Small Scale Generation Setting Schedule

For Power Stations Less Than 5MW Exporting on the Distribution System of Northern Ireland

12/01/2017

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1. INTRODUCTION

In accordance with its Electricity Distribution Licence[1], Northern Ireland Electricity Networks Ltd is required to prepare a **Distribution Code** covering all material technical aspects relating to, connections to and operation & use of the **Distribution System** which is designed to permit the development, maintenance and operation of an efficient, co-ordinated and economical system for the distribution of electricity.

This **Setting Schedule** is prepared by the **DNO** to further clarify the detailed requirements and process to be followed by **Users** wishing to connect a **Power Station** with a **Registered Capacity** greater than or equal to 100kW but less than 5MW on to the **Distribution System**. This **Setting Schedule** forms part of the **Distribution Code**, with any proposed changes governed accordingly.

It explains the process required to manage crucial interactions and data exchange. The process also involves plant testing and reporting to demonstrate compliance with **DNO** requirements including the **Distribution Code**. Other tests or requirements deemed necessary by the **DNO** shall be specified, by agreement, within the **Generator's Connection Agreement**. Where the **Generator's Connection Agreement** specifically requires additional conditions or tests, a programme shall be agreed between the **Generator** and the **DNO**.

This **Setting Schedule** is made up of two main parts:

Sections 3 to 6 detail technical requirements for **Power Stations** less than 5 MW connecting to the **Distribution System**.

Sections 7 and 8 detail compliance, test and reporting requirements for **Power Stations** less than 5 MW connecting to the **Distribution System.**

While these are intended to inform the **Generator** of the necessary process to be followed, reference should also be made to the **Distribution Code**, the relevant **Connection Agreement** and the **Connection Agreement** application process for a complete set of provisions relating to connection of a **Power Station** to the **Distribution System**.

This **Setting Schedule** applies to **Power Stations** connected to the **Distribution System** on or after 1st January 2010 with a Registered Capacity from 100kW; to under 5MW.

[1] Condition 27, Paragraph 1 (March 2013)

2. GLOSSARY OF TERMS

Defined **Distribution Code** terms within this document are in bold.

Defined Small Scale Generation **Setting Schedule** terms are capitalised.

Term	**Definition**
2G	Second generation mobile phone technology
3G	Third generation mobile phone technology
APN	Access Point Name
Cable Termination Cubical (CTC)	The physical interface between the **Power Station** Controller and **DNO** RTU
CB	Circuit Breaker
CB Error Status	A logically invalid Circuit Breaker position indication.
Complex Site	A **Power Station** with **Load** requirements unrelated to the production of electricity and/or have a mixture of **Genset** types or technologies
DCC	Distribution Control Centre
DDI	Double Digital Input
DNO	Distribution Network Operator. In this document refers specifically to Northern Ireland Electricity Networks Ltd.
DNP3	Distributed Network Protocol
Dummy Circuit Breaker	A device whose purpose is to allow integrity checks of communication between the RTU and DCC. Its behaviour should be analogous to that of a main circuit breaker. Acceptable implementations include; a physical latching relay, digital output signals directly fed back into digital inputs or a virtual CB within the RTU or **Power Station** Controller.
EVC	Emergency Voltage Control
Final Compliance Certificate	On completion of the monitoring period and demonstrating successful compliance with the **Distribution Code** and **Connection Agreement**, the **DNO** will issue the Generator with the Final Compliance Certificate
MEC	Maximum Export Capacity
MIC	Maximum Import Capacity
NIE Networks	Northern Ireland Electricity Networks Limited
Operational Telecommunications Network (OTN)	The private radio network used by the **DNO**
PU	Per Unit. Base values as follows: kVA_{base} = **Registered Capacity** V_{base} = Voltage at Connection Point
Restricted Compliance Certificate	If a non-compliance arises at any point from energisation throughout the full operational life of the **Power Station**, the **DNO** may issue the **Generator** with a Restricted Compliance Certificate. This will detail the level of non-compliance of the Power Station, the time frame to rectify the non-compliance and any restrictions applicable to the **Power Station**.

Term	Definition
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SCADA System	The SCADA system used by the **DNO** as part of its Distribution Control Centre
SSG Setting Schedule	The **Setting Schedule** for **Power Stations** less than 5MW Exporting on to the Distribution System of Northern Ireland
Temporary Compliance Certificate	Following commissioning of SCADA and controllability tests, the **DNO** shall issue the **Generator** with a Temporary Compliance Certificate valid for one year from when the **Power Station** begins **Exporting Active Power**. During this period the **DNO** shall actively monitor the **Power Station** and assess its performance against **Distribution Code** and **Connection Agreement** criteria.
Type 1 RTU	A **Power Station** SCADA RTU provided by the **DNO**.
Type 2 RTU	A **Power Station** SCADA RTU provided by the Generator. Operates in two modes, A and B.

3. REMOTE TELEMETRY UNITS AND CONTROL

There is a requirement under the NI **Distribution Code**[2] for a SCADA facility to be provided for **Power Stations** of certain capacities that are connected to the **Distribution System**. For **Power Stations** greater than 5 MW, the **DNO** generally provides for SCADA by the installation of its own Remote Telemetry Unit (RTU). The RTU is the physical interface between the **DNO's** Distribution Control Centre and the **Power Station**.

As a general rule, where a SCADA requirement has been determined by the **DNO** in line with **Distribution Code** requirements:

a) Where a **Power Station** with a **Registered Capacity** greater than or equal to 100kW and less than 5MW is connected at a nominal voltage of 33kV the **DNO** shall provide SCADA by the installation of its own RTU.

b) Where a **Power Station** with a **Registered Capacity** greater than or equal to 100kW and less than 5 MW is connected at a nominal voltage less than 33kV, then the **DNO** is prepared to allow the **Generator** to provide the RTU and associated equipment. It is considered that this will allow a **Generator** to specify and procure RTU equipment in conjunction with their **Power Station** controller.

3.1 RTU Type Definitions

The RTU type will be specified in the connection offer and the **Generator** will be advised of which variant is applicable to their **Power Station** during the application process. This document covers 2 different SCADA/RTU arrangements which are defined below.

These RTUs have different technical requirements and sections 3.2 to 3.4 detail general requirements and those specific to individual RTU types and variants.

3.1.1 Type 1 RTU

Type 1 RTUs are provided by the **DNO**. All signalling is hard wired and the signalling interface between the **DNO** RTU and the **Power Station** shall be a Cable Termination Cubicle.

3.1.2 Type 2 RTU

Type 2 RTUs are provided by the **Generator** and must be capable of operating in the following modes:

- Mode A – The communications link between the **Power Station** and DCC uses 2G or 3G cellular communication. The protocol used between the RTU and **DNO** master station shall be DNP3. The Signalling interface between the **DNO** and the **Power Station** shall be the **DNO's** APN on the mobile cellular network.

- Mode B – The communications link between the **Power Station** and DCC uses the **DNO's** Operational Communications Network. The **DNO** shall provide a radio modem. The signalling interface between the **DNO** and the **Power Station** shall be the serial port on the **DNO** radio modem. The protocol used between the RTU and **DNO** master station shall be IEC-60870-5-101.

[2] Paragraph CC7.15 (February 2015 version)

3.2 Power Supplies

Type 1 RTUs

Responsibilities for power supplies will be detailed in the connection offer.

Type 2 RTUs

The Generator will be responsible for providing the RTU power supply. For loss of mains supply, a battery backup is required to confirm loss of mains to DCC.

For Mode B operation the **Generator** will be required to provide a power supply to a radio. The specification for this is listed in section 3.4.2 of this document.

3.3 RTU Facilities

The facilities required at each RTU are:

- status inputs (indications and alarms)
- controls, single & double
- analogs, inputs & outputs

Type 1B and Type 2 RTUs additionally require:

- communication ports

Type 1 RTUs

For any hard wired signalling, the **Generator** shall provide a Cable Termination Cubicle which forms the interface between the **DNO** and the **Power Station**.

The RTU will be monitoring single digital inputs, double digital inputs and analog inputs. The required analog range for hard wired input signals is 4-20mA DC.

The RTU will be controlling double digital outputs, single digital outputs and analog outputs. The required analog range for hard wired output signals is 4-20mA DC.

The wetting voltage for digital input and output signals shall be provided by the **DNO** and shall be either 24V[3] or 50V[4] DC. The **Generator** will be informed of the wetting voltage during the connection process.

Details of the signals required are given in Appendix D:

Type 2 RTUs – Mode A

The RTU will be monitoring single digital inputs and analog inputs
The RTU will be controlling single digital outputs and analog outputs.

Type 2 RTUs – Mode B

The RTU will be monitoring single digital inputs, double digital inputs and analog inputs
The RTU will be controlling double digital outputs, single digital outputs and analog outputs.

[3] Nominal voltage is 24V with a maximum of 30V
[4] Nominal voltage is 50V with a maximum of 60V

3.3.1 Status Inputs

Type 1 RTUs

For hardwired signals on Type 1 RTUs, these inputs shall be derived from clean, voltage free contacts.

Type 1 & Type 2 Mode B RTUs

Some data points require complimentary pairs of contacts as part of a Double Digital Input with one bit positively indicating open/false (01) and the other bit positively closed/false (10). Values of 00 and 11 are not logically valid and indicate Error Status. These DDIs should be configurable for consecutive digital channels in the RTU and should be configurable so that a delay can be applied before an Error Status is returned to the Distribution Control Centre. Unless otherwise stated by the **DNO** this delay shall be 100ms.

Type 2 RTU – Mode A

Indications from field wiring should use positive indications for both true and false values for a single data point. Where these present a logical error, the RTU shall set the 'On-line' flag bit to 0 for this data point.

3.3.2 Controls

A manual Control Inhibit switch shall be provided at the RTU which prevent controls from operating. Indication of the Control Inhibit switch position will be returned to DCC.

Type 1 RTUs

For a **DNO** supplied RTU, the plant equipment will be controlled from the RTU by operating an interposing relay supplied by the **Generator**. The execute command shall cause the interposing plant relay to be energised for a configurable period of between 0.5 and 5 seconds. The RTU shall control the interposing relays by switching both positive and negative poles of the wetting voltage.

The **Generator** shall install an additional control switch in their control room. This allows the **Generator** to block any remote controls from the **DNO** RTU. This shall normally be selected for 'Grid (Remote) Control'. The **Generator** shall contact DCC to request 'Local Control' and to agree a timeline for 'Grid Control' to be returned.

Type 2 RTUs

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.

Type 2 RTU – Mode A Operation

The RTU shall support 'select before operate' command routine within DNP3.0 protocol.

Type 2 RTU – Mode B Operation

The RTU shall support 'select and execute' command routine within IEC-60870-5-101 protocol.

3.3.3 Analogs

Analog accuracy shall be ±1% or better.

Type 2 RTUs

The scan rate of analogs and any deadband that is applied or can be configured shall be detailed by the **Generator**, reporting at least once per rolling hour and report by exception on excursion outside of a configurable deadband of between 1% and 10%.

Analog outputs must supply a constant value as instructed from DCC. For Type 2 RTUs the **Generator** shall indicate what happens to these analog outputs in the event of communications or power failure and upon restoration of communications and/or power.

Type 2 RTU – Mode A

The RTU shall be capable of logging analog values periodically. This period shall be configurable for each data point with a minimum resolution of 1 second. The **DNO** will inform the generator of the data log interval during the SCADA installation process. These values will be logged and timestamped.

3.3.4 Communication

Type 1 RTUs

The **DNO** is responsible for providing the communication link between the RTU and DCC

Type 2 RTUs

The **Generator** shall indicate the number of communications ports available and the functions of each port for the RTU offered. At least two physical ports and one 2G/3G cellular modem shall be provided. One of the ports shall be able to utilise communication by the **DNO's** Operational Telecommunications Network for Mode B operation. The cellular modem is required for primary communications for mode A operation. One of the ports shall be an Ethernet port providing a secondary IP connection option for mode A or mode B operation. Type 2 RTUs shall be able to operate in both A and B modes. Following a site signal strength survey performed by the **DNO**, the primary mode of operation will be stipulated during the application process. Changes in communications link availability on site may require a switch to a different operating mode. Should neither option be available, then another communication methodology shall be supplied by the **Generator** following agreements of its suitability with the **DNO**.

The **Generator** will be required to demonstrate that the RTU offered will operate satisfactorily while communicating with the SCADA System using DNP3 for mode A or IEC-60870-5-101 for mode B.

Type 2 RTU – Mode A

The **DNO** shall supply the appropriate SIM. The **Generator** shall supply the appropriate modem. The **DNO** shall provide necessary security credentials to connect to the **DNO's** APN. The RTU shall use DNP3 protocol to communicate with DCC. The **DNO** DNP3 master station is part of an iHost SCADA platform provided by Nortech Management Ltd. Contact details are provided in Appendix C: and they will provide technical requirements for iHost Compatible RTUs.

The Ethernet port is intended to provide flexibility for an alternative communication link following a future change in the availability of cellular communications. The **DNO's** preferred method of communication between Type 2 RTUs and the SCADA System is using cellular communication. The Ethernet port shall only be required to communicate with the SCADA System if requested by the **DNO**.

Hardware Requirements:	2G Modem - GPRS/EDGE (900MHz, 1800MHz)
	3G Modem - UMTS/HSDPA (900MHz, 1900MHz, 2100MHz)
	RJ45 Ethernet Port (10/100Mbps)

Type 2 RTU – Mode B

The **DNO** currently uses polled radio to provide communication back to DCC. The communications protocol utilised by the radio modems is presently IEC60870-5-101 operating at a data rate of either 9600 or 19200 bits per second (bps) and is via a RS232 presentation. The **DNO** will supply the communication equipment from the RTU to DCC. The **DNO** will confirm the data rate upon delivery of the communication equipment.

The RTU should also be capable of communicating using IEC 60870-5-104 protocol via the Ethernet port.

Hardware requirements are specified in section 3.4-Equipment Practice and Specification.

3.4 Equipment Practice and Specification

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

Type 2 RTUs

For mode B operation the **Generator** will be issued with some communication equipment. The cabinet for Type 2 RTUs shall be capable of accommodating the following:

3.4.1 Radio_Specification

Radio unit, aerial pole and antenna shall be provided by the **DNO**

Humidity: 95% at 40°C

Temperature Range: -30 to 60°C (full performance)
-40 to 70°C (operational)

Weight: 1.6 Kilograms
Case: Die-cast Aluminium.

Dimensions

Width: 143mm (minimum)
Height: 57mm (minimum)
Depth: 184mm including antenna connector

Aluminium Aerial Pole. 6 metres long x 50mm with a 5mm wall thickness. The antenna design and location will be recommended to the **Generator** following the site survey.

If required, planning permission for the antenna is the responsibility of the **Generator**.

Data Connection:[5] 25 Pin D-type Female connector
Pin 2 – Radio IN (Accepts data from the RTU)
Pin 3 – Radio OUT (Outputs data to the RTU)
Pin 7 – Signal Ground

3.4.2 Primary Power

Shall be provided by the **Generator**

Voltage: 13.8V nominal (10.5 to 16V DC)
TX Supply: 2.5 amps
RX Supply: 150mA (Operational)
25mA (Standby)

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

[5] A fully pinned 25 wire cable for connection must not be used. Use only the required pins for the application. Damage may result if improper connections are made.

Reverse Polarity Protection Diode will be required across the primary input.

3.4.3 Radio Cabinet

Shall be provided by the **Generator**. A cabinet with a minimum IP rating of IP55 is required to house the above radio equipment.

4. REACTIVE POWER REQUIREMENTS

This section details the minimum reactive power envelope that power stations are required to operate within.

4.1 Reactive Capability of Induction Power Stations

These **Power Stations** are classified as Type A in the NI **Distribution Code**.

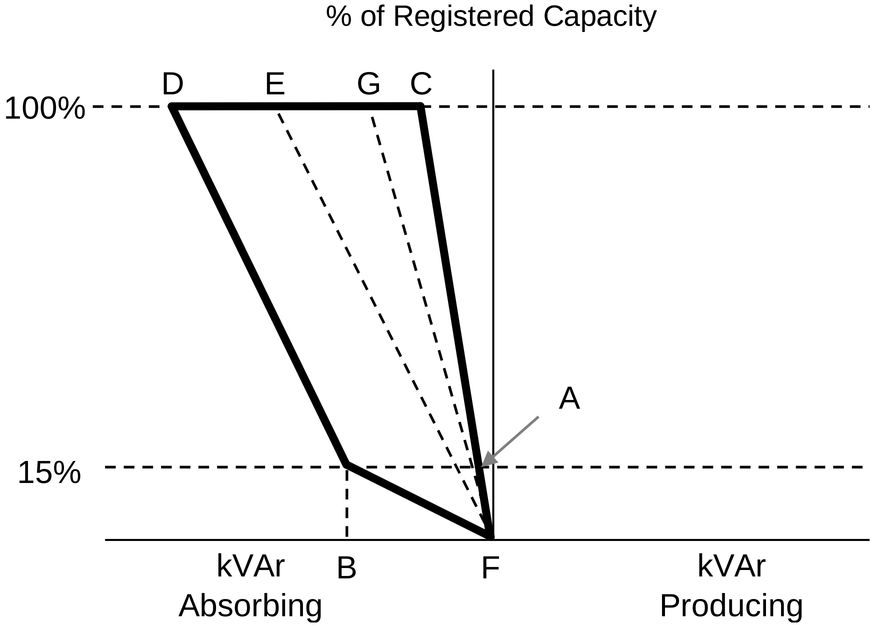

Figure 1 - Reactive Power Performance Chart at Connection Point - Type A Power Stations

Figure 1 above sets out the **Reactive Power** capability at the **Connection Point** for Induction **Power Stations** connecting to the **Distribution System** to which the **Power Station** will be tested in the Compliance Testing and Reporting section of this document.

a) Point A is the minimum absorbing **Reactive Power** capability at 15% **Registered Capacity** (voltage control mode);

b) Point B is the maximum absorbing **Reactive Power** capability at 15% **Registered Capacity** (voltage control mode);

c) Point C is the minimum absorbing **Reactive Power** capability at 100% **Registered Capacity** (voltage control mode);

d) Point D is the maximum absorbing **Reactive Power** capability at 100% **Registered Capacity** (voltage control mode);

e) Point E is the power factor limit of 0.95 absorbing at 100% **Registered Capacity** (power factor control mode);

f) Point F is the **Reactive Power** limit of 0kVAr at 0% **Registered Capacity** (power factor control mode);

g) Point G is the power factor limit of 0.98 absorbing at 100% **Registered Capacity** (power factor control mode);

h) Points A, B, C, D are defined by the capability declared by the **Generator** during the application process. The **Power Station** is also required to declare its **Reactive Power** capability at 0% **Registered Capacity**;

i) The envelope enclosed by points E, F and G describes the minimum reactive capability requirement of a Type A **Power Station**.

4.2 Reactive Capability of Non Induction Power Stations

These **Power Stations** are classified as Type B in the NI **Distribution Code**.

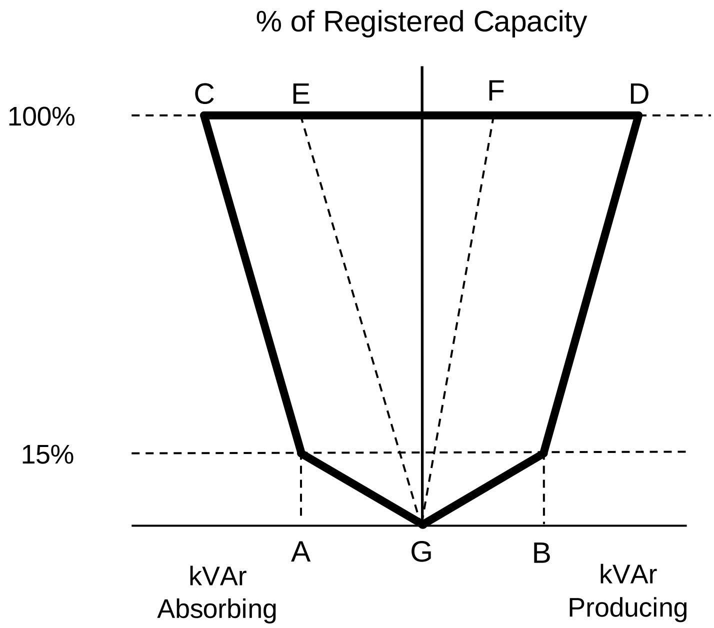

Figure 2 - Reactive Power Performance Chart at the Connection Point - Type B Power Stations

Figure 2 above sets out the **Reactive Power** capability at the **Connection Point** for Non Induction **Power Stations** connecting to the **Distribution System** to which the **Power Station** will be tested in the Compliance Testing and Reporting section of this document.

a) Point A is the maximum absorbing **Reactive Power** capability at 15% **Registered Capacity** (voltage control);

b) Point B is the maximum producing **Reactive Power** capability at 15% **Registered Capacity** (voltage control);

c) Point C is the maximum absorbing **Reactive Power** capability at 100% **Registered Capacity** (voltage control);

d) Point D is the maximum producing **Reactive Power** capability at 100% **Registered Capacity** (voltage control);

e) Point E is the power factor limit of 0.95 absorbing at 100% **Registered Capacity**;

f) Point F is the power factor limit of 0.98 producing at 100% **Registered Capacity**

g) Point G is the **Reactive Power** limit of 0kVAr at 0% **Registered Capacity**;

h) Points A, B, C & D i.e. reactive capabilities are defined by the capability declared by the **Generator** during the application process. The **Power Station** is also required to declare its reactive capability at 0% **Registered Capacity**.

i) The envelope enclosed by E, F and G describes the minimum reactive capability requirement of a Type B **Power Station**.

4.3 Complex Sites

Where **Power Stations** have **Load** requirements unrelated to the production of electricity and/or have a mixture of **Generating Unit** types or technologies, these **Power Stations** are referred to as Complex Sites.

4.3.1 Mixed Genset Types

Where **Power Stations** contain a mixture of induction and non-induction **Generating Units**, they will be classified as Type A or Type B as follows:

- Where the installed capacity of induction **Generating Units** is less than 33% of the total installed capacity then the **Power Station** shall be classified as a Type B.

- Where the installed capacity of induction **Generating Units** is greater than or equal to 33% of the total installed capacity then the **Power Station** shall be classified as a Type A.

4.3.2 Generating Units and Load

For the avoidance of doubt, where **User Systems** involve **Generating Units** and **Load** the entire **User System** shall be considered to be a **Power Station** and must be capable of delivering **Reactive Power** performance at the **Connection Point**.

4.3.3 SCADA Requirements

Complex sites will have additional SCADA requirements in order to assist the **DNO** fulfilling the requirements of P2/6. Additional signals are listed in Appendix F:

5. CONTROL MODES

All **Power Stations** which are connecting to the **Distribution System** must be capable of providing three **Reactive Power** control modes: Power Factor Control, Voltage Control and Emergency Voltage Control. All **Power Stations** shall operate in the control mode instructed by the **DNO**.

Per Unit values quoted here use the following base values:
kVA_{base} = **Registered Capacity**
V_{base} = Voltage at Connection point

5.1 Speed of Response

From paragraph 7.14.2 D-Code 2015, generators, "…must be fitted with a **Fast Acting** control system capable of being switched between Voltage Control mode and power factor control mode…" The response times for Power Stations are split into categories based on the voltage at the connection point and the **Registered Capacity**.

5.1.1 Power Stations ≥1MW and Connected at 33kV

For **Power Stations** connected to the **Distribution System** at 33kV with a **Registered Capacity** greater than or equal to 1MW, **Fast Acting** with regards to Reactive Power Control response is considered as being:

- The speed of response of the control system following a change in the phase angle set-point or voltage set-point at the **Connection Point** by the **DNO** via SCADA shall be such that the **Power Station** shall achieve 90% of its steady-state **Reactive Power** response within 1 second.
- The change in **Reactive Power** commences within 0.2 seconds of the application of the step injection
- Any oscillations settle to within 5% of the change in steady state **Reactive Power** within 2 seconds of the step injection.
- The final steady state reactive value is achieved within 5 seconds of the step injection. Steady state is deemed to have occurred when VAr oscillations settle within ±0.02pu of the new reactive power target.

5.1.2 Power Stations <1MW or Connected below 33kV

For **Power Stations** connected to the **Distribution System** below 33kV or with a **Registered Capacity** less than 1MW, **Fast Acting** with regards to Reactive Power Control response is considered as being:

- The speed of response of the control system following a change in the phase angle set-point or voltages set-point at the **Connection Point** by the **DNO** via SCADA shall be such that the **Power Station** shall achieve 90% of its steady-state **Reactive Power** response within 5 seconds.
- The change in **Reactive Power** commences within 1 seconds of the application of the step injection
- The final steady state reactive value is achieved within 10 seconds of the step injection. Steady state is deemed to have occurred when VAr oscillations settle within ±0.02pu[6] of the new reactive power target.

[6] Example: A 250kW wind turbine site in Power Factor control with setpoint of 0.95 absorbing

kW Output	kVAr Target	Error Margin	Min Power Factor	Max Power Factor
100%	-82kVAr	±5kVAr	0.94	0.96
15%	-11kVAr	±5kVAr	0.90	0.99

5.2 Power Factor Control Mode

Whilst the **Power Station** is operating in Power Factor control mode, it will be required to perform within the envelope EFG of Figure 1 for Type A **Power Stations**; and within the envelope EFG of Figure 2 for Type B **Power Stations**. The **Power Station** must be fitted with a **Fast Acting** control system capable of operating within the envelopes described above, in response to a Phase Angle Set-Point sent from the **DNO**. The phase angle set-point shall be adjustable over the minimum range: -18° to +12° for Type B and -18° to -12° for Type A **Power Stations** with a resolution of 1°. Phase angle shall be measured over the range -180° to +179° with a minimum resolution of 1°.

5.3 Voltage Control Mode

Whilst the **Power Station** is operating in Voltage Control mode, it will be required to perform within the envelope FBDC of Figure 1 for Type A **Power Stations**; and within the envelope GACDB of Figure 2 for Type B **Power Stations**. As a minimum requirement, the **Power Station** will be required to operate within the envelope EFG of Figure 1 for Type A **Power Stations**; and within the envelope EFG of Figure 2 for Type B **Power Stations**.

The **Power Station** is required to operate in Voltage Control with Slope and respond as follows:

The Voltage Control System of the **Power Station** should have a reactive slope characteristic which must be adjustable over a range of between 2 - 7% with a resolution of 0.5% (this shall be set at 3% unless otherwise instructed by the **DNO**). The **Power Station** must demonstrate the ability to operate on a 3% reactive slope characteristic.

The **System** voltage shall be determined by calculating the average of the 3 line voltages measured at the connection point.

Error! Reference source not found. illustrates how a decrease in the **System** voltage of 0.03pu would move the **Power Station** from its maximum leading **Reactive Power** capability (Q_{min}) to its maximum lagging **Reactive Power** capability (Q_{max}). For Type B **Power Stations,** when the **System** voltage is equal to the voltage set-point the Reactive Power output should be zero at unity power factor.

A new voltage set-point instruction would move the slope along the y-axis so that the y-intercept occurs at the new voltage set-point.

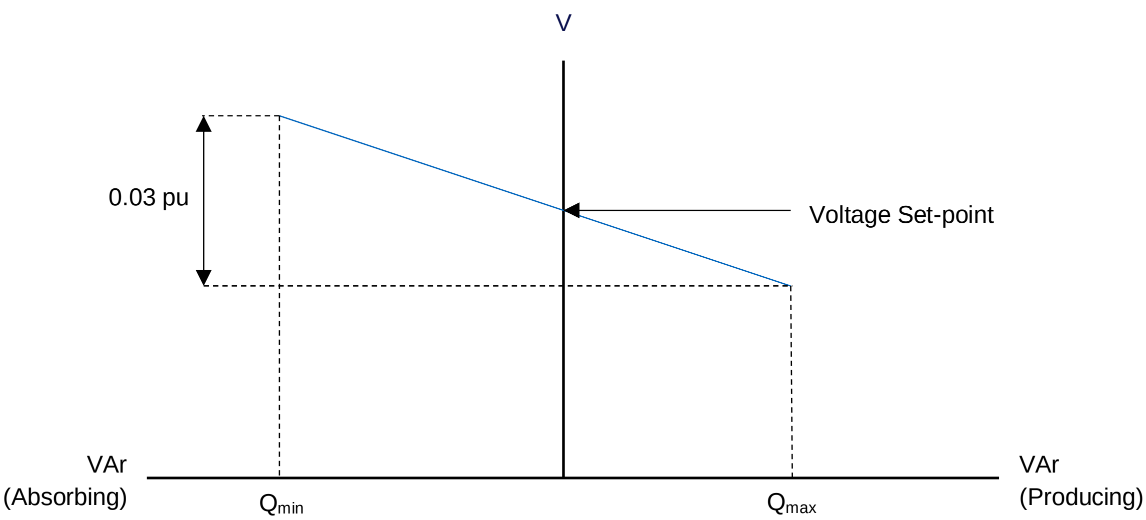

Figure 3 - Voltage Control with Slope

5.4 Emergency Voltage Control

Power Stations are required to be capable of stable operation in both Power Factor and Voltage Control modes. Where a **Power Station** is operating in Power Factor Control and one line voltage at the **Connection Point** exceeds 1.05pu at the upper limit or drops below 0.95pu at the lower limit then the **Power Station** shall perform in Emergency Voltage Control as detailed below:

In emergency voltage control the **System** voltage shall be measured as the line voltage which most exceeds the limits stated above.

On entering Emergency Voltage Control the **Power Station** shall revert to Voltage Control with Slope with a set-point of 1.05pu at the upper limit or 0.95pu at the lower limit. The **Power Station** shall remain in Emergency Voltage Control with a voltage set-point of 1.05pu or 0.95pu until either of the below criteria is met, at which point the **Power Station** will revert back to Power Factor Control Mode at the last instructed phase angle set-point:

- A Power Factor Control Select signal is received from the **DNO**.
- The **Power Station** voltage drops below 1.04 pu at the upper limit or exceeds 0.96 pu at the lower limit.

Where necessary, the **Power Station** shall maintain Q_{min} or Q_{max} until either of the above criteria is met.

Regarding SCADA indications, when the power station enters EVC, the control mode indication shall switch to 'Voltage Control' and operate the 'Voltage Auto Control'[7]/'Emergency Voltage Control'[8] Alarm. Examples of the expected behaviour are given in Appendix H:

[7] For Type 1 RTUs
[8] For Type 2 RTUs

6. MEASUREMENT DEVICES

This section details accuracy requirements for Current Transformers (CT), Voltage Transformers (VT) and transducers used to determine the power flow at the connection point for a power station. All generators will need to take these measurements as part of their reactive power control system and some may also need to report these measurements to the **DNO** as part of their SCADA requirements.

While operating in Voltage Control mode, an accurate voltage measurement is required to correctly determine the amount of reactive support the power station should deliver. The combined accuracy of the VT and transducer used to pass a voltage measurement to the **Power Station** controller shall be ±0.5% or better.

For SCADA arrangements with Type 2 RTUs the generator is responsible for reporting analog measurements to the **DNO**. These shall have an accuracy of ±1% or better.

The following table lists the recommended class of CT, VT and transducer for power stations connected at different voltages.

Connection Point	VT	CT	Transducer
400V	N/A[9]	0.5s	0.5
6.6kV	0.2	0.2s[10]	0.2
11kV	0.2	0.2s[10]	0.2
33kV	0.2	0.2s	0.2

[9] LV connected **Power Stations** shall take a direct voltage measurement to their transducer. Use of a VT is not acceptable.
[10] On existing HVC sites. Use of existing 0.5 CTs would be acceptable.

7. COMPLIANCE PROCESS

7.1 Pre-Energisation

The **Power Station** will not be connected unless all relevant agreements have been signed. To help ensure proper coordination between the parties, this should normally be completed 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 **Power Station** will become fully compliant with all parts of the NI **Distribution Code**.

7.2 Temporary Export Restriction

For Power Stations with a **Registered Capacity** greater than or equal to 1MW, the generator shall limit their export to 50% of their MEC until SCADA commissioning and controllability tests have been completed. This limit is intended to restrict the **Generator** to only operate one **Genset** at a time during testing and commissioning. Should this limit impede the **Generator's** ability to commission the **Power Station**, the **Generator** may apply in writing to the **DNO** to have the limit raised or temporarily removed. The decision to raise or remove the cap will be entirely at the discretion of the **DNO**.

The **Generator** is not expected to install or alter reverse power flow protection at the **Connection Point** as part of this Temporary Export Restriction

7.3 SCADA Commissioning

7.3.1 Type 1 RTU

The **DNO** shall complete their RTU installation before the **Power Station** is energised. Controlability tests will only be performed once the **Generator** has completed their side of the SCADA installation.

7.3.2 Type 2 RTU

Following energisation, the generator should complete their SCADA installation within 12 months. The SCADA installation shall be considered completed following the successful completion of a SCADA Site Acceptance Test conducted by the **DNO**. A copy of the test procedure shall be made available to the **Generator**. Failure to meet this deadline will be considered as non-compliance to the **Distribution Code.**

7.4 Controllability Tests

The **Generator** is required to demonstrate the **Power Station** controller performs correctly for the different reactive power control modes. It should be noted that these are much simpler tests than those used in a full compliance test as detailed in sections 8.5 and 8.6. The purpose of these tests is to demonstrate the controller meets the final steady state criteria from sections 5.1.1 and 5.1.2.

This tests should be performed by the **DNO** using remote control over SCADA. Where this is not available the **DNO** may visit the power station and conduct the test with verbal instructions to the generator. The generator must provide a display indicating the following measurements at the Connection Point.

- Active Power (kW)
- Reactive Power (kVAr)
- Average Line Voltage (kV)

A copy of the test sheet for Type A **Power Stations** can be found in Appendix I: and a copy of the test sheet for Type B **Power Stations** can be found in Appendix J:

7.4.1 Power Stations < 1MW

Following energisation, the **Power Station** has 12 months to successfully complete controllability tests. Failure to meet this deadline will be considered as non-compliance to the **Distribution Code**.

7.5 Post-Energisation Monitoring

Following completion of SCADA and controllability tests the **DNO** shall issue the **Generator** with a Temporary Compliance Certificate valid for one year from when the **Power Station** begins **Exporting Active Power**. During this period (normally 12 months but this may need to be extended in order to prove compliance), the **DNO** shall actively monitor the **Power Station** and assess its performance against **Distribution Code** and **Connection Agreement** criteria.

On completion of the monitoring period and demonstrating successful compliance with the **Distribution Code** and **Connection Agreement**, the **DNO** will issue the **Generator** with the Final Compliance Certificate.

During this period or subsequent to the receipt of a Final Compliance Certificate, if the **DNO** identifies an area of non-compliance, the **DNO** shall issue the **Generator** with a Restricted Compliance Certificate. This Restricted Compliance Certificate will detail the level of non-compliance, the timeframe to rectify non-compliance and any restrictions applicable to the **Power Station**. However, if the relevant conditions necessary to demonstrate compliance are not experienced during the twelve months following energisation, then nevertheless the final compliance certificate will be issued by the **DNO** at the expiration of that twelve month period.

After completion of any works required to make the **Power Station** compliant, the **DNO** shall use the tests outlined within this document as a measure to test compliance.

At least 6 weeks in advance of testing, the **Generator** must provide the **DNO** with a test programme. The **DNO's** objective in seeking this information is to establish from the **Generator's** programme, those tests which may have an impact on the **Distribution System**.

8. COMPLIANCE TESTS & MONITORING

The purpose for testing is for the **Power Station** to demonstrate compliance with **Distribution Code** and **Connection Agreement**. The compliance process is described in detailed in Appendix A.

The tests will then need to be planned into a Commissioning Programme on dates agreeable to both the **Generator** and the **DNO**. All tests will be required to be carried out to agreed procedures. The **DNO** will verify that the proposed tests will comply with **Distribution Code** and **Connection Agreement** requirements, such that following successful completion a Final Compliance Certificate can be issued

8.1 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 the **DNO**. This will not relieve the **Generator** of any responsibility for compliance with the **Distribution Code**. During these controllability tests, it is the responsibility of the **Generator** to record the specified results electronically.

8.2 Test Witnessing

The **DNO** will decide whether test witnessing will be required, and arrange for the presence of witnesses. The **DNO** will inform the **Generator** 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 the **DNO**.

Where the **DNO** decides not to witness any test, this shall not relieve the **Generator** 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 the **DNO** either for compliance or for the consequences of failure to comply. Final approval of all distribution related testing shall be given by the **DNO** after analysing test results.

8.3 Test Results

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

All sinusoidal waveforms should be presented in RMS format and all tests results, as a minimum requirement, must provide RMS parameter magnitudes every 100ms.

It is important that results are legible, clearly labelled and graphs appropriately scaled in engineering units. The **DNO** 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 the **DNO** to fully analyse the test results and determine whether or not the **Power Station** is compliant. The **Power Station** may continue operation during the result evaluation period.

8.4 Connection Report

Where a **Power Station** has been subjected to compliance testing, the **Generator** will be required to submit a 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. The **DNO** will review the submitted data to ensure that the **Power Station** is compliant with all aspects of the requirements mentioned in the **Connection Agreement** and the **Distribution Code**. A breakdown of report components can be seen in Appendix A:

The Connection Report will be a comprehensive collection of the overall **Power Station** development, containing all relevant technical information, and site specific data. The responsibility for deciding whether the reports submitted by the **Generator** satisfy the **Power Station** compliance obligations will rest with the **DNO**. The **DNO** will respond to the Connection Report within 2 months of its receipt.

If the **DNO** considers it necessary, it may require the report(s) to be prepared by an Independent Engineer. In this event, the **DNO** 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 other costs shall be met by the **Generator**.

8.5 Voltage Control Mode Tests

Voltage control is tested in three separate parts:

- Voltage control setpoint
- Automatic Voltage Control
- Emergency Voltage Control

8.5.1 Voltage Control Set Point Test

Purpose of Test:

The Voltage Control Mode Test will be carried out by the **Generator** to demonstrate that, upon receipt of a Voltage Control signal, the **Power Station** enters Voltage Control mode.

The **Power Station** should then control the **Connection Point** voltage with a resolution of ±0.5% of the nominal voltage, whilst operating in direct voltage control (if it has the reactive capability to do so).

The functionality of the voltage control system should be demonstrated at different voltage set points. The **DNO** 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 **Power Station** is greater than 50% of **Registered Capacity** and 100% of the **Power Station Generating Unit**s that are in service, unless otherwise agreed by the **DNO** in advance of the test.

Where a **Power Station** is supplied at LV by a local HV/LV transformer, the **DNO** will require control to be exercised and voltage recorded at the **Connection Point**.

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 Paragraph CC.7.14.2 of the **Distribution Code**

Voltage Control Mode testing will be carried out at a time when the kW Output of the **Power Station** is greater than 50% of **Registered Capacity**, unless otherwise agreed by the **DNO** in advance of the test.

The Voltage Control Mode tests (Sequence 1 and 2) described below are indicative of what the **DNO** would expect to see. However, the **Generator** will have to agree a testing programme with the **DNO** who will advise as to the voltage limits that can be tested at the site. This programme is required to be submitted to the **DNO** for approval at the early stage of the compliance testing process.

Voltage set points sent by the **DNO** to the **Power Station** These set points may be adjusted dependant on prevailing system conditions (Sequence 1)		
Test No.	Action	Voltage set point pu
1	The **DNO** will send the **Power Station** a voltage set point. Upon confirmation from the **Power Station** that the set point was received, the **DNO** will engage Voltage Control mode. The **Power Station** will remain at this set point for 1 minute.	0.94
2	The **DNO** will send the **Power Station** a voltage set point. The **Power Station** will remain at this set point for 1 minute.	0.96
3	The **DNO** will send the **Power Station** a voltage set point. The **Power Station** will remain at this set point for 1 minute.	0.98
4	The **DNO** will send the **Power Station** a voltage set point. The **Power Station** will remain at this set point for 1 minute.	1.00
5	The **DNO** will send the **Power Station** a voltage set point. The **Power Station** will remain at this set point for 1 minute.	1.02
6	The **DNO** will send the **Power Station** a voltage set point. The **Power Station** will remain at this set point for 1 minute.	1.04
7	The **DNO** will send the **Power Station** a voltage set point. The **Power Station** will remain at this set point for 1 minute.	1.06

These tests will be regarded as being compliant if:

- The voltage set point at the **Power Station**'s **Connection Point** is adjustable over the ranges +/- 6% with a resolution of better than ±0.5%.
- The **Power Station** will hold the required **Connection Point** voltage to within 1% of the set point based on nominal voltage if the reactive capability is there to do so.

8.5.2 Automatic Voltage Control Test

Purpose of Test:

The Automatic Voltage Control Test will be carried out by the **Generator** to verify that the **Power Station** is equipped with a fast-acting automatic voltage control that meets the requirements of paragraph CC.7.14.2 of the **Distribution Code**.

i) A comprehensive suite of tests will be carried out to fully explore the behaviour of voltage control following a voltage excursion on the system.

ii) The automatic voltage control tests 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 the **DNO** for approval at the early stage of the compliance testing process.

Tests 1-8 will be carried out by changing the tap position of the transformer.

These tests will be carried out at a time when the kW Output of the **Power Station** is greater than 65% of **Registered Capacity**, unless otherwise agreed by the **Generator** with the **DNO** in advance of the test.

Where a **Power Station** is supplied at LV by a local HV/LV transformer, the **DNO** will require control to be exercised and voltage recorded at the **Connection Point**

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

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 paragraphs CC.7.14.2 and CC.5.3 of the **Distribution Code**.

Criteria of Assessment for a distribution-connected **Power Station**:
The test results will be assessed against the criteria below unless varied by the **Connection Agreement**.

The tests will be regarded as supporting compliance if:

1 The **Power Station** should reach 90% of step change within 1 seconds (or other time agreed with the **DNO**) following the application of the step change.

2 Any oscillations settle to within 5% of the change in steady state **Reactive Power** within 10 seconds (steady state) of the application of the step injection.

8.5.3 Emergency Voltage Control

Emergency Voltage Control Test
The **Power Station** should select Power Factor Control Mode before executing the following steps:

Voltage Injections to the **Power Station** Controller			
Test No.	Action	Voltage Injection	Notes
1	Inject step to the **Power Station** Voltage Reference set point. Hold for 1 minute, remove injection as a step and hold for 1 minute.	+5% (D-connected **Power Station**)	
2	Inject step to the **Power Station** Voltage Reference set point. Hold for 1 minute, remove injection as a step and hold for 1 minute.	-5% (D-connected **Power Station**)	

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 paragraphs CC.7.14.2 and CC.5.3 of the **Distribution Code**.

Criteria of Assessment for a distribution-connected **Power Station**:
The test results will be assessed against the criteria below unless varied by the **Connection Agreement**.

The tests will be regarded as supporting compliance if:

1. If the voltage exceeds the specified band that the power factor control reverts to voltage control to the **Connection Point** voltage reference whilst the **Power Station** is operating in power factor mode.

2. The **Power Station** should reach 90% of step change within 1 seconds (or other time agreed with the **DNO**) following the application of the step change.

3. Any oscillations settle to within 5% of the change in steady state **Reactive Power** within 10 seconds (steady state) of the application of the step injection.

8.6 Power Factor Control Mode Tests

Purpose of Test:

The **DNO** will require a demonstration of the power factor capability of the **Power Station** as per the envelopes shown in section 4, Reactive Power Requirements.

The **DNO** will communicate with each **Generator** prior to testing to discuss technical connection characteristics. Power Factor 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 the **DNO**.

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

Given the steady state nature of the Power Factor 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 suite of tests taking into account wind availability and voltage constraints
- A report from the **Power Station** showing results of studies and simulations.

For each test, the **DNO** will give the **Power Station** a power factor set point and turn on Power Factor mode.

This test will be co-ordinated by the **DNO** at a time agreed with the **Generator**.

Results Required:

Time series record and Microsoft Excel Plot showing:

- kW Output
- kVAr Output
- Power Factor Set Point
- Power Factor
- Voltage at the **Connection Point**

8.7 Reactive Capability Tests

Purpose of Test:
The **DNO** will require a demonstration of the **Reactive Power** capability of the **Power Station**.

The required tests should demonstrate the capability of the **Power Station** within the appropriate envelopes shown in section 4.

The **DNO** will communicate with each **Generator** 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 the **DNO**.

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

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 suite of tests taking into account wind availability and voltage constraints
- A report from the **Power Station** showing results of studies and simulations.

For each test, the **DNO** will give the **Power Station** a power factor or voltage set point and turn on Power Factor or Voltage Control mode in each case.

This test will be co-ordinated by the **DNO** at a time agreed with the **Generator**.

Results Required:
Time series record and Microsoft Excel Plot showing:
- kW Output
- kVAr Output
- Voltage at the **Connection Point**

8.8 Power Station Control System Tests

Purpose of Test:

The **DNO** places great reliance on the reliability of **Power Station** control systems. Normal controller operation and operation in the event of a controller or plant malfunction/failure is of particular importance to the **DNO**.

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

- **Power Station** Controller Failure
- **Power Station** Transducer Failure

After a **Power Station** control system has failed, the **Generator** must contact the **Distribution Service Centre** before re-energisation. This is to ensure that the **Distribution System** can facilitate the generation.

Power Station Controller Failure Compliance Tests will be carried out by the **Generator** to verify that, in the event of **Power Station** controller failure, the **Power Station** will shut down and the **Power Station Export** will go to zero kVA. On restoration of supplies, to any part of the controller, the output of the **Power Station** will not exceed a zero kVA output for at least 60 seconds.

Power Station Transducer Failure Compliance Tests will be carried out by the **Generator** to verify that, in the event of **Power Station** controller loss of:

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

the **Power Station Export** shall decrease to zero kVA.

These tests will be carried out at a time when the kW Output of the **Power Station** is greater than or equal 50% of **Registered Capacity**, unless otherwise agreed by the **Generator** with the **DNO** in advance of the test.

Results Required:

Time series record and Microsoft Excel Plot showing:

- kW Output
- Grid Controller Operational

Transducer Failure:

- In the event of a control systems failure, the **Generator** or designate must contact the **Distribution Service Centre** before re-energisation.

Appendix A: Connection Report for the DNO

Outline Structure

The outline structure of the Report required is given below. This example should be used as a guide. Certain **Generators** may be required to provide further information. The Report is to be submitted to the **DNO** in an agreed format within two months of completion of **Distribution Code** Compliance testing.

Commercial and Legal

- Introduction
- Commissioning and test programs
- Statements of Compliance

Connection Technical Data

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

Power Station Technical Data

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

Appendix B: NIE Networks Ltd Contacts

Distribution Control Centre
Telephone: 03457 643643

Near Time Operations Department
Email: ssg.nto@nienetworks.co.uk
Telephone: 028 3836 8654

Appendix C: Nortech Management Ltd Contacts

Telephone: +44 8700 111 992
Email: info@nortechonline.co.uk
Address: Nortech Management Ltd
Unit 2, Deer Park Business Centre
Woollas Hill
Eckington
Pershore
WR10 3DN
United Kingdom

Appendix D: Type 1 RTU SCADA Signals

This section details the signalling requirements for sites with Type 1 RTUs.
The signals listed in this section will be tested point to point from the **Power Station**'s terminal box to the **DNO** RTU and through to the DCC. The signals if hardwired ranged 4-20mA should be simulated from the terminal box and if using a serial protocol tested as close to the transducers as possible.

Table 1 – Analog Input Signals (to Control Centre) from Power Station – Type 1 RTU

Signal[11]	**Description**	**Range**	**Units**	**Scale Min**	**Scale Max**	**Display Units**
MW[12]	The flow of **Active Power** at the **Connection Point**.[13]	4 - 20	mA	TBC		MW
MVAr[12]	The flow of **Reactive Power** at the **Connection Point**.[14]	4 - 20	mA	TBC		MVAr
kV Setpoint Cfmd	Confirmation of the HV voltage set point for Voltage Control mode operation.	4 - 20	mA	TBA[15]		kV
kV[12]	Indication of the HV line voltage.	4 - 20	mA	TBC		kV
P/F Setpoint Cfmd	Confirmation of the phase angle set point for Power Factor control mode operation.	4 - 20	mA	TBA[15]		Degrees
Phase Angle Measurement[12]	Measurement of the phase angle at the **Connection Point**.	4 - 20	mA	TBC		Degrees

[11] These signals will report by exception within a dead band range of 1% - 10% determined by the **DNO**.
[12] Provided by the **DNO** as part of the connection arrangements. Included for completeness. These indications must come directly from the transducers.
[13] A positive value indicates **Export** of **Active Power** from the **Power Station** to **Distribution System**. A negative value indicates the **Import** of **Active Power** from the **Distribution System** to the **Power Station**.
[14] A positive value indicates **Export** of **Reactive Power** from the **Power Station** to the **Distribution System**. A negative value indicates the **Import** of **Reactive Power** from the **Distribution System** to the **Power Station**.
[15] Scale to be agreed with the **DNO**.

Table 2 - Analog Output Signals (from Control Centre) to Power Station – Type 1 RTU

Signal	Description	Range	Units	Scale Min	Scale Max	Display Units
kV Set-point	Analog output indicating the new set-point for voltage control mode.	4 - 20	mA	TBA[16]		kV
Power Factor Set-point	Analog output indicating the new set-point for power factor control mode. Value is given as phase angle.	4 – 20	mA	TBA[16]		Degrees

[16] Scale to be agreed with the **DNO**

Table 3 - Digital Input Signals (to Control Centre) from Power Station – Type 1 RTU

Signal	Description	Contact Arrangement
Power Factor Control ON	Indication that power factor control mode has been selected	Double[17]
Power Factor Control OFF	Indication that power factor control mode is not currently selected	
Voltage Control ON	Indication that voltage control mode has been selected	Double[17]
Voltage Control OFF	Indication that voltage control mode is not currently selected	
Voltage Auto Control[18]	Alarm indication that the control mode has automatically changed to voltage control	Single
CB1 Open[χ]	Indication that the DNO Circuit Breaker at the **Connection Point** is open	Double[19]
CB1 Closed[χ]	Indication that the DNO Circuit Breaker at the **Connection Point** is closed	
G59 Island Trip	Alarm indication that G59 protection has operated	Single
Dummy Circuit Breaker Open[χ]	Indication that the DNO dummy circuit breaker is open	Double[20]
Dummy Circuit Breaker Closed[χ]	Indication that the DNO dummy circuit breaker is closed	

[17] Power Factor and Voltage Control indications shall be arranged as complementary bits of a double bit indication
[18] Automatic changeover to voltage control mode will occur if the voltage moves beyond the limits of a deadband agreed between the **DNO** and the generator
[χ]Provided by the **DNO** as part of the connection arrangements. Included for completeness
[19] CB Open & Closed indications shall be arranged as complementary bits of a double bit indication
[20] Dummy CB Open & Closed indications shall be arranged as complementary points of a double bit indication

Signal	Description	Contact Arrangement
Grid Control Selected	The **Power Station** Controller will respond to remote controls from the DNO	Double
Local Control Selected	Indication that supervisory/remote control has been disabled. The **Power Station** Controller will not permit remote controls from the DNO	
Transducer Faulty	Indication that a primary input to the power station controller has been lost	Single
Grid Controller Faulty	Indication of a power or component failure of the power station controller	Single
AC Main Fail[21]	Alarm indication that the mains power supply to the RTU has been lost and is running on battery backup	Single
Emergency Soft Stop ON	Confirmation that soft-stop has been requested. Apparent power output should reduce to zero.	Double
Emergency Soft Stop OFF	Confirmation that soft-stop has been removed. No restriction on apparent power output.	
Emergency S.S. (Soft-Stop) Complete	Alarm Indication that the generator shutdown action has been completed and the apparent power output is zero.	Single

[21] Provided by the **DNO** as part of the connection arrangements. Included for completeness

Table 4 - Digital Output Signals (from Control Centre) to Power Station – Type 1 RTU

Signal Description	Description	Permanent Common Signal	Pulse[22] Open Signal	Pulse[22] Close Signal
Voltage Control ON Common	Instruction to operate in voltage control mode	0V		TBA V dc
Power Factor Control ON Common	Instruction to operate in power factor control mode	0V		TBA V dc
CB1 Close[23] Common CB1 Open[23]	Close the DNO Circuit Breaker at the **Connection Point** Open the DNO Circuit Breaker at the **Connection Point**	0V	TBC V dc	TBA V dc
Close Dummy CB[23] Common Open Dummy CB[23]	Close the DNO Dummy Circuit Breaker Open the DNO Dummy Circuit Breaker	0V	TBA V dc	TBA V dc
Emergency Soft Stop ON[24] Common Emergency Soft Stop OFF[25]	Instruction to reduce generator apparent power output to zero Instruction removing restriction on **Power Station** apparent power output	0V	TBA V dc	TBA V dc

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[22] Pulse length will be configurable over the range 0.5 to 5.0 seconds. The pulse length will be specified by the **DNO** during the SCADA connection process
TBA - Signal voltage to be agreed with the **DNO**

[23] Provided by the **DNO** as part of the connection arrangements. Included for completeness

[24] Generator Shutdown allows the **DNO** to temporarily remove generation from a circuit. The generator shall disconnect or ramp down their output by a method of their own choosing in a time frame agreed with the **DNO**. Once their shutdown action is complete they shall return a Generator Shutdown Sequence Completed alarm indication. If the generator is already in a zero output or disconnected state when the inhibit command is applied it must remain in this state.

[25] Removes restriction on generator output and allows it to return to normal running conditions.

Appendix E: Type 2 RTU SCADA Signals

This section details signalling requirements for **Power Stations** with Type 2 RTUs

Table 5 – Analog Inputs (from Power Station) to Control Centre

No.	Name	Description	Scale Min	Scale Max	Units
0	kVAr	The flow of **Reactive Power** at the **Connection Point**.	TBC	TBC	kVAr
1	kW	The flow of **Active Power** at the **Connection Point**.	TBC	TBC	kW
2	Power Factor	Power Factor at Connection Point	-1.00	1.00	N/A
3	Phase Angle Set-Point Confirmation	Confirmation of the phase angle set point for Power Factor control mode	-180	179	Degrees
4	Phase Angle φ_1	Measurement of the phase angle on L_1 at the Connection Point	-180	179	Degrees
5	Phase Angle φ_2	Measurement of the phase angle on L_2 at the Connection Point	-180	179	Degrees
6	Phase Angle φ_3	Measurement of the phase angle on L_3 at the Connection Point	-180	179	Degrees
7	RSSI[26]	Received Signal Strength Indication	TBC	TBC	TBC
8	V_{ab}	Indication of the line voltage measured between L_1 and L_2 at the Connection Point	0	1.2 PU	V
9	V_{bc}	Indication of the line voltage measured between L_2 and L_3 at the Connection Point	0	1.2 PU	V
10	V_{ca}	Indication of the line voltage measured between L_3 and L_1 at the Connection Point	0	1.2 PU	V
11	Voltage Setpoint Confirmation	Confirmation of the voltage set point for Voltage Control mode	0	1.2 PU	V
12	HV Current[27]	Measurement of the phase current on L2 at the Connection Point[28]	TBC	TBC	A

[26] This shall be either the measured physical value in dBm or a reference value in Arbitrary Strength Units. For RTUs reporting in ASU, the **Generator** shall provide documentation detailing how it can be mapped to an equivalent value in dBm.
[27] Sites with a nominal voltage above 1000V at the **Connection Point** shall provide a current measurement
[28] A positive value indicates the flow of current from the **Power Station** to the **Distribution Network**. A negative value indicates the flow of current from the **Distribution Network** to the **Power Station**

Table 6 - Analog Outputs (from Control Centre) to Power Station

No.	Signal	Description	Scale Min	Scale Max	Units
0	Phase Angle Set-Point Instruction	Analog output indicating the new set-point for power factor control mode	-18	12	Degrees
1	Voltage Set-Point Instruction	Analog output indicating the new set-point for power factor control mode	0.96 PU	1.04 PU	TBC

Table 7 - Digital Outputs (from Control Centre) to Power Station

No.	Signal	Description	False/0/10	True/1/01
0	Control Mode	Instruction from DNO to select power factor control or voltage control mode	Power Factor Control	Voltage Control
1	Dummy CB	Instruction from the DNO to open or close the Dummy Circuit Breaker	Open	Close
2	Emergency Soft-Stop	Instruction from the DNO to shut down all Generating Units or to operate as normal	Soft Stop On (Shutdown)	Soft Stop Reset (Generate as Normal)

Table 8 - Digital Inputs (from Power Station) to Control Centre

No.	Signal	Description	False/0/10	True/1/01
0	RTU Control Switch	Indication that supervisory/remote control has been disabled	OFF- Local Control	ON – Remote Control
1	Control Mode	Indication that power factor or voltage control mode has been selected	Voltage Control	Power Factor Control
2	Customer G59 CB	Indication of the status of the CB associated with the power station G59 Protection	Open	Closed
3	Dummy CB	Indication of the Status of the Dummy CB.	Open	Closed
4	Emergency Voltage Control	Alarm indication that the power station has now automatically switched to Emergency Voltage Control.	Reset	Operated
5	G59 Protection Trip	Alarm indication that a G59 trip event has occurred	Reset	Operated
6	Phase Angle Set-Point out of Range	Alarm indication that the **Power Station** has been instructed to reach a phase angle outside of D-Code reactive capability requirements	Reset	Operated
7	Power Factor Indication	Indication to complement AI-2. 0provides additional clarity	Capacitive	Inductive
8	AC Mains Fail	Alarm indication that the power supply to the RTU has failed and it is now running on battery backup.	Reset	Operated
9	RTU Local Comms Fault	Alarm indication that the communication link between the power plant controller and the RTU has failed.	Comms OK	Operated
10	Soft Stop Sequence Complete	Alarm Indication that the generator shutdown action has been completed and the apparent power output is zero.	Soft Stop Complete	Reset
11	Emergency Soft Stop	Confirmation that soft-stop has been requested/reset by DNO	Soft-Stop On (Shutdown)	Soft-Stop Reset (Generate as Normal)
12	Voltage Set-Point Out of Range	Alarm indication that the **Power Station** has been instructed to reach a voltage outside of statutory limits	Reset	Operated

Appendix F: Complex Site Signals

The signals listed in these tables are only intended as a template. The signal list may be extended or reduced to accommodate the different numbers of **Genset** technologies or circuit breakers associated with G59 protection on a site by site basis. A full signal list specific to each **Power Station** will be issued by the **DNO** during the SCADA commissioning process.

Table 9 - Complex Site Analog Inputs

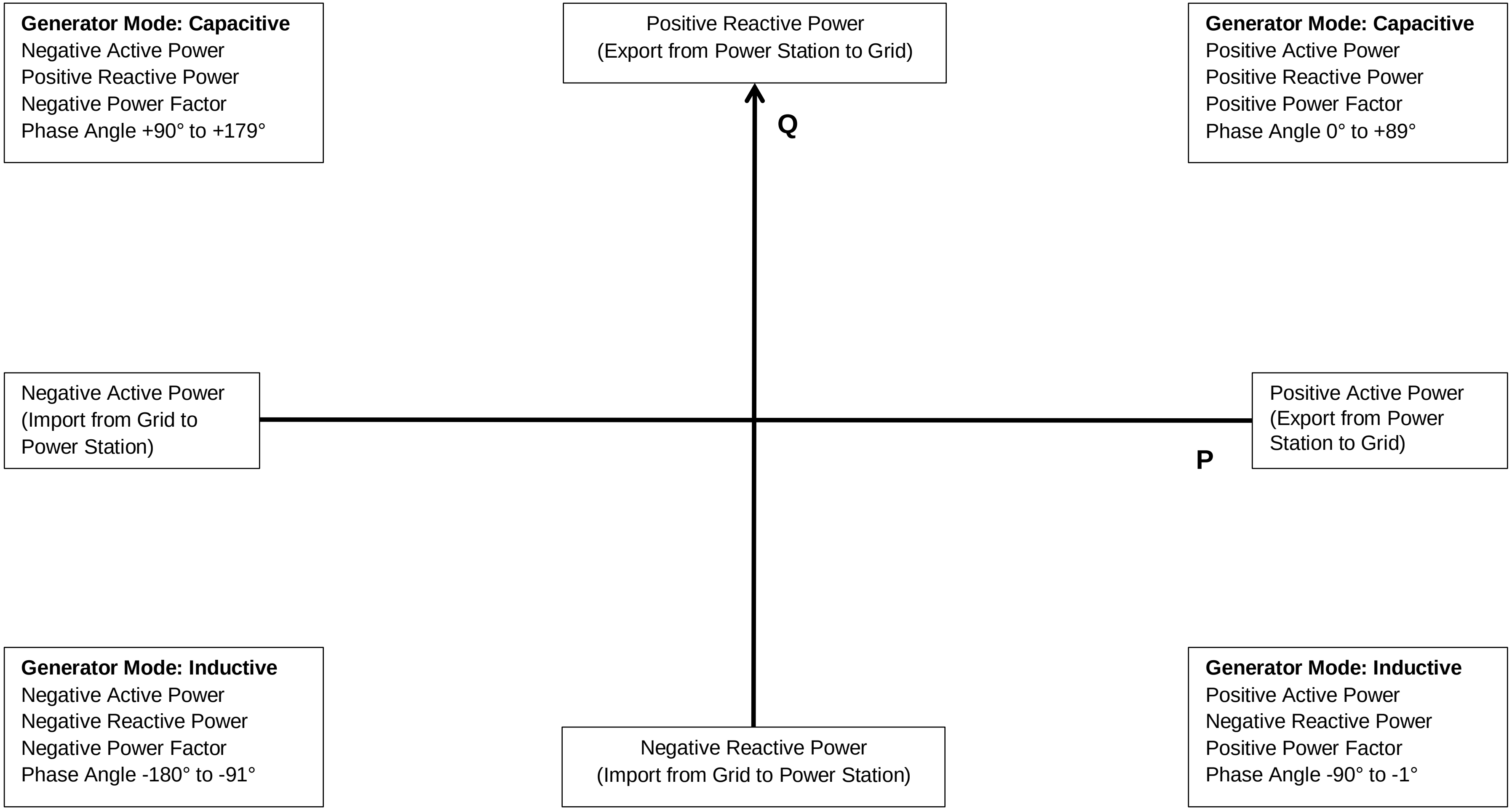
No.	Name	Description	Scale Min	Scale Max	Units
13	kVAr [Tech 'x']	The gross output[29] of **Reactive Power** from technology 'x' **Gensets**	TBA	TBA	kVAr
14	kW [Tech 'x']	The gross output of **Active Power** from technology 'x'.**Gensets**	0	TBA	kW
15	kVAr [Tech 'y']	The gross output of **Reactive Power** from technology 'y' **Gensets**	TBA	TBA	kVAr
16	kW [Tech 'y']	The gross output of **Active Power** from technology 'y'.**Gensets**	0	TBA	kW

Table 10 - Complex Site Digital Inputs

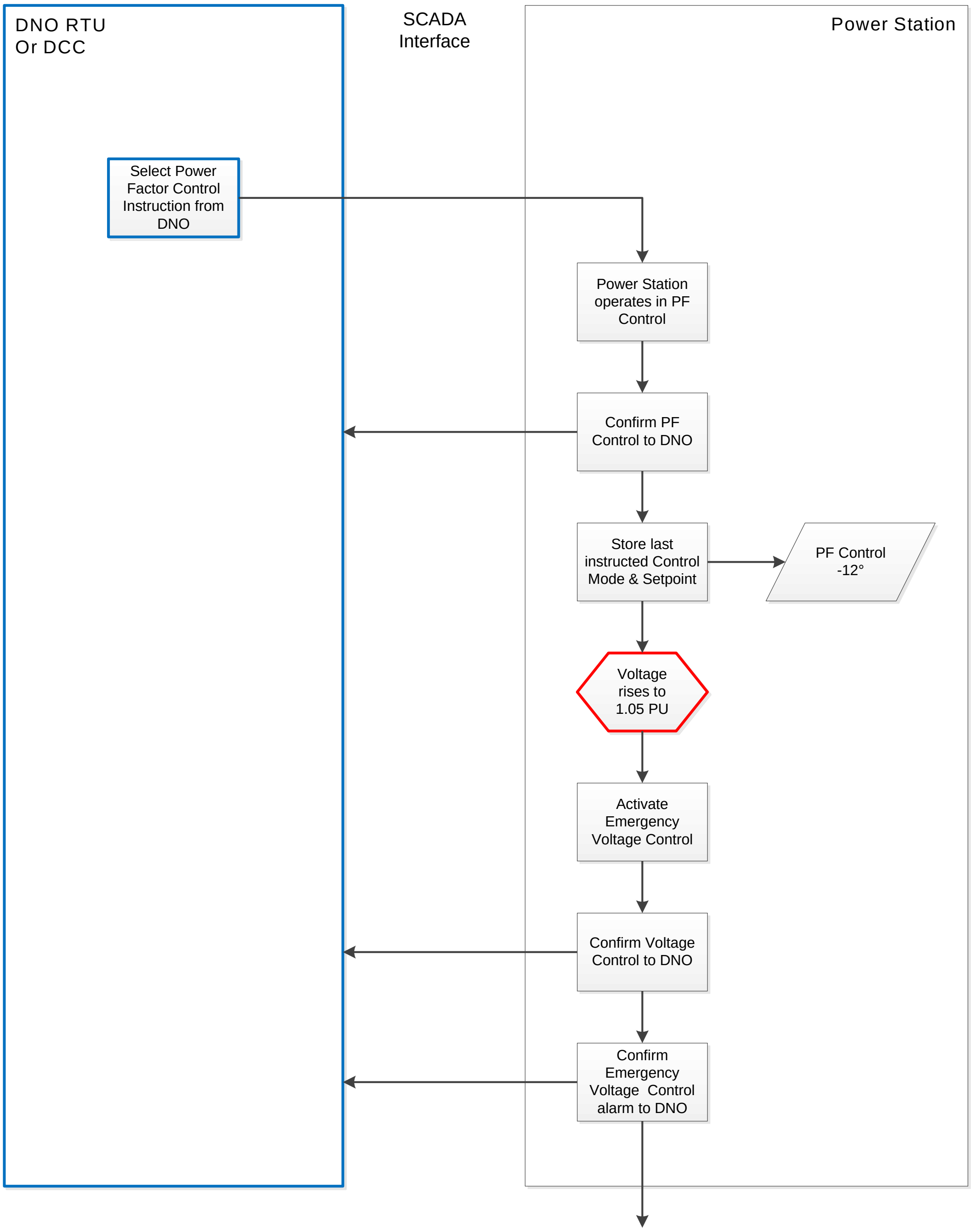
No.	Signal	Description	False/0/10	True/1/01
13	Customer G59 CB [No. 2]	Indication of the status of the CB associated with the **Power Station** G59 Protection	Open	Closed
14	Customer G59 CB [No. 3]	Indication of the status of the CB associated with the **Power Station** G59 Protection	Open	Closed

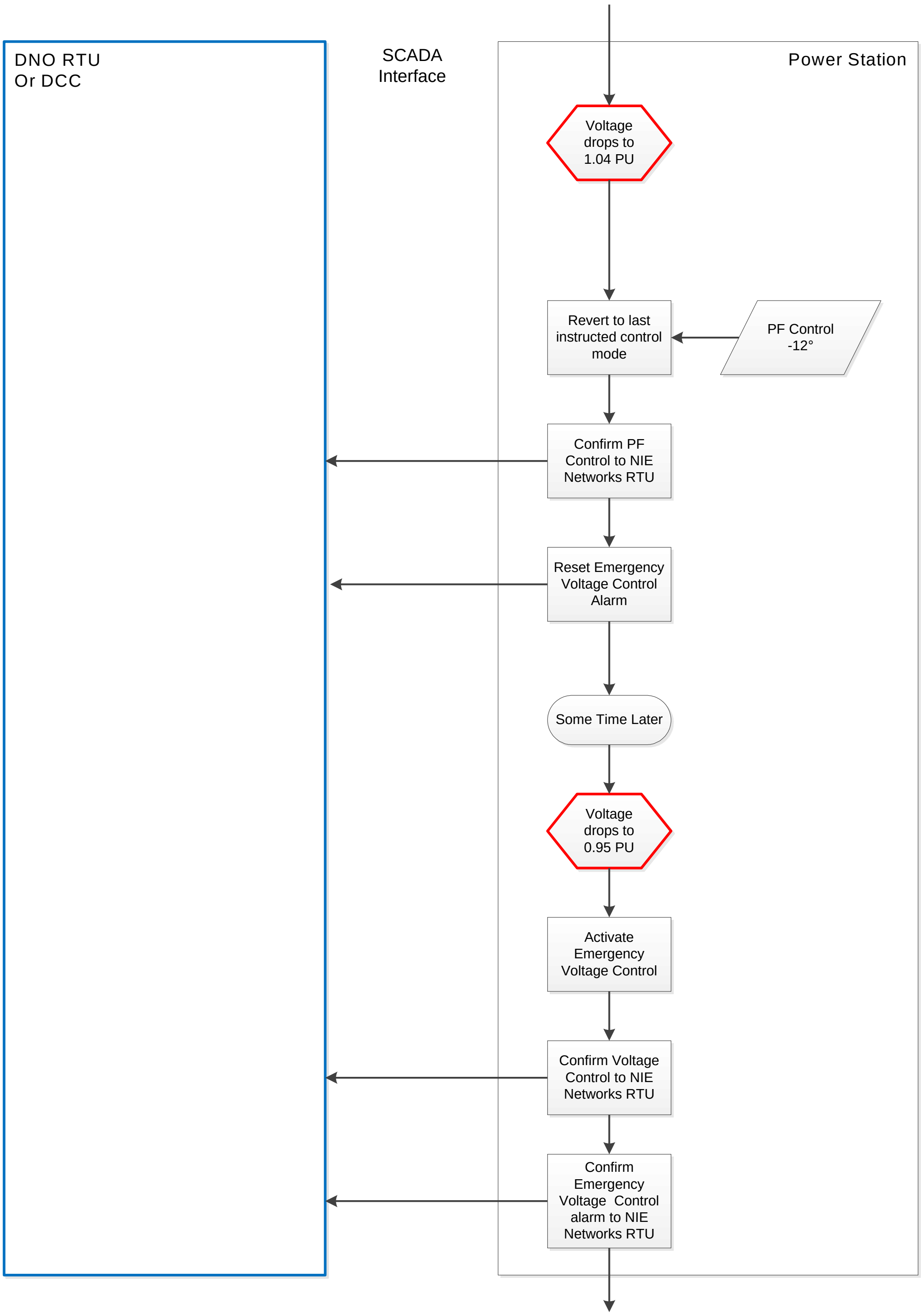
[29] The measured value from the terminals of the **Genset**. Measured values should be summated for **Power Stations** with multiple **Gensets** with the same technology

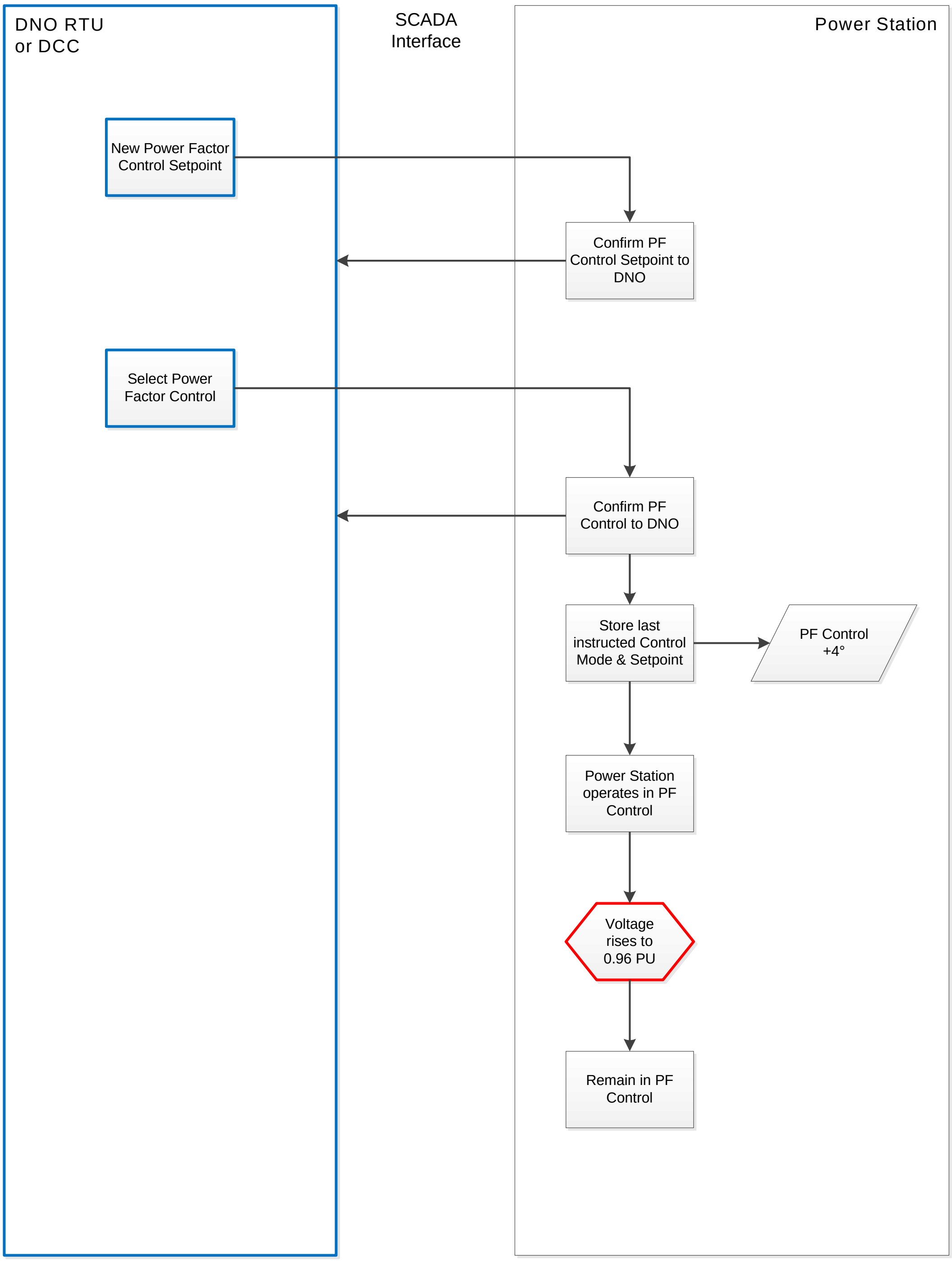
Appendix G: Power Factor Quadrants



Appendix H: Emergency Voltage Control Example




DNO RTU
Or DCC
SCADA
Interface
Power Station
Voltage
drops to
1.04 PU
Revert to last
instructed control
mode
PF Control
-12°
Confirm PF
Control to NIE
Networks RTU
Reset Emergency
Voltage Control
Alarm
Some Time Later
Voltage
drops to
0.95 PU
Activate
Emergency
Voltage Control
Confirm Voltage
Control to NIE
Networks RTU
Confirm
Emergency
Voltage Control
alarm to NIE
Networks RTU



DNO RTU
or DCC
SCADA
Interface
Power Station
New Power Factor Control Setpoint
Confirm PF Control Setpoint to DNO
Select Power Factor Control
Confirm PF Control to DNO
Store last instructed Control Mode & Setpoint
PF Control +4°
Power Station operates in PF Control
Voltage rises to 0.96 PU
Remain in PF Control

Appendix I: SSG Type A Controllability Test

Generator: ____________________________ **Test Date:** _________________

Size: _____ **Circuit:** ________ **S/S:** _________________________________

Power Factor Testing

Given suitable wind condition the power factors should be sent to the machine to test controllability;

Power Factor	SCADA Scale Degrees	Recorded Power Factor	Voltage Recorded		kW Output	kVAr Output
-.95	-18			V2		
-.98	-12			V1		

After verifying the power factor range the generator should be placed on power factor control at -12 deg

Voltage Control Testing

The recorded voltages V1 & V2 should be sent to the machine to test controllability

Control Mode	Voltage Set Point	Voltage Recorded	kW Output	kVAr Output
voltage control	=V1			
voltage control	=V2			

On completion the generator should be returned to power factor control at -12 deg

Testing completed by: ____________________

Appendix J: SSG Type B Controllability Test

Generator: ___________________________ **Test Date:** ________________

Size: ____ **Circuit:** _______ **S/S:** _______________________________

Power Factor Testing

The following power factors should be sent to the machine to test controllability

Power Factor	SCADA Scale Degrees	Actual Power Factor	Voltage Recorded	kW Output	kVAr Output
-.95	-18		V2		
-.98	-12		V1		
+.98	+12		V3		

After completion of the test the generator should be left on power factor control at +12 deg

Voltage Control Testing

The recorded voltages V3, V2 & V1 should be sent to the machine to test controllability

Control Mode	Voltage Set Point	Voltage Recorded	kW Output	kVAr Output
voltage control	=V3			
voltage control	=V2			
voltage control	=V1			

If during the tests it is anticipated voltage at the point of generator connection will exceed +/_6% the test should be suspended and a mail sent to the Network Generation Manager

Testing completed by: _____________________________