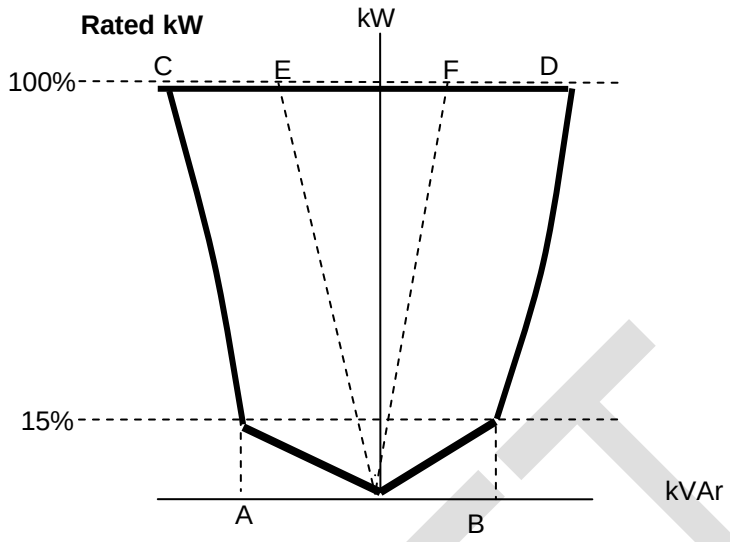
Point C is the minimum absorbing reactive power capability at 100% rated kW output and Power Factor limit of 0.98 absorbing either in power factor or voltage control

Point D is the maximum absorbing capability at 100% rated kW output (voltage control)

Point E is the Power Factor limit of 0.95 absorbing at 100% rated kW output power factor control

Note :-Points 'B' and 'D' ie maximum and minimum reactive capability are defined by the capability declared by the applicant during the application process

Summary of Reactive Capability Tests Synchronous Machines



The figure above sets out the reactive power capability at the point of connection to the LV network.

Point A is the minimum absorbing reactive power capability at 15% Rated kW output (voltage control)

Point B is the minimum producing reactive power capability at 15% rated kW output (voltage control)

Point C is the minimum absorbing reactive power capability at 100% rated kW output (voltage control)

Point D is the maximum producing reactive power capability at 100% rated kW output (voltage control)

Point E is the power factor limit of 0.95 absorbing at 100% rated kW output

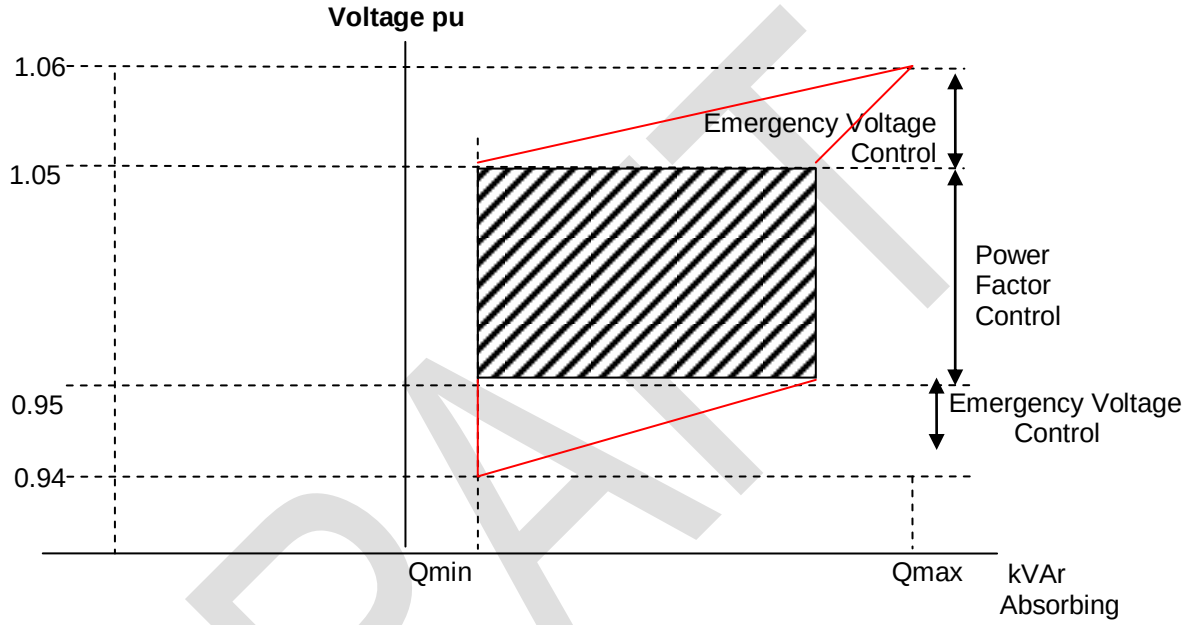
Point F is the power factor limit of 0.98 producing at 100% rated kW output

Note points A,B,C & D ie maximum and minimum reactive capability are defined by the capability declared by the applicant during the application process

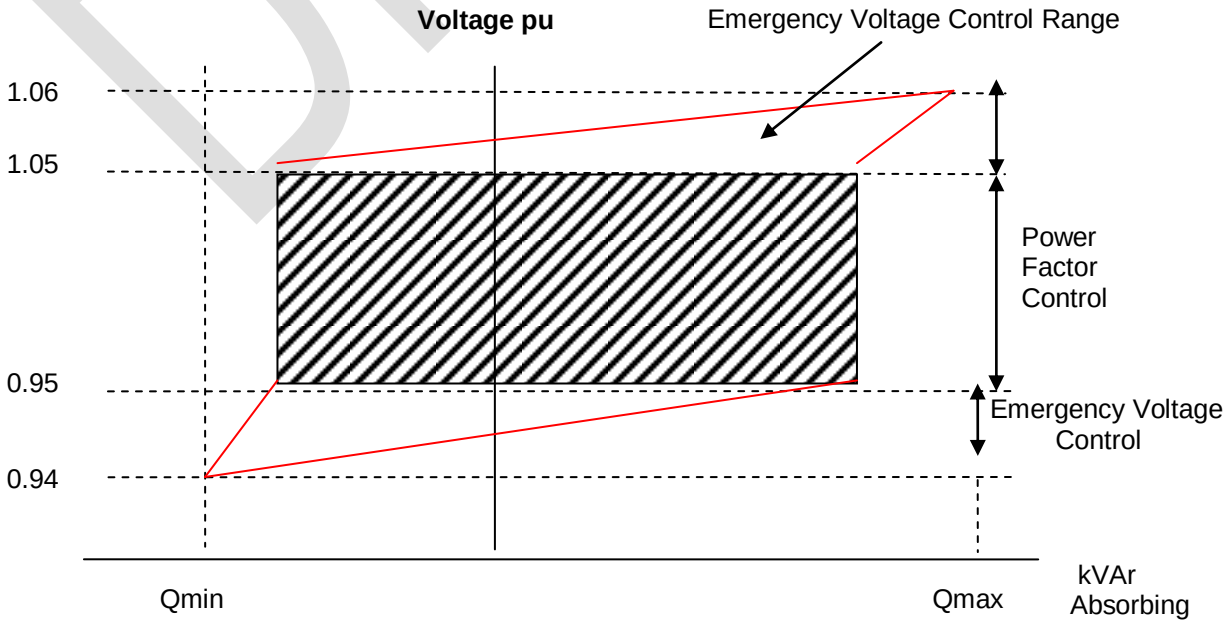
Summary of Emergency Voltage Control Requirements for Distribution Connected Generators

There is a requirement for generators to be capable of stable operation in both power factor and voltage control modes. Where a generator is operating in power factor control and the voltage exceeds a preset level then the generator shall perform in emergency control mode compliant with the performance charts set out below.

Emergency Voltage Control Performance Chart for Induction Generators



Emergency Voltage Control Performance Chart for Synchronous Generators



For clarification:

The Induction generator must demonstrate the ability to operate at 0.98 Power Factor to 0.95 Power Factor absorbing between 15% - 100% Rated kW for the synchronous generator the Power Factor range would be 0.95 absorbing and 0.98 producing .These requirements only define the minimum capability.
When entering emergency voltage control the Generator voltage set point shall be 1.05pu at the upper limit and 0.95pu at the lower limit. In emergency voltage control mode the generator move towards either Qmax or Qmin at 3% of $\Delta Q/s$ where ΔQ is the difference between Q actual and Qmax or Qmin as appropriate. Where necessary the generator shall maintain Qmax or Qmin until system voltage returns within power factor limits.

4.0 Appendix A - SCADA I/O Facilities

TYPE	NUMBER REQUIRED
Single Digital Input	4
Double Digital Input (CB status)	3 (2 for 2 CBs & 1 for PF/Voltage control selected).
Analogue Inputs	7
Analogue Outputs	2
Double Digital Outputs	3
Single Digital Outputs	1

5.0 Appendix B Contact Names

Sam Alexander
Network Generation Manager

Tel 08457 643643

Gorman Hagan
Technical Director

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Compliance, Test and Reporting Requirements for Generators less than 5 MW Exporting to NIE Distribution Systems

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COMMISSIONING and TESTING PROCESS

1.0 Pre-Energisation

The generator cannot be connected unless all relevant agreements are signed at least 4 weeks in advance of the connection date. The generator shall, prior to energised, declare compliance with G59 protection codes, the relevant sections of BS7671 and that the generator will become fully compliant with all parts of the distribution code.

1.1 Post Energisation Monitoring

Following energisation NIE shall issue the generator with a Temporary Compliance Certificate valid for one year from when the generator begins exporting active power. During this period NIE shall actively monitor the performance of the generator against Distribution Code and Connection Agreement criteria.

During this monitoring period (normally 10 months but this may need to be extended in order to prove compliance NIE will be assessing the generator performance in a number of areas including:

- Distribution Code Compliance
- Fault Ride Through
- Harmonics (ER G5/4)
- Flicker (ER P28)

On completion of the monitoring period and demonstrating successful compliance with the Distribution Code and Connection Agreement NIE will issue the generator with the Final compliance certificate.

If the generator has not proven compliance during this period or subsequent to the receipt of a Final Compliance Certificate NIE may issue the generator with a Restricted Compliance Certificate. This restricted certificate will detail the level of non-compliance, the timeframe to rectify non-compliance and any restrictions applicable to the generator.

After completion of any works required making the generator compliant NIE shall use the tests outlined within this document as a measure to test compliance

At least 6 weeks in advance of testing, the applicant must provide NIE with a commissioning schedule. NIE's objective in seeking this information is to establish from the applicants schedule those tests which may have an impact on the Distribution System

2.0 Compliance Tests & Monitoring

The purpose for testing is for the generator to demonstrate compliance with Distribution Code and other tests, as required. The compliance process description is detailed in appendix A.

The tests will then need to be planned into a Commissioning Programme on dates agreeable to both the applicant and NIE. All tests will be required to be carried out to agreed procedures. NIE will verify that the proposed tests will comply with Distribution Code and connection agreement requirements, such that following successful completion a final compliance certificate will be issued

2.1 Controllability Testing

Some of the tests mentioned may be required to be carried out and witnessed by third parties. Final approval will however be given by NIE. This will not relieve the applicant of any responsibility for compliance with the Distribution Code. During these controllability tests it is the responsibility of the applicant to record the specified results electronically.

2.2 Test Witnessing

NIE will decide whether test witnessing will be carried out and arrange witnesses. NIE will inform the applicant of the schedule of tests to be witnessed and may vary this by reasonable notice. Some of these tests may be carried out remotely by SCADA by agreement with NIE.

Where NIE decides not to witness any test, this shall not relieve the applicant of any responsibility for compliance with the Distribution Code, connection agreement or other standard to be used as a fair measure, nor shall the act of witnessing be deemed to transfer any responsibility to NIE either for compliance or for the consequences of failure to comply. Final approval of all distribution related testing shall be given by NIE after analysing test results.

3.0 Test Results

It is the responsibility of the applicant to achieve acceptable results for each test. Failure to do so may require the applicant to repeat certain tests. The format of the results, for example in graphical and tabular form, should be agreed with NIE 6 weeks in advance of the tests taking place. The applicant must provide fast speed recording equipment for the purpose of analysing test results.

It is important that results are legible, clearly labelled and graphs appropriately scaled in engineering units. NIE may require that certain tests are appropriately annotated.

Test results will be required 1 week after the completion of the tests. Reasonable time will be required for NIE to fully analyse the test results and determine whether or not the generator is compliant. The generator may continue operation during the result evaluation period.

4.0 Connection Report

Where a generator has been subjected to compliance testing, the generator will be required to submit compliance Connection Report up to 2 months after Distribution Code compliance tests have been completed. The Connection Report will provide a structure where information in support of compliance statements can be submitted and commented upon. NIE will review the submitted data to ensure that the generator is compliant with all aspects of the agreements mentioned in connection agreement and the Distribution Code. A breakdown of report components can be seen in Appendix B.

The Connection Report will be a comprehensive collection of the overall generator development, containing all relevant technical information, and site specific data. The responsibility for deciding whether the reports submitted by the generator satisfy the generator compliance obligations will rest with the Network Generation Manager.

If NIE considers it necessary, it may require the report(s) to be prepared by an Independent Engineer. In this event, NIE will be responsible for informing the generator as soon as it is practical to do so. The Engineer shall be agreed between the parties and the Engineer's fees and costs shall be met by the generator.

5.0 Voltage Control Mode Test

Distribution Code Compliance Testing/Monitoring
Title of Test: Voltage Control Mode Test
Purpose of Test: The Voltage Control Mode Test will be carried out by the applicant to demonstrate that; upon receipt of a 'Voltage Control' signal, the generator enters 'Voltage Control' mode. The generator should make an attempt to control the connection point voltage with a resolution of ±0.25% on target voltage. The functionality of the voltage control system should be demonstrated at different voltage set points. NIE will confirm the voltage range to avoid unnecessary risk to the system. This test will be carried out at a time when the kW Output of the generator is greater than 50% of Installed Capacity, unless otherwise agreed by NIE in advance of the test. Where a generator is supplied at LV by a local HV/LV transformer NIE will generally require control to be exercised and voltage recorded at the HV level. To facilitate this, NIE will provide for a Voltage Transformer as part of the connection and provide the generator with AC voltage signals from the VT.
Results Required: Time series record and Microsoft Excel Plot showing: • kW Output • KVAr Output • Voltage set point • Voltage at the Connection Point
Test Assessment: The test results will be assessed against: • CC.7.9.2 of the D-Code

5.1 Voltage Control Mode Test Procedure

Voltage Control Mode testing will be carried out at a time when the kW Output of the generator is greater than 50% of Installed Capacity, unless otherwise agreed by NIE in advance of the test.

The Voltage Control Mode tests described below are given indicative of what NIE expect to see. However, the developer will have to agree a testing programme with NIE who will advise as to the voltage limits that can be tested at the site. This programme is required to be submitted to NIE for approval at the early stage of the compliance process.

Voltage set points sent by NIE to Gen-these set points may be adjusted dependant on prevailing network condition		
Test No.	**Action**	**Voltage set point pu**
1	NIE will send Gen a nominal voltage set point. Upon confirmation from the generator that the set point was received, NIE will engage 'Voltage Control' mode. Hold until conditions stabilise. The Gen will remain at this set point for 1 min.	0.9
2	NIE will send generator a voltage set point. Upon confirmation from the generator that the set point was received, NIE will engage 'Voltage Control' mode. Hold until conditions stabilise. The generator will remain at this set point for 1 min.	1.00
3	NIE will send generator a voltage set point. Upon confirmation from the generator that the set point was received, NIE will engage 'Voltage Control' mode. Hold until conditions stabilise. The generator will remain at this set point for 1 min.	1.05
4	NIE will send generator a voltage set point. Upon confirmation from the generator that the set point was received, NIE will engage 'Voltage Control' mode Hold until conditions stabilise. The generator will remain at this set point for 1 min.	1.1
5	NIE will send generator a voltage set point. Upon confirmation from the generator that the set point was received, NIE will engage 'Voltage Control' mode Hold until conditions stabilise. The generator will remain at this set point for 1 min.	1.05
6	NIE will send generator a voltage set point. Upon confirmation from the GENERATOR that the set point was received, NIE will engage 'Voltage Control' mode Hold until conditions stabilise. The generator will remain at this set point for 1 min.	1.0
7	NIE will send generator a voltage set point. Upon confirmation from the generator that the set point was received, NIE will engage 'Voltage Control' mode Hold until conditions stabilise. The generator will remain at this set point for 1 min.	0.90

Voltage Control Mode Test Sequence for Test No.1-7	
Step No.	**Action**
1	NIE will send the generator a Voltage set point.
2	The generator will send NIE confirmation of the Voltage set point.
3	NIE will turn on 'Voltage Control' mode.
4	Hold until conditions stabilise.
5	The generator will be required to remain at this voltage set point for 1 min.

The tests will be regarded as being compliant if:

The voltage set point at the generators connection point should be adjustable over the ranges +/- 3.5% with a resolution of better than ±0.25%.

6.0 Automatic Voltage Control Test

Distribution Code Compliance Testing/Monitoring

Title of Test: Voltage Control Test

Purpose of Test:

The **Automatic Voltage Control Test** will be carried out by the Generator to verify that the generator is equipped with a fast-acting automatic voltage control that meets the requirements of CC.7.9.2 of the D-Code. Dead-band for voltage control, applicable within the voltage ranges a described on figure 2.

i) A comprehensive suite of tests will be carried out to fully explore the behavior of voltage control following a voltage excursion on the system.
ii) The automatic voltage control tests are to be arranged and conducted by the applicant; it is their responsibility to propose a test programme to suit their site specific requirements.

These tests will be carried out at a time when the kW Output of the generator is greater than 50% of rated capacity, unless otherwise agreed by the applicant with NIE in advance of the test.

Where a generator is supplied at LV by a local HV/LV transformer NIE will generally require control to be exercised and voltage recorded at the HV level. To facilitate this, NIE will provide for a Voltage Transformer as part of the connection and provide the generator with AC voltage signals from the VT.

Results Required:

Time series record and Microsoft Excel Plot showing:

- kW Output
- KVAr Output
- Voltage at the Connection Point
- Voltage Set Point

Test Assessment:

The test results will be assessed against:

- CC.7.9.2 & CC.5.3 of the D-Code

Criteria of Assessment for D connected Generator:

The test results will be assessed against the criteria below unless varied by the Connection Agreement.

1 The oscillation of voltage should not exceed ±5% of the voltage step change.
2 The steady state voltage should be achieved by 10 seconds, or other time agreed with NIE.
3 In addition to these tests NIE may test capability by tapping network transformers

7.0 Reactive Capability & Power Factor Control Capability Test

7.1 Reactive Capability Test

Distribution Compliance Testing/Monitoring
Title of Test: Reactive Capability
Purpose of Test: NIE will require a demonstration of the reactive power capability of the generator. NIE will communicate with each applicant prior to testing to discuss technical connection characteristics. Reactive Power Capability testing will be achieved by the generator for different kW Output levels for an agreed duration. The test duration will be for a minimum period of 1 hour at kW Output or a duration stipulated by NIE. This test will be co-ordinated by NIE at a time agreed with the applicant.
Results Required: Time series record and Microsoft Excel Plot showing: • kW Output • KVAr Output • Voltage at the Connection Point (Network)
Test Assessment: The test results will be assessed against the criteria below unless varied by the Connection Agreement. **Criteria of Assessment for D connected:** • The generator should demonstrate the ability to move to a voltage set point instruction, as outlined previously • The reactive power transfer at the generator's Terminals when generating more than 15% active power.

7.2 Reactive Capability and Power Factor Control Compliance Tests

The available power on the day of testing should be greater than 50% of the kW Rated Capacity.

The required tests should demonstrate the capability of the generator of the envelopes shown in Figures 1&2. Given the steady state nature of the Reactive Capability requirements implying that reactive output can be maintained indefinitely, the tests are carried out over a longer period than other compliance tests. Compliance will be demonstrated by

a) A suite of tests taking into wind availability and voltage constraints
b) Report from wind farm showing results of studies and simulations.

For each test, NIE will give the generator a Power Factor or Voltage set point and turn on Power Factor or Voltage Control mode in each case. In emergency voltage control, the generator shall demonstrate the ability to automatically move from power factor control to emergency voltage control when thresholds are exceeded.

8.0 Generator Control System Tests

Distribution Compliance Testing/Monitoring

Title of Test: Generator Control System Tests

Purpose of Test:

NIE place great reliance on the reliability of generator control systems. Normal controller operation and operation in the event of a controller or plant malfunction/failure is of particular importance to NIE.

The suite of tests to be carried out will examine the following scenarios:

- Generator Controller Failure
- Generator Transducer Failure
- Generator Controller Set point source test

After a generator control system has failed, the generator must contact the NIE control centre before re-energisation. This is to ensure that the NI network can facilitate the generation.

Generator Controller Failure Compliance Test will be carried out by the developer to verify that; in the event of generator controller failure, the generator will shut down and the site will go to zero kW. On restoration of supplies to any part of the controller, the output of the wind farm will not exceed a zero kW output for a period not greater than 60 seconds.

Generator Transducer Failure Compliance Tests will be carried out by the developer to verify that; in the event of generator controller loss of:

1. Voltage transformer input(s)
2. Current transformer input(s)
3. Transducer output

all result in the generator output being decreased to zero. Loss of any primary inputs should result in the generator shutting down and the site will go to zero kW

These tests will be carried out at a time when the kW Output of the generator is greater than or equal 50% of Installed Capacity, unless otherwise agreed by the developer with NIE in advance of the test.

Results Required:

Time series record and Microsoft Excel Plot showing:

- kW Output
- Generator Controller ON/OFF

Test Assessment:

- The test results should show the generator will operate as per the test scenarios above

Normal Running

- In the event of a control systems failure the generator or designate must contact NIE Control Centre before re-energisation.

9.0 Automatic Voltage Control Compliance Tests

Automatic Voltage Control testing should be carried out when the available power on the day of testing should be greater than 65% of Registered Capacity.

A comprehensive suite of tests will be carried out to fully explore the behaviour of a generator following a voltage excursion on the system.
The automatic voltage control tests described below are to be arranged and conducted by the Generator; it is their responsibility to propose a test programme to suit their site specific requirements. A typical example of the test programme is given below. This programme is required to be submitted to NIE for approval at the early stage of the compliance process.
Tests 1-8 will be carried out by changing the tap position of the transformer.

Altering the tap position of the Step-down transformers			
Test No.	**Action**	**Tap Change**	**Notes**
1	Tap up 1 position, hold for 10 sec	+1 Tap	
2	Tap up 1 position (i.e. up 2 positions from starting position) , hold for 10 sec	+1 Tap	
3	Tap down 1 position (i.e. up 1 position from starting position) , hold for 10 sec	-1 Tap	
4	Tap down 1 position (i.e. back to starting position) , hold for 10 sec	-1 Tap	
5	Tap down 1 position (i.e. down 1 position from starting position) , hold for 10 sec	-1 Tap	
6	Tap down 1 position (i.e. down 2 positions from starting position) , hold for 10 sec	-1 Tap	
7	Tap up 1 position (i.e. up 1 position from starting position) , hold for 10 sec	+1 Tap	
8	Tap up 1 position (i.e. back to starting position) , hold for 10 sec	+1 Tap	

Voltage Injections to the GENERATOR Controller			
Test No.	**Action**	**Voltage Injection**	**Notes**
9	Inject step to the generator Voltage Reference Set point . Hold for 1 min, remove injection as a step and hold for 1 min.	+7% (D-connected generator)	
10	Inject step to the generator Voltage Reference Set point . Hold for 1 min, remove injection as a step and hold for 1 min.	-7% (D-connected generator)	

The tests will be regarded as supporting compliance if:

- The generator should reach 90% of step change within 1 seconds (or other time agreed with NIE).
- Any oscillations settle to within 5% of the change in steady state reactive power within 10 seconds of the application of the step injection.

- The final steady state reactive value according to the slope characteristic is achieved within 10 seconds of the step application.
- If the voltage exceeds the specified band that the power factor control reverts to voltage control to the connection point voltage reference whilst the generator is operating in power factor mode.

10.0 Appendix A Compliance Process

Step No	Step	Description
1	Pre-energisation tests completed	
2	Energisation Notice	NIE will confirm the Generator is ready to be energised
3	Generator is Energised	NIE Circuit Breaker/Fuses closed
4	Temporary Compliance Certificate issued	A temporary compliance certificate is issued when the generator is energised. This certificate is valid for one year from when the generator begins exporting active power
5	NIE conduct continuous monitoring	For the full duration of the Temporary Compliance Certificate the generator will be subject to continuous monitoring. Should the generator prove non compliant it may be subject to compliance testing as described within the Technical document.
6	Has the generator performed satisfactorily during the monitoring period?	NIE shall confirm if compliance has been demonstrated. If the generator has performed satisfactorily NIE shall issue a Full Compliance Certificate
7	Issue Full Compliance Certificate	
8	NIE issue a Restricted Compliance Certificate	If non compliance arises at any point from energistaion throughout the full operational life of the generator, NIE may issue the generator with a Restricted Compliance Certificate which will detail the level of non compliance, the timeframe to rectify the non-compliance and any restrictions applicable until the non-compliance is rectified

11.0 Appendix B Connection Report for NIE

11.1 Outline Structure

The outline structure of the Report is given below. This example should be used as a guide; certain generators may require further information. The Report is to be submitted to NIE in an agreed format within two months of completion of Distribution Code Compliance testing.

11.2 Commercial and Legal

Introduction
Commissioning and test programs
Statements of Compliance

11.3 Connection Technical Data

Planning Data
User System Layout & Single line diagram
Substation infrastructure
Protection Systems and Settings
Generator controller details
Generator control diagrams (voltage)

11.4 Generator Technical Data

Generating Unit Technical data
Generator Protection
Compliance test results
Compliance Simulation Studies
Model verification
Reactive Capability & Voltage Range
Voltage Control & Stability
Fault Ride Through

12.0 Appendix C Contact Names

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