Frequency Changes during Large Disturbances and their Impact on the Total System – GC0079

**Specification for protection change requirements**

# Background

The implementation of GC0079 requires that all embedded generation is modified such that any discrete loss of mains protection (LoM) relays are only of the rate of change of frequency (RoCoF) type and set with a new specific setting. At the same time all vector shift (VS) relays are disabled or removed

The above work is likely to require every DG site smaller than 50MW registered capacity (excepting domestic installations) to be visited to ascertain what protection is installed and then to undertake any remedial action for that site. There are approximately 40 000 sites in the scope of the GC0079 proposals. It is required that the programme to undertake these works is completed within three years of it starting.

# Definitions

Agent The party acting on behalf of [DNO/NGET] implement the protection changes and data collection at each customer’s site.

Customer A DNO connected customer with a DG installation. For the purpose of this work it does not include domestic or other small customers with G83 compliant generation.

# DNO requirements and interface

There are six DNO companies and [six] independent DNOs, all of whom own the connexion arrangements with customers (ie each DG site, hereafter referred to as customers). Although the broad arrangements for managing the customer interface are common, each of the [12] companies will have its own detailed requirements for customer interaction and data recording etc.

As far as possible, and certainly as far as the technical requirements are concerned/implemented, the approach should be common across GB. However the detailed interaction with each customer will need to be conducted in accordance with the specific customer-service policy requirements of the company whose network the customer is connected to.

Each DNO will also expect the agent to work within the DNO’s offices and using the DNO’s systems to expedite the necessary work. Each DNO will specify the exact local requirements etc for access and provide the necessary arrangements. Any DNO requirements need to be strictly adhered to.

# Identification and Location of DG installations

Each DNO will be able to provide a database of its connected customers. The information within such databases will be partial and include significant out of date and erroneous data. The agent will need to use this information, together with other public domain information (EG the FiT register) to create a complete (as far as is reasonably practicable using reasonable endeavours) overall register of customers.

Each customer will need to be visited by the agent at least once during this process, and that visit will be key to ensuring the known data for each customer is complete and up to date.

# Customer Service and Management

Each DNO will have its own detailed rules for customer interaction, for example codes of practice customer service, complaints etc. The agent will need to apply all relevant rules for the agent’s interaction with customers. The DNO may require that the agent is indistinguishable from the DNO’s own staff, or the DNO may require the agent to be obviously distinct from the DNO’s staff, although clearly authorised to work for the DNO. Each DNO will advise.

[Note the overall project management of the programme may determine there is specific commonality to be applied, eg branding, letter wording etc – to be confirmed]

Site visits arranged specifically (as opposed to an unannounced speculative visit) all constitute formal appointments and the DNO will advise on the exact rules, record keeping and accuracy of arrival times etc.

# Protection setting changes

It is expected that each customer’s installation will have loss of mains protection comprising either a RoCoF protection relay or a VS relay – or a relay which implements both.

## All Generators

Establish as far as possible that there are no other protection types, especially generator owned, that would trip the generator within the frequency, voltage and LoM requirements in the D Code etc. Such protection could be implemented in the generator control scheme etc. For generation installed pre the RfG entering into force, this is only highly undesirable and should be amended if at all possible. For post RfG units it is not allowed.

The overfrequency protection setting should be a single stage and set to 52.0Hz. If there is two stage overfrequency protection present, it should be disabled such that there is a single stage set at 52.0Hz.

If this is not possible, see section 7.2 below.

## Synchronous Generators

In the case of a RoCoF relay, the setting should be set to 1Hzs-1 with a definite time delay of 500ms. If this setting cannot be achieved on the relay see section 7 below.

Note that some existing synchronous generators installed between August 2014 and August 2016 legitimately have a RoCoF setting of 0.5Hz s-1  in perpetuity - these should not be changed. Check the D Code for complete details.

A multi-function relay should be set to RoCoF with the above settings and the VS capability disabled.

In the case of a VS relay only it will need to be replaced with a RoCoF relay – see section 7 below.

## Asynchronous Generators

In the case of a RoCoF relay, the setting should be set to 1Hzs-1 with a definite time delay of 500ms.A multi-function relay should be set to RoCoF with the above settings and the VS capability disabled.

In the case of a VS relay only it must be permanently disabled or removed. Removing a trip link etc is not permanently disabled; however the physical removal of some part of the trip circuit wiring to the VS relay would meet the requirement.

# Protection equipment replacement

## General

The funding for the installation of new or replacement relays is the responsibility of the customer.

The agent’s responsibility is to discuss the issues with the customer and the DNO and follow the DNOs instructions on a case by case basis. The agent will work with the customer and be prepared to “project manage” whatever is required to assist the customer in modifying his installation as agreed and to the agreed timescale.

## Overfrequency

The agent will brief the DNO on the particulars of the case and agree with the DNO the optimal approach to correcting the defect.

## RoCoF relay for synchronous generator

The agent will brief the DNO on the particulars of the case and agree with the DNO the optimal approach to correcting the defect.

A possible solution in these cases is that, by mutual agreement between the customer and the DNO, no LoM protection is required.

# Record keeping and information

Throughout this project agents will be in a position to collect all necessary data on each customer. Note that such information is bound by strict rules of confidentiality and must not be disclosed.

The data template at Appendix 1 must be completed for each customer. DNOs will already hold most of this data, but it must be checked, completed and where necessary corrected.

The agent will also be expected to report regularly on progress, ie how many customers in total, how many complete, how many work in progress and how many yet to start etc.

Appendix 1

Customer’s details:

|  |  |
| --- | --- |
| Company Name : |  |
| Company registered No. |  |
| Postal Address : |  |
|  |  |
|  |  |
|  |  |
|  |  |
| Contact Name : |  |
| Email Address : |  |
| Telephone No. |  |
| Fax No. |  |

Generation Installation Details

|  |  |
| --- | --- |
| Power station name : |  |
| Postal Address or site boundary plan (1:500) : |  |
|  |  |
|  |  |
|  |  |
|  |  |
| Commissioning Date |  |
| Connection Point (OS grid ref or description) : |  |
|  |  |
|  |  |
|  |  |
| Connection point voltage : | V |
| Single line diagram of any on-site existing or proposed electrical plant or, where available, operation diagrams | Please attach |
| No. of generation sets in power station : |  |
| Are all generation sets of same design/rating? | Y/N |
| Does power station operate in island mode? | Y/N |
| Does generation plant supply electricity to on-site premises? | Y/N |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Registered capacity (maximum active power export) | MW |  | Peak asymmetrical short circuit current at 10ms (ip) for a 3φ short circuit fault at the connection point | kA |
| Maximum reactive power export (lagging) | MVAr |  | RMS value of the initial symmetrical short circuit current (Ik”) for a 3φ short circuit fault at the connection point | kA |
| Maximum reactive power import (leading) | MVAr |  | RMS value of the symmetrical short circuit current at 100ms (Ik(100)) for a 3φ short circuit fault at the connection point | kA |

**Generation set general data**

|  |  |  |
| --- | --- | --- |
| Number of generation sets to which this data applies: | |  |
| Type of generation set  (please tick box) | Synchronous generator □ | |
| Fixed speed induction generator □ | |
| Double fed induction generator □ | |
| Series converter / inverter connected generator □ | |
| Other (provide details) □ | |
|  | |
|  | |
| Type of prime mover: |  | |
|  |  | |
|  |  | |
| Operating regime  (see Note B1). Please tick box | Intermittent □ | |
| Non-intermittent □ | |

**Generation set Active Power capability**

|  |  |
| --- | --- |
| Rated terminal voltage (generator) | V |
| Rated terminal current (generator) | A |
| Generation set registered capacity (net) | MW |
| Generation set apparent power rating (to be used as base for generator parameters) | MVA |
| Generation set rated active power  (gross at generator terminals) | MW |

**Generation set Reactive Power capability at rated Active Power (gross, at generator terminals)**

|  |  |
| --- | --- |
| Maximum reactive power export (lagging). For HV connected generators only | MVAr |
| Maximum reactive power import (leading). For HV connected generators only | MVAr |

**PART 1b**

**Generation set maximum fault current contribution   
(see Note B2)**

|  |  |
| --- | --- |
| Peak asymmetrical short circuit current at 10ms (ip) for a 3φ short circuit fault at the generation set terminals (HV connected generators only) | kA |
| RMS value of the initial symmetrical short circuit current (Ik”) for a 3φ short circuit fault at the generation set terminals (HV connected only) | kA |
| RMS value of the symmetrical short circuit current at 100ms (Ik(100)) for a 3φ short circuit fault at the generation set terminals | kA |

Note B1 – Intermittent and Non-intermittent Generation is defined in Engineering Recommendation P2/6 as follows:   
Intermittent Generation: Generation plant where the energy source for the prime mover can not be made available on demand.   
Non-intermittent Generation: Generation plant where the energy source for the prime mover can be made available on demand.

Note B2 - See Engineering Recommendation G74, ETR 120 and IEC 60909 for guidance on fault current data. Additionally, fault current contribution data may be provided in the form of detailed graphs, waveforms and/or tables.

|  |  |
| --- | --- |
| O/V setting Stage 1 |  |
| O/V setting Stage 2 |  |
| U/V setting |  |
| U/V setting (stage 2 if fitted) |  |
| O/F setting |  |
| O/F setting (stage 2 if fitted) |  |
| U/F setting Stage 1 |  |
| U/F setting Stage 2 |  |
| RoCoF setting |  |
| Manufacturer’s name and type of RoCoF relay |  |

**PART 2a**

**Generation set model data: Synchronous generation sets (or equivalent synchronous generation sets)**

|  |  |
| --- | --- |
| Generation set identifier: |  |
| Type of generation set (wound rotor, salient pole or asynchronous equivalent). See Note C1 |  |
| Positive sequence (armature) resistance  (HV connected generators only) | per unit |
| Inertia constant (generation set and prime mover). (HV connected generators only) | MWsec/MVA |
| Direct axis reactances; |  |
| Sub-transient (X”d) – unsaturated / saturated | per unit |
| Transient (X’d) – unsaturated / saturated (HV connected generators only) | per unit |
| Synchronous (Xd) – unsaturated / saturated (HV connected generators only) | per unit |
| Time constants: |  |
| State whether time constants are open or short circuit (HV connected only) |  |
| D-axis sub-transient – unsaturated / saturated (HV connected generators only) | s |
| D-axis transient – unsaturated / saturated (HV connected generators only) | s |

Note C1 – Asynchronous generators may be represented by an equivalent synchronous generator data set

**PART 2b**

**Generation set model data: Fixed speed induction generation sets (see Notes D1 and D2)**

|  |  |
| --- | --- |
| Magnetising reactance  (HV connected generators only) | per unit |
| Stator resistance  (HV connected generators only) | per unit |
| Stator reactance  (HV connected generators only) | per unit |
| Inner cage or running rotor resistance (HV connected generators only) | per unit |
| Outer cage or standstill rotor reactance (HV connected generators only) | per unit |
| State whether data is inner-outer cage or running-standstill  (HV generators connected only) |  |
| Slip at rated output  (HV connected generators only) | % |

|  |  |  |
| --- | --- | --- |
| Total effective inertia constant (generator and prime mover).  HV connected generators only | | MWsec/MVA |
| Shunt capacitance connected in parallel at % of rated output: |  |  |
|  | Starting | kVAr or graph |
|  | 20% | kVAr or graph |
|  | 40% | kVAr or graph |
|  | 60% | kVAr or graph |
|  | 80% | kVAr or graph |
| 100% | | kVAr or graph |
| Active power and reactive power import during start-up | | MW-MVAr / time graphs |
| Active power and reactive power import during switching operations e.g. ‘6 to 4 pole’ change-over  (HV connected generators only) | | MW-MVAr / time graphs |
| Under voltage protection setting & time delay | | puV, s |

Note D1 – Asynchronous generators may be represented by an equivalent synchronous data set

Note D2 – You will need to provide the above data for each asynchronous generation set based on the number of pole sets (i.e. two data sets for dual speed 4/6 pole machines)

**PART 2c**

**Generation set model data: Doubly fed induction generation sets**

|  |  |
| --- | --- |
| Generation set maximum fault current contribution data (see Note E1) |  |
| Magnetising reactance  (HV connected generators only) | per unit |
| Stator resistance  (HV connected generators only) | per unit |
| Stator reactance  (HV connected generators only) | per unit |
| Running rotor resistance  (HV connected generators only) | per unit |
| Running rotor reactance  (HV connected generators only) | per unit |
| Standstill rotor resistance  (HV connected generators only) | per unit |
| Standstill rotor reactance  (HV connected generators only) | per unit |
| State whether data is inner-outer cage or running-standstill  (HV generators connected only) |  |
|  |
|  |

|  |  |
| --- | --- |
| Generator rotor speed range – Minimum to rated speed  (HV connected generators only) | rpm |
| Total effective inertia constant at rated speed (generator and prime mover). HV connected generators only | MWsec/MVA |

Note E1 – Fault current contribution data should be provided in Part 1 of this application form

**PART 2d**

**Generation set model data: Series converter / inverter connected generation sets**

|  |  |
| --- | --- |
| Generation set maximum fault current contribution data (see Note E1) |  |
| Generator rotor speed range (HV connected generators only) | rpm |
| Total effective inertia constant (generator and prime mover). HV connected generators only | MWsec/MVA |

Note E1 – Fault current contribution data should be provided in Part 1 of this application form

**PART 2e**

**Transformer information**

|  |  |
| --- | --- |
| Transformer identifier |  |
| Transformer type (Unit/Station/Auxiliary) |  |
| Number of identical units |  |
| Type of cooling |  |
| Rated (apparent) power | MVA |
| Rated voltage ratio (on principal tap) | kV/kV |
| Positive sequence resistance (HV connected only) | per unit |
| Positive sequence reactance at principal tap | per unit |
| Winding configuration  (e.g. Dyn11). HV connected only |  |
| Type of tap changer  (on load / off circuit) |  |
| Tap step size | % |
| Maximum ratio tap | % |
| Minimum ratio tap | % |
| Method of voltage control (HV connected only) |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |