Network Operations

SSG SCADA Guidance Document

Document Number: NTO-1001-E

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08/08/2016

DOCUMENT CONTROL

Document Version	Approval Date	Author	Section(s)	Modifications
A	30/09/2015	Stephen Hammond	All	Original
B	04/11/2015	Stephen Hammond	Appendix E	Changes to LV connected generator scales for kW and kVAr measurements
C	12/11/2015	Stephen Hammond	Appendix E	Corrections made to document formatting
D	16/06/2016	Stephen Hammond	Appendix D	Signal names changed to match CTC template
E	08/08/2016	Stephen Hammond	Appendix D	Format changes to highlight signals provided by NIE Networks.

Contents

1. INTRODUCTION

This document is intended to act as guidance for generators and developers regarding SCADA requirements for small scale generators. It is based on the latest draft of the 'Setting Schedule for Power Stations less than 5MW Exporting on to the Distribution System' following the June 2014 consultation.

In accordance with the Distribution Code, the requirement for SCADA at a Power Station will be stated within the Generator's connection agreement. This guidance document covers technical requirements and responsibilities where SCADA is required at Power Stations with a capacity greater than or equal to 100kW but less than 5MW connected to the Distribution Network.

2. GLOSSARY OF TERMS

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

Defined SSG SCADA Guidance Document terms are capitalised.

Term	**Definition**
2G	Second generation mobile phone technology
3G	Third generation mobile phone technology
APN	Access Point Name
Cable Termination Cubicle (CTC)	The physical interface between the **Power Station** Controller and NIE Networks RTU
CB	Circuit Breaker
CB Error Status	A logically invalid Circuit Breaker position indication.
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.
Final Compliance Certificate	On completion of the monitoring period and demonstrating successful compliance with the **Distribution Code** and **Connection Agreement**, NIE Networks 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 NIE Networks
PU	Per Unit
Restricted Compliance Certificate	If a non Compliance arises at any point from energisation throughout the full operational life of the **Power Station**, NIE Networks 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**.
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition

Term	Definition
SCADA System	The SCADA system used by NIE Networks 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
Temporary Compliance Certificate	Following energisation, NIE Networks 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 NIE Networks 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 NIE Networks. Has two variants, Type 1A and Type 1B
Type 1A RTU	A Type 1 RTU where all signalling is hard wired and the signalling interface between the NIE Networks' RTU and the **Power Station** shall be a Cable Termination Cubicle.
Type 1B RTU	A Type 1 RTU where some or all of the signalling is provided via a serial or IP data link between the NIE Networks' RTU and **Power Station** Controller. Any signals not provided via data link shall be hard wired. The signalling interface between NIE Networks and the **Power Station** shall be the comms port on the **DNO** RTU. The signalling interface between NIE Networks and the **Power Station** for any hard wired signalling shall be a CTC.
Type 2 RTU	A **Power Station** SCADA RTU provided by the Generator. Operates as two variants, Type 2A and Type 2B.
Type 2A RTU	A Type 2 RTU where the communications link between the **Power Station** and Distribution Control Centre uses 2G or 3G cellular communication. The protocol used between the RTU and the **DNO** master station shall be DNP3. The Signalling interface between the **DNO** and the **Power Station** shall be NIE Networks' APN on the mobile cellular network.
Type 2B RTU	A Type 2 RTU where the communications link between the **Power Station** and Distribution Control Centre uses NIE Networks' Operational Telecommunications Network. NIE shall provide a radio modem. The signalling interface between NIE and the **Power Station** shall be the serial port on the NIE radio modem. The protocol used between the RTU and NIE master station shall be IEC-60870-5-101.

3. SCADA REQUIREMENTS AND RESPONSIBILITIES

There is a requirement under the NI **Distribution Code**[1] 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 NIE Networks' Distribution Control Centre and **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. For existing **Power Stations** already connected, NIE Networks will perform signal tests where required and inform the Generator which RTU variant is applicable to their installation. This document covers 4 different SCADA/RTU arrangements which are defined as follows:

Type 1 RTUs are provided by NIE and have two variants:

- Type 1A – All signalling is hard wired and the signalling interface between the **DNO** RTU and the **Power Station** shall be a Cable Termination Cubicle.

- Type 1B – Some or all of the signalling is provided via a serial or IP data link between the NIE RTU and **Power Station** Controller. Any signals not provided via data link shall be hard wired. The signalling interface between the **DNO** and the **Power Station** shall be the comms port on the **DNO** RTU. The signalling interface between the **DNO** and the **Power Station** for any hard wired signalling shall be a CTC.

Type 2 RTUs are provided by the **Generator** and operate as two variants. A Type 2 RTU shall be capable of operating as both a Type 2A & 2B variant. The **DNO** will advise the **Generator** of the primary mode of operation:

- Type 2A – The communications link between the **Power Station** and **DNO** Control Centre 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 NIE Networks' APN on the mobile cellular network.

- Type 2B – The communications link between the **Power Station** and **DNO** Control Centre uses NIE Networks' 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.

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

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

4. RTU FACILITIES

The facilities required at each RTU are:

- power supplies
- status inputs (indications and alarms)
- controls, single & double
- analogues, inputs & outputs

Type 1B and Type 2 RTUs additionally require:

- communication ports

4.1.1 Type 1A & 1B RTUs

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

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

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

The wetting voltage for digital input and output signals shall be provided by NIE and shall be either 27.6V[2] or 56V[3] DC. The **Generator** shall be advised of the wetting voltage during the planning process.

Details of the quantities of signals required are given in Appendix A.

4.1.2 Type 1B RTUs

If requested by the **Generator**, the use of any serial data connection between the **Power Station** and RTU shall be agreed with the **DNO**.

4.1.3 Type 2A RTUs

The RTU will be monitoring single digital inputs and analogue inputs.

The RTU will be controlling single digital outputs and analogue outputs.

4.1.4 Type 2B RTUs

The RTU will be monitoring single digital inputs, double digital inputs and analogue inputs.

The RTU will be controlling double digital outputs, single digital outputs and analogue outputs.

[2] Nominal voltage is 27.6V with a maximum of 30V
[3] Nominal voltage is 56V with a maximum of 60V

4.2 Power Supplies

4.2.1 Type 1 RTUs

The **DNO** will be responsible for providing the RTU power supply.

4.2.2 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 over SCADA.

On Type 2B variants the **Generator** will be required to provide a power supply to a **DNO** radio. The specification for this is listed in section 4.8.2 of this document.

4.3 Status Inputs

4.3.1 Type 1 RTUs

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

4.3.2 Type 1 & Type 2B RTUs

Circuit breaker monitoring requires complimentary pairs of contacts as part of a Double Digital Input with one bit positively indicating the Circuit Breaker as open (01) and the other bit positively indicating the CB as closed (10). Values of 00 and 11 are not logically valid and indicate CB 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 a CB Error Status is returned to the Distribution Control Centre. Unless otherwise stated by the **DNO**, this delay shall be 100ms.

4.3.3 Type 2A RTUs

On Type 2A RTUs CB position shall be indicated by two Single Bit Indications. CB Error Status shall be determined on the **DNO** side of the SCADA System.

4.4 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.

The design of the RTU and **Power Station** Controller shall prevent a control mal-operation in the event of any single component failure or loss of power to any device.

4.4.1 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 period of 5 seconds. The RTU shall control the interposing relays by switching both positive and negative poles of the wetting voltage.

4.4.2 Type 2A RTUs

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

4.4.3 Type 2B RTUs

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

4.5 Analogues

Analogue accuracy shall be ±1% or better. For Type 2 RTUs the scan rate of analogues 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%.

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

4.6 Communication

4.6.1 Type 1B RTUs

The specification of the data connection between the **Power Station** controller and **DNO** RTU shall be agreed on a case by case basis.

4.6.2 Type 2A & 2B 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 NIE Networks' Operational Telecommunications Network for a Type 2B variant. The cellular modem is required for primary communications for a Type 2A variant. One of the ports shall be an Ethernet port providing a secondary IP connection option for a Type 2A variant. Type 2 RTUs shall be able to operate as both A and B variants. 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 variant. 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 Type 2A or IEC-60870-5-101 for Type 2B.

4.6.3 Type 2A RTUs

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. NIE Networks' 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. NIE Networks' preferred method of communication between Type 2A 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)

4.6.4 Type 2B RTUs

NIE Networks' 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.

Hardware requirements are specified section 4.8 - Radio and Cabinet Specification.

4.7 Equipment Practice and Specification

The **Generator** should detail the specifications of all equipment offered including 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.

4.8 Radio and Cabinet Specification

Installations using a Type 2B RTU will require a radio and antenna supplied by the **DNO** to connect to the SCADA System.

The **Generator** shall supply a cabinet, power supply, data cable and antenna mast that meet the following specifications. This should be capable of accommodating the radio unit as specified in section 4.8.5.

4.8.1 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.

4.8.2 Radio Power Supply

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)

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

4.8.3 Data Cable

Data Connection:[4] 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

4.8.4 Antenna Mast

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**.

[4] 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.

4.8.5 Radio Specification

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

Appendix A: SCADA I/O Facilities

Signal Type	Number Required		
	Type 1	Type 2A	Type 2B
Single Digital Input	3	15	7
Double Digital Input	3	0	4
Analogue Inputs	6	10	10
Analogue Outputs	2	2	2
Double Digital Outputs	4	0	3
Single Digital Outputs	1	6	0

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 NIE Networks 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 – Analogue Input Signals (to Control Centre) from Power Station – Type 1 RTU

Signal[5]	**Description**	**Range**	**Units**	**Scale Min**	**Scale Max**	**Display Units**
MW*	The flow of **Active Power** at the **Connection Point**.[6]	4 - 20	mA	TBA+		MW
MVAr*	The flow of **Reactive Power** at the **Connection Point**.[7]	4 - 20	mA	TBA+		MVAr
kV Setpoint Cfmd	Confirmation of the HV voltage set point for Voltage Control mode operation.	4 - 20	mA	TBA+		kV
kV*	Indication of the HV line voltage.	4 - 20	mA	TBA+		kV
P/F Setpoint Cfmd	Confirmation of the phase angle set point for Power Factor control mode operation.	4 - 20	mA	TBA+		Degrees
Phase Angle Measurement*	Measurement of the phase angle at the **Connection Point**.	4 - 20	mA	TBA+		Degrees

[5] These signals will report by exception within a dead band range of 1% - 10% determined by NIE Networks.

* Provided by NIE Networks as part of the connection arrangements. Included for completeness. These indications must come directly from the transducers.

[6] 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**.

TBA - Scale to be agreed with NIE Networks

[7] 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**.

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

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

TBA - Scale to be agreed with NIE Networks

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[8]
Voltage Control ON	Indication that voltage control mode has been selected	
Voltage Auto Control[9]	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[10]
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[11]
Dummy Circuit Breaker Closed[χ]	Indication that the DNO dummy circuit breaker is closed	
Grid Control Selected	The power station will respond to remote controls from the DNO	Double
Local Control Selected	Indication that supervisory/remote control has been disabled. The power station will not respond to remote controls from the DNO	
Transducer Faulty	Indication that a primary input to the power station controller has been lost	Single

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

Signal	Description	Contact Arrangement
Grid Controller Faulty	Indication of a power or component failure of the power station controller	Single
AC Main Fail[12]	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

[12] Provided by NIE Networks 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	5sec pulse Open Signal	5sec pulse Close Signal
Voltage Control ON Common Power Factor Control ON	Instruction to operate in voltage control mode Instruction to operate in power factor control mode	0V	TBA V dc	TBA V dc
CB1 Close[#] Common CB1 Open[#]	Close the DNO Circuit Breaker at the **Connection Point** Open the DNO Circuit Breaker at the **Connection Point**	0V	TBA[Δ]V dc	TBA V dc
Close Dummy CB[#] Common Open Dummy CB[#]	Close the DNO Dummy Circuit Breaker Open the DNO Dummy Circuit Breaker	0V	TBA[Δ]V dc	TBA[Δ]V dc
Emergency Soft Stop ON[13] Common Emergency Soft Stop OFF[14]	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

TBA - Signal voltage to be agreed with NIE Networks

[#] Provided by NIE Networks as part of the connection arrangements. Included for completeness

[13] Generator Shutdown allows NIE Networks 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 NIE Networks. 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.

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

Appendix E: Type 2 RTU SCADA Signals

This section details the signalling requirements for sites where the **Power Station** supplies the RTU.

Table 5 - Analogue Input Signals (to Control Centre) from Power Station – Type 2 RTU

Signal		Description		Scale Min	Scale Max	Display Units
kW[15]		The flow of **Active Power** at the **Connection Point**.	LV[16]	See Table 6		kW
			HV[17]	120% of MIC[18]	120% of MEC[19]	
kVAr[20]		The flow of **Reactive Power** at the **Connection Point**.	LV	See Table 6		kVAr
			HV[21]	-max(MIC,MEC)	max(MIC,MEC)	
Voltage Set Point Confirmation		Confirmation of the voltage set point for Voltage Control mode operation.		0	1.2	PU
Voltage 3Φ[22]	Line Voltage V_{ab}	Indication of the line voltage measured between L1 and L2		0	1.2	PU
	Line Voltage V_{bc}	Indication of the line voltage measured between L2 and L3		0	1.2	PU
	Line Voltage V_{ca}	Indication of the line voltage measured between L3 and L1		0	1.2	PU
Phase Angle Set Point Confirmation		Confirmation of the phase angle set point for Power Factor control mode operation.		-180	179	Degrees
Phase Angle Measurement[23]	Phase Angle θ_a	Measurement of the phase angle on L1		-180	179	Degrees
	Phase Angle θ_b	Measurement of the phase angle on L2		-180	179	Degrees
	Phase Angle θ_c	Measurement of the phase angle on L3		-180	179	Degrees

[15] A positive value indicates **Export** of **Active Power** from the **Power Station** to the **Distribution Network**. A negative value indicates the **Import** of **Active Power** from the **Distribution Network** to the **Power Station**.
[16] Where the nominal voltage at the **Connection Point** is 400V
[17] Where the nominal voltage at the **Connection Point** is above 650V
[18] The minimum negative end of the scale shall be 120% of the Maximum Import Capacity as stated on the **Connection Agreement**
[19] The maximum positive end of the scale shall be 10% of the Maximum Export Capacity as stated on the generator **Connection Agreement**
[20] 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**.
[21] The scale boundaries shall be determined by whichever is greatest of the Maximum Export Capacity and Maximum Import Capacity
[22] Line voltage measurements at the **Connection Point**
[23] Phase Angle measurement at the **Connection Point**

Table 6 - LV Connected Generator Real and Reactive Power Scales

Connection Size[24]	Scale Min	Scale Max
0 - 165	-260	260
166 - 275	-440	440
276 - 445	-700	700
446 - 555	-880	880
556 - 835	-1320	1320
836 - 1000	-1760	1760

Table 7 - Analogue Output Signals (from Control Centre) to Power Station – Type 2 RTU

Signal	Description	Scale Min	Scale Max	Display Units
Voltage Set Point Instruction	Analogue output indicating the new set point for voltage control mode[25]	0	1.2	PU
Phase Angle Set point Instruction	Analogue output indicating the new set point for power factor control mode[26]	-180	179	Degrees

[24] The connection size shall be determined by whichever is greatest of the Maximum Export Capacity and Maximum Import Capacity

[25] This uses the same scale for HV Line Voltage measurements and HV set point confirmation to allow 1:1 comparison. The controller should reject and ignore values above 1.06 PU and below 0.94 PU. If the RTU receives a value outside of these ±6% limits it shall raise an alarm using the 'Voltage Set Point Out of Range' indication

[26] This uses the same scale as Phase Angle Measurement and Phase Angle Confirmation to allow 1:1 comparison. The controller should reject and ignore values outside of its required reactive capability. If the RTU receives a value outside of this it shall raise an alarm using the 'Phase Angle Set Point Out of Range' indication.

Table 8 - Digital Input Signals (to Control Centre) from Power Station – Type 2 RTU

Signal	Description	Data Point Type	
		Type 2A[27]	Type 2B
Power Factor Control Selected	Indication that power factor control mode has been selected	Single	Double[28]
Voltage Control Selected	Indication that voltage control mode has been selected	Single	
Voltage Control Auto Change Over	Alarm indication that the control mode has automatically changed to voltage control	Single	Single
CB1 Open	Indication that the **Power Station** Circuit Breaker is open	Single	Double[29]
CB1 Closed	Indication that the **Power Station** Circuit Breaker is closed	Single	
G59 Protection Trip	Alarm indication that G59 protection has operated	Single	Single
Dummy Circuit Breaker Open	Indication that the **Power Station** dummy circuit breaker is open	Single	Double[30]
Dummy Circuit Breaker Closed	Indication that the **Power Station** dummy circuit breaker is closed	Single	
Control Switch Off	Indication that supervisory/remote control has been disabled	Single	Single
AC Main Fail	Alarm indication that the mains power supply to the RTU has been lost and is running on battery backup	Single	Single
Voltage Set Point Out of Range	Alarm indication that the **Power Station** has been instructed to reach a voltage outside of statutory limits	Single	Single
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	Single	Single
Generator Shutdown (On)	Indication that generator shutdown has been activated	Single	Double[31]
Generator Shutdown (Off)	Indication that generation shutdown is disabled	Single	
Generator Shutdown Sequence Complete	Alarm indication that the controller's generation shutdown program has completed and apparent power output on all **Generating Units** is now zero.	Single	Single

[27] NIE Networks' DNP3 Master Station does not currently support double bit indications. All indications brought back over DNP3 shall be single bit points
[28] Power Factor Selected & Voltage Control Selected shall be arranged as complementary points of a double bit indication
[29] CB1 Open & CB1 Closed shall be arranged as complementary points of a double bit indication
[30] Dummy CB Open & Dummy CB Closed shall be arranged as complementary points of a double bit indication
[31] Generation Inhibit Enabled & Disabled shall be arranged as complementary points of a double bit indication

Table 9 - Digital Output Signals (from Control Centre) to Power Station – Type 2 RTU

Signal	Description	Command Type	
		Type 2A[32]	Type 2B
Voltage Control Select[33]	Instruction to operate in voltage control mode	Single	Double[34]
Power Factor Control Select[35]	Instruction to operate in power factor control mode	Single	
Close Dummy CB	Instruction to close the dummy circuit breaker	Single	Double[36]
Open Dummy CB	Instruction to open the dummy circuit breaker	Single	
Generator Shutdown (On)[37]	Instruction to reduce **Power Station** apparent power output to zero	Single	Double[38]
Generator Shutdown (Off)[39]	Instruction removing restriction on **Power Station** apparent power output	Single	

[32] NIE Networks' DNP3 Master Station does not currently support double command outputs. All commands sent via DNP3 shall be single command outputs
[33] Shall have an XOR relationship with Power factor control mode. Controller should have logic in place that disables power factor control
[34] Power Factor and Voltage Control select instructions should be arranged as complementary points of a double command output
[35] Shall have an XOR relationship with voltage control mode. Controller should have logic in place that disables voltage control
[36] Dummy CB Open & Close instructions shall be arranged as complementary points of a double command output
[37] Generator Shutdown allows NIE Networks 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 NIE Networks. 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.
[38] Generator Shutdown On and Off instructions shall be arranged as complementary points of a double command output
[39] Removes restriction on generator output and allows it to return to normal running conditions.