RENEWABLE ENERGY SUB-CODE

for NITS connected Variable Renewable Energy Power Plants in Ghana

JANUARY 2015

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Measurement

W	Watt	Wp	Watt peak	Wh	Watt hour
kW	Kilowatt	kWp	Kilowatt peak	kWh	Kilowatt hour
MW	Megawatt	MWp	Megawatt peak	MWh	Megawatt hour
GW	Gigawatt	GWp	Gigawatt peak	GWh	Gigawatt hour

List of Acronyms

AFLC	Automatic Frequency Load Control
DN	Distribution Network
DU	Distribution Utility
EHV	Extra High Voltage
ETU	Electricity Transmission Utility
HV	High Voltage
IEC	International Electro-technical Committee
IEEE	Institute of Electrical and Electronics Engineers
IPP	Independent Power Producer
NITS	National Interconnected Transmission System
POC	Point of Connection
SCADA	Supervisory Control and Data Acquisition
VRPP	Variable Renewable Power Plant

PART A:

1 Introduction

The Republic of Ghana seeks to develop, manage and utilize renewable energy sources in an effective and environmentally suitable manner for the production and distribution of electricity according to its 'Renewable Energy Act, 2011 (Act 832)'. This requires guidelines to facilitate the connection and dispatch of variable renewable energy sources in the existing National Interconnected Transmission System (NITS) without affecting overall system operation.

This Renewable Energy Sub-Code proposes minimum technical connection conditions for a Variable Renewable Power Plant (VRPP) to the NITS. This Sub-Code is in line with the National Electricity Grid Code and international best practices and standards.

A VRPP applicant seeking connection to the NITS shall comply with this Sub-Code and all applicable articles of the National Electricity Grid Code.

1.1 Scope

This Renewable Energy Sub-Code constitutes the basic technical performance requirements that a VRPP needs to comply with in order to connect its generating facility to the NITS in Ghana.

(1). This Sub-Code defines rules and standards that the network operator shall follow when connecting VRPPs to the NITS.

(2). Compliance with this Sub-Code is meant to ensure safe, reliable and secure operation of all NITS connected VRPPs.

(3). The basic technical performance requirements provided in this Sub-Code applies to all VRPPs connected at voltage levels greater than 36 kV.

(4). Electricity Transmission Utility (ETU) and the VRPP operator shall supply each other with the necessary data and information about their network or plant that is required for ensuring compliance with this Sub-Code.

1.2 Status

This Sub-Code constitutes an Addendum to the National Electricity Grid Code.

1.3 Terms and Definitions

Asset Owner

A person who owns the whole or part of the NITS or any facility connected to the NITS.

Available Generation Capacity

It is the maximum actual generation capacity of the generator unit that could be generated stably and continuously in the determined period.

Capability Curve

A curve developed for generators showing the limits of reactive and active power that a generator can produce without overheating or becoming unstable.

Connection Agreement

It is an agreement between the ETU and a Grid Participant that seeks connection of its facilities to the NITS and sets out the rights, obligations and liabilities of both parties.

Connection Point

The point of physical linkage to or with the NITS for the purpose of enabling the flow of electricity as the boundary between the NITS and a facility or other equipment.

Continuous Operation Range

Network frequency or voltage operating range, outside normal range of operation, within which no generating unit is allowed to disconnect and where power output restrictions may exist.

Distribution Network

In relation to a Distribution Utility, means a system of electric lines and associated equipment (generally at nominal voltage levels of 36 kV or below) , which that Distribution Utility is licensed to use to distribute electricity for supply under its distribution licence excluding public lighting assets.

Distribution Utility

Electricity Distribution Company licensed by the Energy Commission that operates the distribution network to provide services in accordance with the Performance and Reliability Standards of the National Electricity Distribution Code.

Disturbance

An unplanned event that produces an abnormal system condition or any occurrence that adversely affects normal power flow in a system.

Echo

In relevance to park control system, it is the signal that is sent from a VRPP to the communication system of the network operator.

Electricity Transmission Utility (ETU)

The entity charged with operation of the NITS by virtue of the Energy Commission Act, 1997 (ACT 541) that operates the NITS to provide services in accordance with the Performance and Reliability Standards of the National Electricity Grid Code.

Emergency

Any abnormal system condition that requires automatic or immediate manual action to prevent or limit loss of generation supply or transmission facilities that could adversely affect the reliability of the electric system.

Frequency Control

The retention of the frequency on the power system within acceptable limits.

Frequency Regulation

The automatic adjustment of active power output by a generation unit, initiated by fast acting frequency controller action in response to continuous minor fluctuations of frequency on the power system.

Flicker

A fast fluctuation in voltage leading to quick intermittent coming on, of an appliance and gives the impression of unstable visual sensation induced by a light stimulus with luminance or spectral distribution that fluctuates with light.

Generating Unit

An equipment or plant for producing electric energy from other forms of energy.

Generation Facility

A facility comprising of generators for producing electric energy from other forms of energy expressed in watt-hours (Wh).

Grid Code

The Ghana National Electricity Grid Code of the Republic of Ghana.

Grid Participant

A Wholesale Supplier or VRPP facility owner, Distribution Company or Bulk Customer with facilities that are connected to the NITS.

Harmonics

A sinusoidal wave having a frequency that is an integral multiple of a fundamental frequency.

Interconnected System

It is a system consisting of two or more individual electric systems that normally operate in synchronism and that have connecting tie-lines.

Individual Harmonic Distortion

IHD is the ratio between RMS value of the individual harmonic content and the RMS value of the fundamental voltage expressed in percentage.

$$IHD = \sqrt{\frac{V_i^2}{V_1^2}} * 100\ \%$$

V_i = Voltage component of harmonic order i;

V_1 = Voltage component of fundamental frequency (50 HZ).

Island

A portion of a power system or several power systems that is electrically separated from the inter-connection due to the disconnection of NITS equipment.

National Interconnected Transmission System (NITS)

An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or to other electric systems.

Nominal Voltage

The voltage by which the system is designated and to which certain operating characteristics are related, and the voltage at which the system operates and is normally about 5 to 10 percent below the maximum system voltage for which system components are designed.

Operating Reserve

The additional megawatt output required from a generation unit or demand reduction which must be realizable in ten (10) minutes time operation to contain and correct any potential power system frequency deviation to an acceptable level.

Point of Connection (POC)

Point on a public power supply system where the installation under consideration is, or can be connected.

Note: A supply system is considered as being public in relation to its use, and not its ownership.

Ramp Rate

The rate of change at which the power output of a generator can be increased or decreased (in MW/min)

Rated Power

Is the rated installed power capacity of a generating unit that is connected to the network and whose output is continuously available to the network.

Single Contingency

Includes the singular that involves,

(a). …sudden, unexpected failure or outage of any single component of a power system, like generating unit, transmission line, transformer, etc.; or

(b). …removal from service of an element of the power system like generating unit, transmission line, transformer etc. as part of the operation of a remedial action scheme, the occurrence of which shall not affect the normal operation of the NITS.

Synchronize

The process of connecting two previously separated alternating current apparatuses after matching frequency, voltage and phase angles like paralleling a generator to the electric system.

System Protection Dependability

A measure of the ability of protection to initiate successful tripping of circuit-breakers which are associated with a faulty item of apparatus. It is calculated by using the formula:

$$D_p = 1\text{-}F_1/A$$

Where: A = Total number of faults

F_1 = Number of system faults where there was a failure to trip a circuit breaker.

Total Harmonic Distortion

THD shall be defined as the ratio of the RMS voltage of the harmonic content to the RMS value of the fundamental voltage, expressed in percent.

$$THD = \sqrt{\frac{\sum V_i^2}{V_1^2}} * 100\ \%$$

THD = Total Harmonic Distortion of voltage;

V_i = Voltage component of harmonic order i;

V_1 = Voltage component of fundamental frequency (50 HZ).

Unrestricted Operation Range

Normal network frequency or voltage operating range during which no generating unit is allowed to disconnect and where there is no technical restriction with regard to the delivery of active power or reactive power.

Variable Renewable Power Plant (VRPP)

Renewable power plants with continuously varying power output following the availability of primary energy without any storage (Wind and solar PV farms).

Voltage Control

The control of transmission voltage within acceptable limits through adjustments in generator reactive output or by transformer tap changing or by switching.

Voltage Regulatory System

A centralized control system at a VRPP that measures voltage compared to a set point voltage and controls reactive power devices.

VRPP Applicant/VRPP Owner/IPP

The owner of a generation facility or an independent power producer (IPP) seeking connection with the NITS to interconnect their facility with NITS or DN.

VRPP Operator

Operator of a VRPP seeking connection to or already connected to the NITS.

Wholesale Supplier

A person licensed under the Energy Commission Act, 1997 (Act 541) to install and operate a facility to procure or produce electricity for sale to a bulk customer or to a distribution company for distribution and sale to consumers.

PART B:

2 Technical Connection Conditions

2.1 General

In the implementation of this Sub-Code, the following general rules shall apply:

(1). The interconnection of a VRPP to the NITS shall not deteriorate system security.

(2). A VRPP shall meet the requirements of this Sub-Code at the POC unless otherwise specified in this document or by the ETU.

(3). The design, installation, commissioning, maintenance and operation of the generation facility shall be conducted in a manner that ensures safety and security of both VRPP and NITS.

(4). A VRPP operator shall maintain and operate power plants in accordance with the instructions of the ETU to supply electricity through NITS to consumers.

(5). ETU shall not assume any responsibility for the protection of a Grid Participant's plant or equipment or any other portion of the Grid Participant's electrical equipment. A Grid Participant shall be responsible for protecting its equipment in such a manner that faults or other disturbances in NITS does not cause damage to the Grid Participant's equipment.

(6). A VRPP shall at all times comply with applicable requirements and conditions of connection for generating units and in accordance with any Connection Agreement with the ETU.

(7). A VRPP operator shall permit and arrange the participation of the ETU in the inspection, testing or commissioning of facilities and equipment to be connected to the NITS.

(8). At the request of the ETU, a VRPP operator shall conduct equipment parameter tests to certify specification of power plant from time to time.

2.2 Frequency Range of Operation

(1). A VRPP shall be capable of staying connected to the NITS within the frequency ranges and times specified in Table 1.

Table 1: Frequency Ranges of Operation (Must remain connected conditions)

Frequency (Hz)	Operation
$47.5 \leq F < 48.75$	90 Minutes
$48.75 \leq F < 51.25$	Unlimited (Continuous Range)
$51.25 < F \leq 51.5$	90 Minutes
$51.5 < F \leq 52$	15 Minutes

(2). In case of frequencies outside the frequency and time ranges specified in Table 1, a VRPP shall be allowed to disconnect from the NITS.

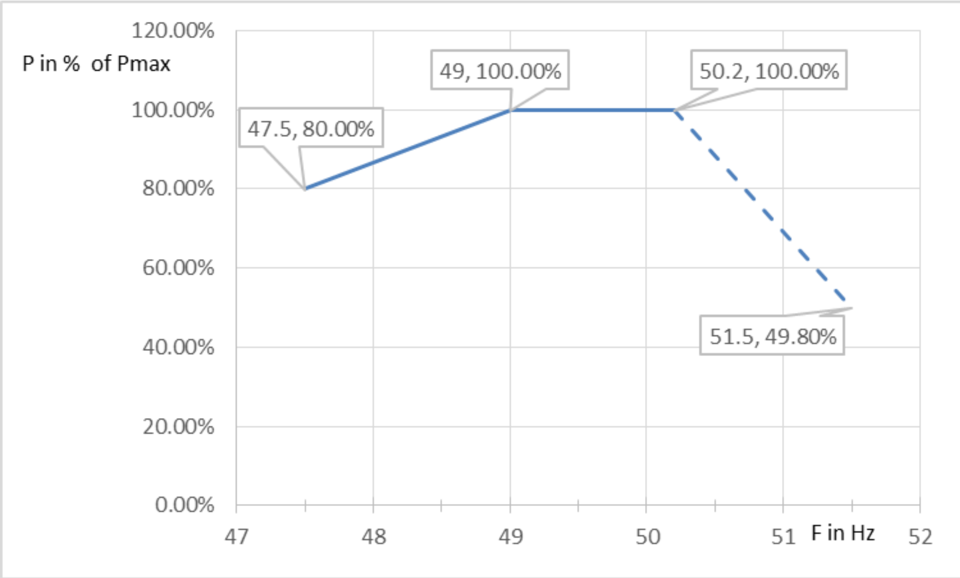

Figure 1: Maximum Active Power Capability in Function of Frequency

(3). There shall no technical restriction with regard to the delivery of active power or reactive power within the frequency range of 49 Hz to 51 Hz and a VRPP shall be permitted within of unrestricted operation within this frequency range.

(4). The minimum active power output that a VRPP shall be capable of delivering is depicted in Figure 1.

Note 1: The frequency dependent power limits according to Figure 1 relate to the technical capability under the condition that sufficient primary energy is available (e.g. wind speed, solar irradiation). Additional limits due to limited primary energy may apply but these limits are not frequency dependent.

Note 2: The dashed line displayed for frequencies >50.2 Hz results from the high frequency response according to section 2.8.1. and doesn't represent a technical restriction.

2.3 Voltage Range of Operation

(1). For a VRPP, no disconnection of any unit within a power park is permitted as long as voltage at POC remains within +/-10% of nominal voltage or within IEC-voltage limits for continuous operation, whichever is the narrower voltage range (Continuous Voltage Range).

(2). For voltages at the POC between +/-5% of nominal voltage, no restrictions with regard to the provision of active or reactive power are permitted (Unrestricted Voltage Range).

2.4 Power Quality

(1). A VRPP shall ensure that the power it injects into the NITS is within the limits prescribed in this sub-section.
(2). A VRPP operator shall continuously monitor the power quality in accordance with Part C and submit periodic report
(3). All power quality parameters shall be monitored at POC and shall comply with limits presented in this section.

Note: For the purpose of this Sub-Code, power quality parameters refer to voltage, flicker and harmonics.

2.4.1 Rapid Voltage Changes

(1). During regular switching operations within a VRPP such as switching operation on a wind turbine within a wind farm or switching of a shunt reactor/capacitor, the resulting voltage change at POC shall not deviate more than 2 % of the nominal voltage.

(2). The maximum permitted voltage change at any point in the network shall be limited to 5 % of nominal voltage in respect of changes resulting from

a. switching of several units within a VRPP,

b. connection of a complete VRPP, or

c. disconnection of a complete VRPP.

2.4.2 Flicker

(1). An ETU shall apportion flicker emission limits to each VRPP based on flicker planning levels according to Article 12.16 of the National Electricity Grid Code (P_{lt} =0.6 , P_{st}=0.8), existing background flicker levels, possible future installations and the total size of a VRPP to be connected. The methodology for apportioning VRPP-specific flicker limits shall be in-line with IEC61000-3-7.

(2). In the absence of any flicker limits apportioned by the ETU, flicker caused by a VRPP shall not exceed the limits depicted in Table 2.

Table 2: Flicker limits to be applied in the absence of apportioned limits

Parameter	Emission Limit (HV-EHV)
P_{st}	0.3
P_{lt}	0.3

2.4.3 Voltage Unbalance

(1). A VRPP shall not cause phase voltage unbalance exceeding 1 % in unrestricted operation range and 2 % when in continuous operation range. A VRPP shall also be capable of withstanding the same in the NITS.

Note: Voltage unbalance is measured in terms of negative sequence voltage in per cent of nominal voltage.

2.4.4 Harmonics

(1). An ETU operator shall apportion individual harmonic distortion limits to each VRPP based on a planning level for THD according to Article 12.14 of the National Electricity Grid Code, existing background disturbances, possible future installations and the total size of a VRPP to be connected, according to methodology described in IEEE std 519-1992.

(2). In the absence of any apportioned limits, harmonic voltage distortion limits at POC according to Table 3. shall apply.

Table 3: Harmonic Voltage Distortion limit for NITS connected generators

Voltage at POC (kV)	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
$36 < V \leq 69$	3.0	5.0
$69 < V \leq 161$	1.5	2.5
$161 < V$	1	1.5

2.5 Reactive Power Capability

(1). A VRPP shall operate within a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of POC.

(2). For voltages between 0.9 and 1.0p.u., a VRPP shall provide maximum reactive support to the system or for voltages between 1.0 and 1.1p.u., a VRPP shall provide full bucking at the POC.

(3). A VRPP shall be capable of varying power factor continuously in the entire range of 0.95 under-excited to 0.925 over-excited during operation with maximum active power output and voltage within the Unrestricted Range of Operation.

(4). A VRPP shall be capable of varying reactive power at the POC within their reactive power capability range as defined by Figure 3, when operating within the Unrestricted Voltage Range and at an active power output level between 5% and 100% of Rated Power.

(5). If voltage is outside the Unrestricted Voltage Range but within the Continuous Voltage Range the reactive power capability limits of a VRPP according to Figure 3 can be adjusted to the voltage dependent limits according to Figure 2.

Note: P_n in MW corresponds to the rated installed capacity of a VRPP minus the sum of the installed capacity of all units being temporarily out of service (e.g. on maintenance).

(6). In the case of operation with active power below 5% of P_n, there is no reactive power capability requirement but in this range, reactive power must be within the tolerance range of +/-5% of P_n.

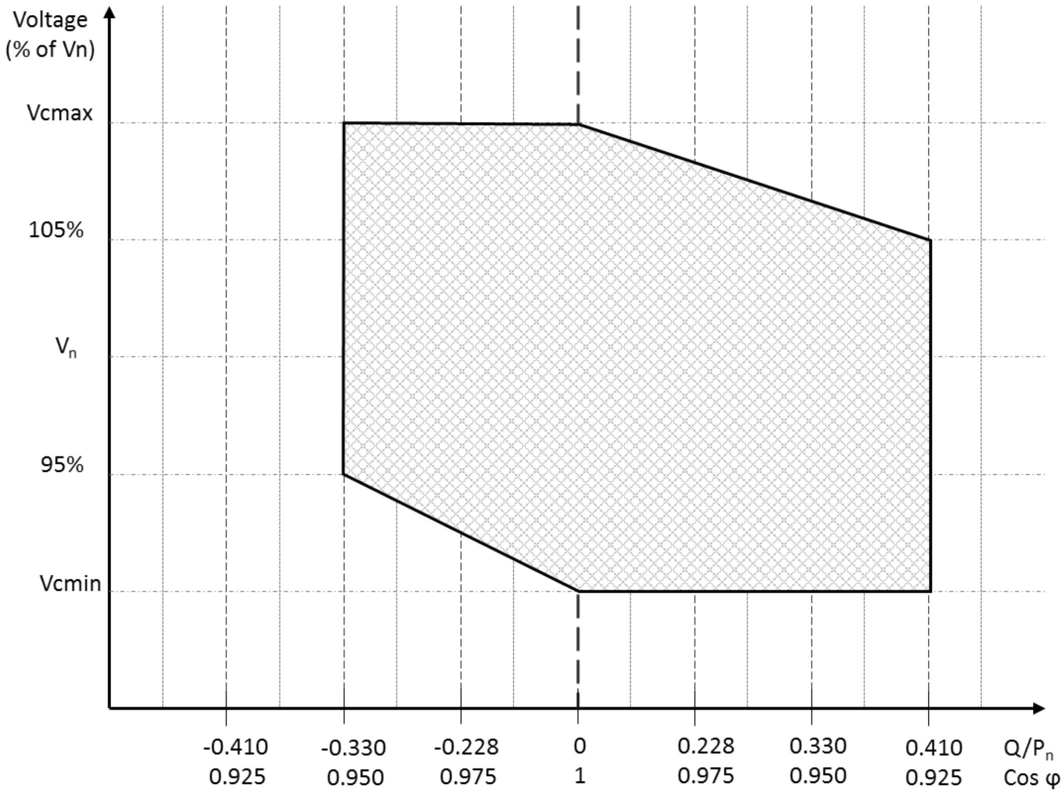

Figure 2: Reactive power requirements for NITS connected VRPPs (corresponding to voltage)

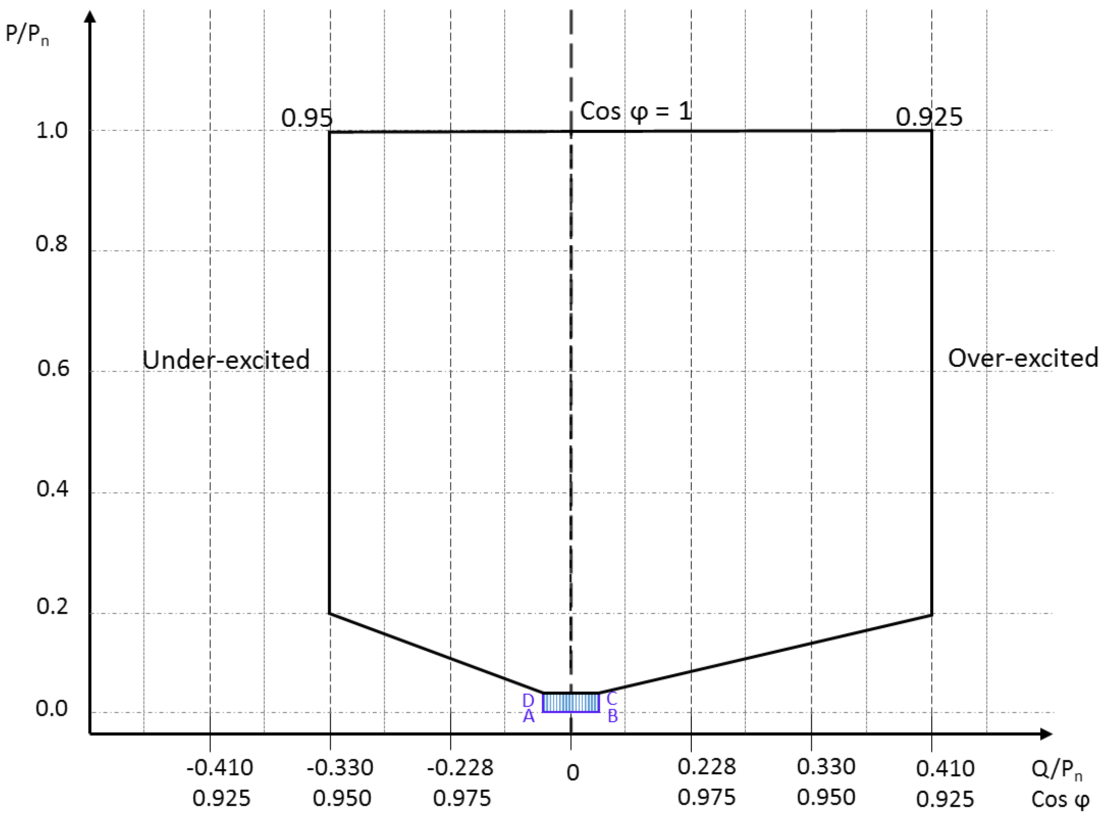

Figure 3: Reactive power requirements for NITS connected VRPPs at full/partial active power output conditions

2.6 Voltage/Reactive Power Control Requirements

2.6.1 General

(1). A VRPP shall be equipped with control functions to control reactive power or voltage at the POC via orders using set-points and gradients. The parameter settings shall be agreed between the ETU and the VRPP operator or shall be as documented in the relevant System Operational Manual.

(2). A VRPP shall support each of the following control functions:

a. Voltage control (details in section 2.6.2)
b. Q control (details in 2.6.3)
c. Power Factor Control

(3). The choice of control mode and the definition of target values shall be within the responsibility of the ETU and it must be possible for the ETU to change control mode and target values at any time during the lifetime of a VRPP.

2.6.2 Voltage Control

(1). A VRPP shall be equipped with a voltage control function that is capable of controlling voltage at the POC according to a voltage target specified by the ETU and according to a droop-characteristic, as defined in Figure 4.

(2). In the case that the ETU choses a “droop” characteristic, the “droop” shall be specified by the maximum voltage change in p.u. at maximum reactive power output (Q_{max}).

(3). If the voltage control target is changed by ETU, such change shall be completed no later than 2 minutes after the receipt of the new set-point value

(4). The maximum permitted deviation of the actual voltage from the target voltage shall be no greater than 0.5% of nominal voltage, that is 0.005 p.u., 2 minutes after change of voltage-target, during steady system conditions.

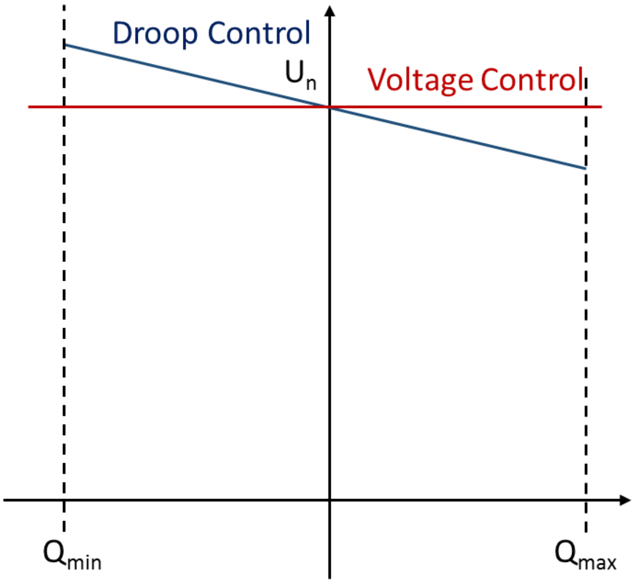

Figure 4: Voltage control function of NITS connected VRPP

2.6.3 Reactive Power Control (Q Control)

(1). A VRPP shall be capable of controlling reactive power at the POC either to a constant reactive power target (Q-target) or an active power dependent reactive power target (Q(P)).

(2). The ETU shall define the actual settings of the Q/ Q(P) control characteristic (shape of Q(P)-characteristic, target values).

(3). If the control target is changed by ETU, such change shall be completed not later than 2 minutes after the receipt of the new target value.

(4). The maximum permitted deviation of actual reactive power from the Q-target shall be no greater than 2% of rated power, that is 0.02 p.u., 2 minutes after change of Q-target during steady system conditions.

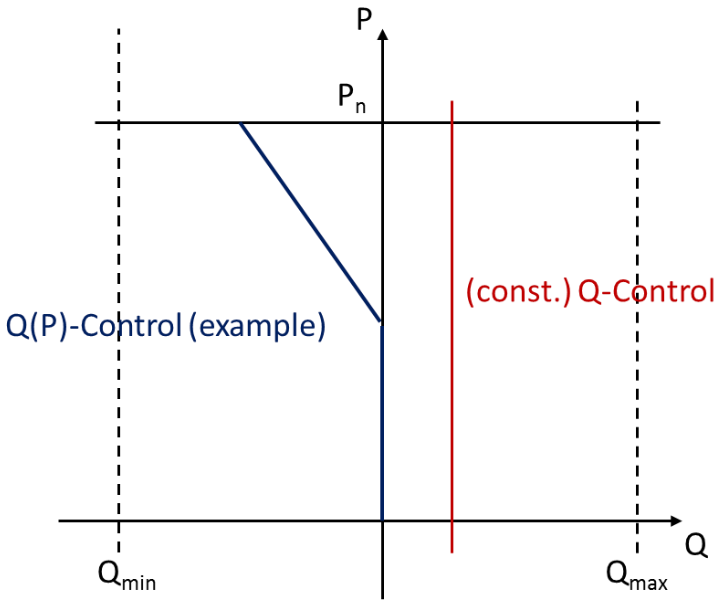

Figure 5: Reactive power control function of a NITS connected VRPP (const Q-control and Q(P)-control)

2.6.4 Power Factor Control (cosφ-Control)

(1). A VRPP shall be capable of controlling power factor at the POC either to a constant power factor target (cosφ-target) or an active power dependent power factor target (cosφ(P)).

(2). The ETU shall define the actual settings of the cosφ/ cosφ(P) control characteristic (shape of cosφ(P)-characteristic, cosφ-target).

(3). If the control target is changed by ETU, such change shall be completed no later than 2 minutes after the receipt of the new target value.

(4). The maximum permitted deviation of actual power factor from the cosφ-target shall be no greater than Δcosφ=0.005, that is 2 minutes after change of cosφ-target during steady system conditions).

2.7 Active Power Control

(1). For system security reasons it may be necessary for the ETU to curtail a VRPP active power output.

(2). A VRPP shall be capable of operating at a reduced power level if active power has been curtailed by ETU, for network or system security reasons;

(3). The accuracy of the control performed and of the set-point shall not deviate by more than ±1 % of the rated power.

(4). The type of communication between ETU and VRPP operator must be agreed between the parties and specified as part of the bilateral connection agreement (as specified in section 2.12.3 of this Sub-Code).

2.8 Frequency Response

2.8.1 High Frequency Response for VRPPs

(1). During high frequency operating conditions in NITS, each VRPP shall be required to operate at reduced active power output in order to stabilize grid frequency.

(2). When the frequency on the NITS exceeds 50.2 Hz, each VRPP shall be required to reduce active power as a function of change in frequency as illustrated in figure below.

(3). High frequency response must operate with a minimum ramp rate of 100% of rated power per minute as provided by the primary frequency control time scales.

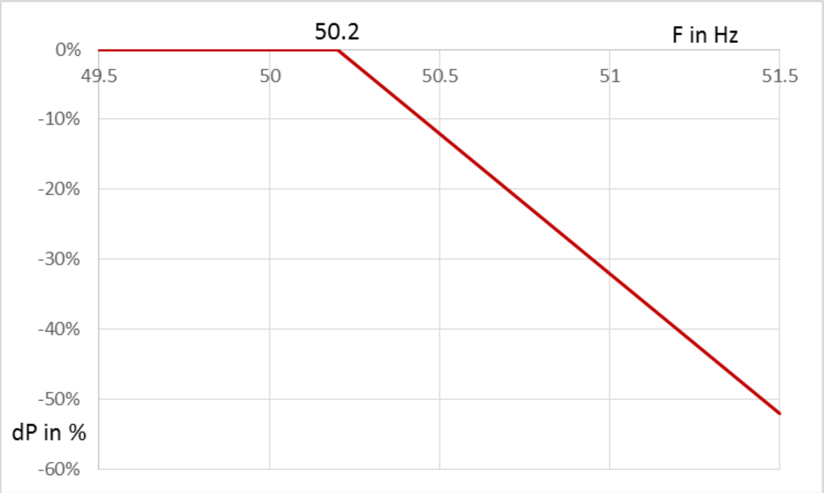

Figure 6: Mandatory high frequency response for all NITS connected VRPPs

Note: 'dP' in the figure represents percentage of active power by which the output has to be decreased in case of increasing system frequency.

2.8.2 Primary and Secondary Frequency Control

(1). Unless otherwise required by the ETU, a VRPP is exempted from primary or secondary frequency control capabilities except from high frequency response according to section 2.8.1.

2.9 Behaviour during Abnormal Voltage Conditions

2.9.1 Low Voltage Ride Through (LVRT)/High Voltage Ride Through (HVRT) Capability for VRPPs

(1). A VRPP shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below.

(2). A VRPP shall be designed to have LVRT and HVRT capability as illustrated in Figure 7.

(3). For all voltages at the POC, which are between HVRT and LVRT according to Figure 7, no disconnection of a VRPP or of individual units within a VRPP is permitted.

(4). The voltage at POC is defined to be the lowest of the three line-line or line-earth voltages.

(5). If the voltage reverts to the Continuous Voltage Range (between Vcmin and Vcmax) during a fault sequence (e.g. resulting from reclosing, subsequent voltage drops or voltage spikes shall be regarded as new LVRT or HVRT condition.

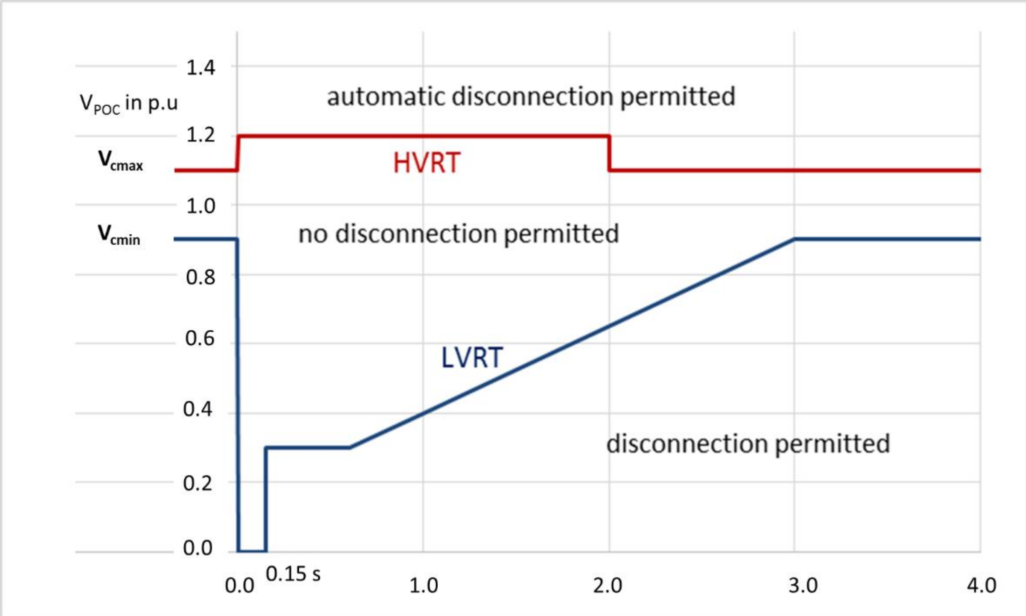

Figure 7: LVRT and HVRT capability for NITS connected VRPPs

2.9.2 Reactive Current Support During LVRT/HVRT Situations

(1). During LVRT and HVRT situations, both symmetrical and asymmetrical, all units within a VRPP shall support the voltage by injecting or absorbing additional reactive current ΔI_q at the generator terminals proportional to the change of the unit's terminal voltage ΔV_t, as depicted in Figure 8.

(2). The factor of proportionality between additional reactive current and voltage deviation is named K ($\Delta I_q = K \Delta V_t$) and the factor K must be settable in the range of 0<=K<=10.

(3). The absolute value I of current in each of the three phases of the unit's terminals may be limited to rated current (1 p.u.).

Notes:

1. Voltages and currents in this section are defined to be positive sequence components of fundamental frequency value of voltages and currents respectively. This applies to pre-fault and post-fault voltages and currents.
2. The additional reactive current ΔI_q shall be injected in addition to the pre-fault voltage.
3. The positive sign of ΔI_q in Figure 8 is voltage supporting injection of reactive power.
4. The voltage deviation ΔV_t is defined by the difference between the pre-fault and the post-fault voltage.
5. The pre-fault current and pre-fault voltage are defined by the 1-minute average of current and voltage respectively.

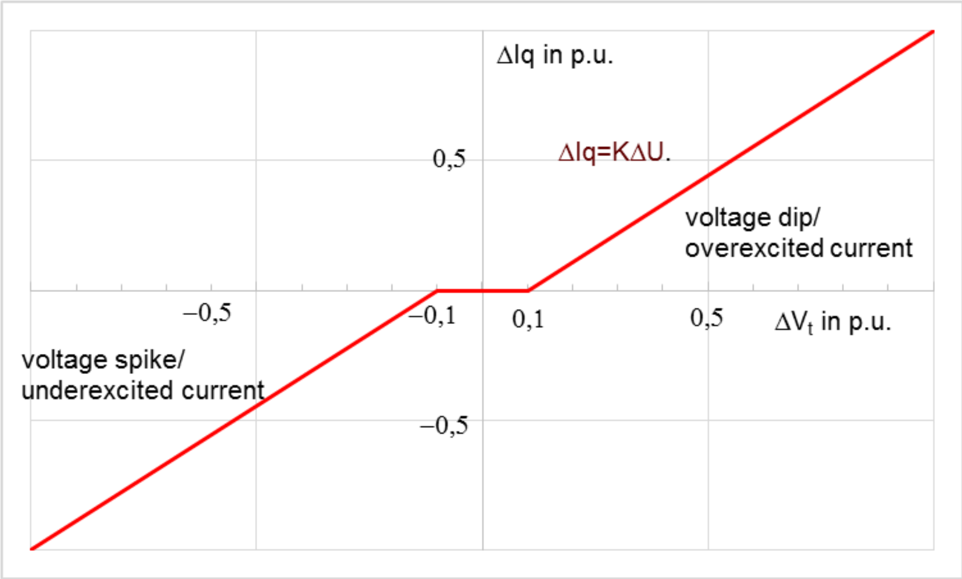

Figure 8: Reactive current support ΔI_q during LVRT and HVRT situations at the unit's terminals

(4). During dynamic performance, after 60ms the additional current must have settled, meaning that it shall remain within a tolerance band of ±20% around the value according to Figure 8.

(5). During LVRT and HVRT conditions, the active current I_P shall be reduced in proportion to the voltage change ΔV_t.

2.9.3 Active and Reactive Power Behaviour During Voltage Recovery

(1). After voltage at POC has returned into the Continuous Voltage Range, a VRPP shall restore its active power output to at least 90% of its pre-fault value within 1 second.

(2). During voltage recovery, a VRPP shall not absorb more reactive power than prior to the LVRT situation.

2.10 Automatic Resynchronisation

(1). Automatic synchronization device and automatic close equipment shall be installed to allow a VRPP to connect to the NITS automatically, with a delay of 5 minutes if the NITS is in a Normal State, as defined in the National Electricity Grid Code.

(2). During automatic connection or synchronisation, a VRPP must ensure compliance with “rapid voltage change” requirements according to section 2.4.1.

2.11 Protection and Fault Levels

(1). A VRPP operator shall design, implement, coordinate and maintain its protection system to ensure the desired speed, sensitivity and selectivity in clearing faults on VRPP's side of the connection point (POC).

(2). Protection functions required for protecting the ETU grid from getting out of normal operating ranges will be specified by the ETU, including trip-settings, response times for over-/under-voltage protection, and over-/under-frequency protection.

(3). A VRPP shall be equipped with effective detection of islanded operation in all system configurations and shall have the capability to shut down generation of power in such condition within 2 seconds.

(4). The islanded operation with part of the NITS is not permitted unless specifically agreed with the ETU.

(5). The coordination among protections at connection point must be agreed between ETU and the VRPP operator.

(6). The circuit breaker used for connection switching in NITS connected generators shall be equipped with a disconnection system to ensure safe operation during re-connection/re-synchronization to the grid.

(7). The ETU may request that the set values for protection functions be changed following commissioning if it is deemed to be of importance to the operation of the NITS, except that, such a change shall not result in a VRPP being exposed to negative impacts from the NITS lying outside of the design requirements.

(8). The ETU shall inform a VRPP operator of the highest and lowest short-circuit current that shall be expected at the POC as well as any other information about the NITS as may be necessary to define the VRPP's protection functions.

(9). Where VRPP's protection equipment is required to communicate with the ETU's protection equipment it must meet the communications interface requirements specified by the ETU and this Sub-Code.

2.12 Communication and Control

(1). A VRPP shall be equipped to receive target values for control purposes from the ETU such as voltage/reactive power control according to section 2.6, active power curtailment according to 2.7 and other control functions as it may be applicable.

(2). A VRPP owner shall be responsible for data relating to MW forecast estimates and a VRPP availability estimates, at least a prediction intervals of 2 days-ahead, 1 day-ahead and 4 hours-ahead of real time. This data shall be made available to the ETU by a VRPP operator on a daily basis.

(3). All further requirements with regard to the exchange of information will be agreed on between a VRPP operator and the ETU within the bilateral connection agreement.

2.13 Supervisory Control and Data Acquisition

(1). A VRPP shall provide Supervisory Control and Data Acquisition (SCADA) with the capability to transmit data and receive instructions from the ETU to protect system reliability.

PART C:

3 Renewable Generating Facility Forecasting

(1). A VRPP shall install equipment necessary to automatically communicate to the ETU the expected and real-time renewable generation output and data for the purposes of generation forecast.

PART D:

4 Testing, Inspection and Compliance Monitoring

(1). A VRPP shall demonstrate compliance with all applicable requirements specified in this Sub-Code and any other applicable code or standard approved by the ETU, as applicable, before being allowed to connect to the NITS and operate commercially.

(2). A VRPP operator shall review and confirm to the ETU, compliance by a VRPP with every requirement of this Sub-Code and shall do so according to Articles 8.102 to 8.108 of the National Electricity Grid Code.

(3). VRPP operator shall conduct tests or studies to demonstrate that the VRPP complies with each of the requirements of this code and do so according to Articles 8.121 to 8.126 of the National Electricity Grid Code.

(4). The VRPP operator shall continuously monitor its compliance in all material respects with all the connection conditions of this Sub-Code.

(5). Each VRPP operator shall submit to the ETU a detailed test procedure, emphasising system impact, for each relevant part of this code prior to every test and do so according to procedures indicated in Articles 8.112 to 8.120 of the National Electricity Grid Code.

(6). A VRPP operator shall also conduct tests on protection system and co-operate with the ETU regarding the same according to articles 8.109 to 8.111 of the National Electricity Grid Code.

(7). The ETU may issue an instruction requiring a VRPP operator to carry out a test to demonstrate that the VRPP complies with the code requirements and the VRPP operator shall not refuse such an instruction.

(8). A VRPP operator shall keep records relating to the compliance of the VRPP with each section of this Sub-Code, or any other code applicable to that VRPP, setting out such information that the ETU reasonably requires for assessing power system performance, including actual VRPP performance during abnormal or continuous operating conditions.

(9). Records generated under Part D of this Sub-Code shall be kept for a minimum of 5 years unless otherwise specified in this Sub-Code commencing from the date the information was generated.