Comments on Andrew Roscoe's data - Part 3

Introduction

This data is a follow on from my Part 1 and 2 comments.

It is essential that to get the Grid Code approved that any and all topics that are secondary to the basic principle of GBGF technology are dealt with in the **Best Practice Guide**

The data listed in Parts 1 to 3 of these comments that will be a part of the **Best Practice Guide** will be included in the NGESO's notes on the next version of the Grid Code.

SGRE Item 1.7.

The Grid Code in ECC.6.3.19.3 (vii) includes the following text

For submitting either Figure ECC.6.3.19.3.2 (a) or Figure ECC.6.3.19.3.2 (b), each User or Non-CUSC Party can use their own design, that may be very different to the Figures ECC.6.3.19.3.2 (a) or ECC.6.3.19.3.2 (b), but should contain all relevant functions.

This makes it clear that very different diagrams can be submitted to NGESO.

The proposed change is:

For submitting either Figure ECC.6.3.19.3.2 (a) or Figure ECC.6.3.19.3.2 (b), each User or Non-CUSC Party can use their own design, that may be very different to the Figures ECC.6.3.19.3.2 (a) or ECC.6.3.19.3.2 (b), but should contain all relevant functions that can include simulation models and other equivalent data and documentation.

If the submitted data contains any IPR of the User or Non-CUSC Party they must clearly mark this data as containing IPR and agreed in advance with NGESO the procedure relating to this IPR data.

SGRE Item 1.8.

Any User or Non-CUSC Party can submit as many columns as are needed to cover the parameter changes that inherently occur for different operating scenarios.

SGRE Item 1.9.

It is agreed that the Tables in ECC.6.3.19.3.2 should define:

That the Active Inertia Power should be linear up to a ROCOF of 1 Hz / s.

SGRE Item 1.10.

The present Grid Code text is:

The output of the Grid Forming Plant shall be designed such that following a disturbance on the System, the Active Power output and Reactive Power output shall be adequately damped. The damping shall be judged to be adequate if the corresponding Active Power response to a disturbance decays within two cycles of oscillation.

The proposed Grid Code text is:

The output of the Grid Forming Plant shall be designed such that following a disturbance on the System, the Active Power output and Reactive Power output shall be adequately damped. The damping shall be judged to be adequate if the corresponding Active Power response to a disturbance decays with a response that is in line with the response of second order system that has the same equivalent **Damping Factor**.

SGRE Item 1.11.

We agree to the proposed change "The Nichols chart or other suitable analysis methods"

The expert group for the **Best Practice Guide** should be starting very soon and the other points raised are key topics to be included in the guide.

The spelling needs to be corrected

SGRE Item 1.12.

We agree that data needs to be added to cover the test values if the impedance at the test site is different to the defined site conditions

SGRE Item 1.13.

The 60 degree angle is the setting of the NGESO reclosing synchronising permissive relay so all NGESO must withstand is this angle which is only expected to occur on a very rare basis. For the avoidance of doubt this applies to all GBGF- S plant.

SGRE Item 1.14.

The word injection is the term used in the existing Grid Code that were provided by a Current controlled system. We agree with the words “Current Provision”. There is however an issue that

SGRE Item 1.15.

Your initial statements are correct and the FRT tests listed in the CC.6.3.15 will still apply.

The Figure ECC.6.3.19.5 (a) is a replacement for the equivalent Figure ECC.6.3.16(a) in the existing Grid code that has been previously accepted.

All the extra details that you have listed will be better dealt with the expert group for the **Best Practice Guide** that should be starting very soon.

SGRE Item 1.16.

The ECC.6.6.1.9 existing Grid Code is:

In order to accurately monitor the performance of a Grid Forming Plant, each Grid Forming Plant shall be equipped with a facility to accurately record the following parameters at a rate of 10 ms : -

- System Frequency with a high immunity to Grid phase jumps
- Rate of change of System Frequency
- Grid Phase Jumps

The proposed Grid Code is:

In order to accurately monitor the performance of a Grid Forming Plant, each Grid Forming Plant shall be equipped with a facility to accurately record the following parameters at a rate of 10 ms : -

- **System Frequency** using a nominated algorithm as defined by **The Company**
- The **ROCOF** rate using a nominated algorithm as defined by **The Company** based on a 500 ms rolling average
- The value of the time period, of the built in half cycle zero crossing detectors, for the 3 line to neutral voltages with a time resolution of 1 microsecond

The NGESO nominated algorithms and the details of the built in half cycle Zero Crossing Detectors will be defined by the expert group for the **Best Practice Guide** that should be starting very soon.
This system will enable post event analysis to be consistently carried out by any company

SGRE Item 1.17.

The relevant part of the existing Grid Code in ECC.6.6.3.2 is:

(iv) 1 MHz for **Grid Forming Plant** tests

The proposed Grid Code is:

(iv) 1 kHz for **Grid Forming Plant** signals including fast fault current measurements

(v) 100Hz for the other **Grid Forming Plant** tests carried out in accordance with ECC.6.6.1.9

It will then only be the responsibility of the **Company** to provide and use the necessary data logging system.

This method will enable post event analysis to be consistently carried out by any company.

The details of suitable equipment and analysis methods can be defined by the expert group for the **Best Practice Guide** that should be starting very soon.

SGRE Item 1.18.

The existing Grid code is:

To demonstrate the **Grid Forming Plant** model is capable of contributing to **Damping Active Power**, the **GBGF-I Plant** owner is required to supply a simulation study by injecting a **Test Sine Wave** into the **GBGF-I Plant** model as supplied in ECPA.3.9.2.

The test Sine wave comprises of a 50 Hz fundamental with a low frequency disturbance equivalent to balance positive sequence changes produced by a varying load. This is produced by a Test Sine Wave with equations:

- Fac(t) = Sine (50 x 2 x Pi x t).
- Fac(t) is the basic 50 Hz sine wave.
- Amp(t) = 1 + A1 x Sine (Ft x 2 x Pi x t).
- Amp(t) is the variation in the amplitude of the 50 Hz sine wave.
- Where A1 is the low frequency defined amplitude.
- Where Ft is the defined low-test frequency.
- Test(t) = Amp(t) x Fac(t).
- Where Test(t) is the complete test signal.
- Test(t) = (1 + A1 x Sine(Ft x 2 x Pi x t)) x Sine (50 x 2 x Pi x t)).

The **GBGF-I Plant** model should take the equivalent form shown in either Figure ECP.A.3.9.6(a) or Figure ECP.A.3.9.6(b) as applicable and the following tests completed and results supplied to verify the following criteria: -

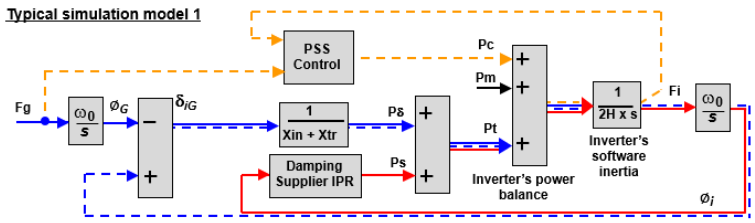

Figure ECP.A.3.9.6(a)

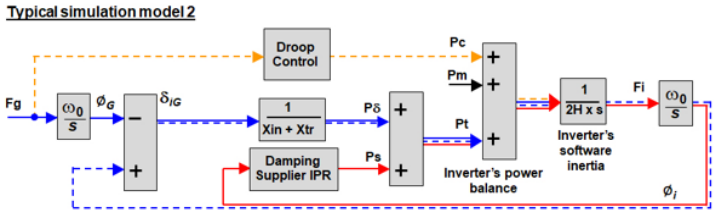

Figure ECP.A.3.9.6(b)

i) Demonstration of phase based **Damping Active Power** (or Pδ) by injecting the **Test Sine Wave** at the **Grid Oscillation Value** and frequency into the Grid Fg input as shown in Figure ECP.A.3.9.6(b) to demonstrate damping power supplied through the **GBGF-I Plant's** impedance. An acceptable performance would be judged when the result matches the **NFP Plot** declared by the **Grid Forming Plant** owner as submitted in ECC.6.3.19.3(viii).

ii) Test i) is repeated for **Test Sine Wave** inputs starting at 0.5 Hz in steps of 0.5 Hz to 10 Hz with a test amplitude of 0.01 per unit which is a total of 20 tests. An acceptable performance would be judged when the result matches the **NFP Plot** declared by the **Grid Forming Plant** owner as submitted in ECC.6.3.19.3(viii).

iii) Demonstration of phase based **real control output power** (or Pc) by injecting a normal 2Hz sine wave with an amplitude of 0.1 per unit into the **Grid Forming Plant** controller to demonstrate that the **Control Based Real Power** output is supplied below the 5Hz bandwidth limit An acceptable performance would be judged where the overshoot and decay matches the **Damping Factor**

declared by the **Grid Forming Plant** owner as submitted in ECC.6.3.19.3(viii) in addition to assessment against the requirements of CC.A.6.2.6.1 or ECC.A.6.2.6.1 or CC.A.7.2.2.5 or ECC.A.7.2.5.2 as applicable.

We agree that this part of the Grid Code needs to be simplified and carried out in the Time Domain.

If the models provided are correctly formatted then the damping for a test will correctly represent the sum of the internal and external damping.

We do consider the proposed Test Signal Type 2 is correct for use in Time Domain simulations with very low frequency tests as it does correctly represent the effects seen in the AC grid where the alternative Test Signal Type 1 can produce effects not seen in the AC grid and cause saturation in magnetic components as the allow maximum DC component is typically 0.5%.

There is no need to define a Test Signal for the proposed NFP plots as the Gain Plot provides sufficient data.

The proposed Grid Code has been substantially updated to read:

ECP.A.3.9.6 To demonstrate the **Grid Forming Plant** model is capable of contributing to **Active Damping Power**, the **GBGF-I Plant** owner is required to supply a simulation study by injecting a **Test Signal** in the time domain into the **GBGF-I Plant Owner's** plant model. Two **Test Signals** are defined. **Test Signal 1** is normally used and **Test Signal 2** often gives better results at low values of Ft.

The time domain **Test Signal Type 1** comprises of a 50Hz fundamental with a low frequency sine wave as the disturbance.

Test Signal Type 1 (t) = Sine (50 x 2 x Pi x t)) + A1 x Sine (Ft x 2 x Pi x t)).

The time domain **Test Signal Type 2** comprises of a 50 Hz fundamental with a low frequency disturbance equivalent to balance positive sequence changes produced by a varying load. This is produced by a **Test Sine Wave** with equations:

- Fac(t) = Sine (50 x 2 x Pi x t).
- Fac(t) is the basic 50 Hz sine wave.

- Amp(t) = 1 + A1 x Sine (Ft x 2 x Pi x t).
- Amp(t) is the variation in the amplitude of the 50 Hz sine wave.
- Where A1 is the low frequency defined amplitude.
- Where Ft is the defined low-test frequency.

- **Test Signal Type 2**(t) = Amp(t) x Fac(t).
- Where **Test Signal Type 2** (t) is the complete test signal.
- **Test Signal Type 2** (t) = (1 + A1 x Sine(Ft x 2 x Pi x t)) x Sine (50 x 2 x Pi x t)).

The parameters used in these equations shall be agreed between **The Company** and the **User** or **Non-CUSC Party**.

The **GBGF-I Plant** model should take the equivalent form shown in either Figure ECP.A.3.9.6(a) or Figure ECP.A.3.9.6(b) as applicable. Each **User** or **Non-CUSC Party** can use their own design, that may be very different to Figures ECP.A.3.9.6(a) or ECP.A.3.9.6 (b) but should contain all relevant functions. In either case the following tests should be completed, and results supplied to verify the following

criteria: -

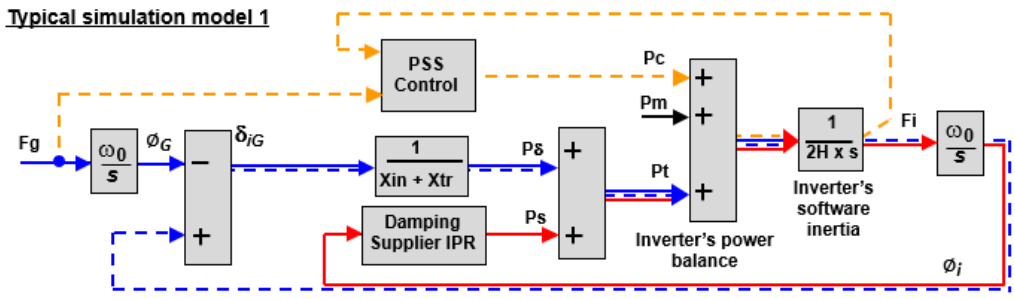

Figure ECP.A.3.9.6(a)

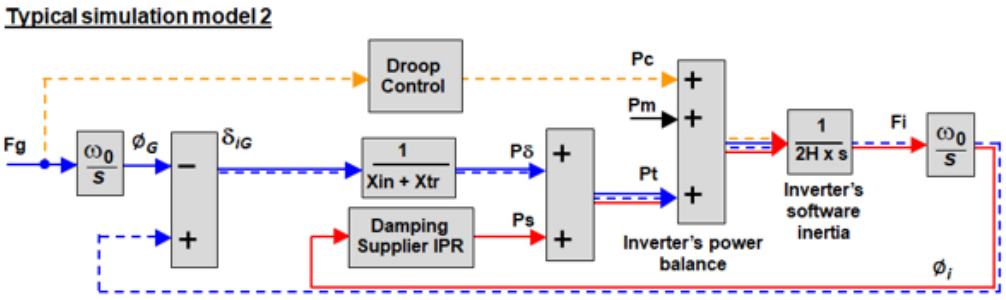

Figure ECP.A.3.9.6(b)

iv) Demonstration of **Damping** by injecting the **Test Sine Wave in the Time domain** at the **Grid Oscillation Value** and frequency into the **GBGF-I Plant** owner's plant model. An acceptable performance would be judged when the result matches the **NFP Plot** declared by the **Grid Forming Plant** owner as submitted in ECC.6.3.19.3(viii).

v) Test i) is repeated for test Sine wave inputs starting at 0.5 Hz in steps of 0.5 Hz to 10 Hz with a test amplitude of 0.01 per unit which is a total of 20 tests. An acceptable performance would be judged when the result matches the **NFP Plot** declared by the **Grid Forming Plant** owner as submitted in ECC.6.3.19.3(viii).

vi) Demonstration of phase based **Active Control Output Power** (or Pc) by injecting a normal 2Hz sine wave with an amplitude of 0.1 per unit into the **Grid Forming Plant** controller to demonstrate that the **Active Control Based Power** output is supplied below the 5Hz bandwidth limit An acceptable performance would be judged where the overshoot and decay matches the **Damping Factor** declared by the **Grid Forming Plant** owner as submitted in ECC.6.3.19.3(viii) in addition to assessment against the requirements of CC.A.6.2.6.1 or ECC.A.6.2.6.1 or CC.A.7.2.2.5 or ECC.A.7.2.5.2 as applicable.

The exact detail of implementing these test will be finalised by the expert group for the **Best Practice Guide** that should be starting very soon.

SGRE Item 1.19.

We agree that the table in ECPA.4.3.6 should be deleted and replaced with a reference to the revised ECP.6.6.1.9 data

SGRE Item 1.20.

We accept your comments and the change will be made to the Grid code

For consistency, therefore, and practical considerations, the assessment should standardise on measurements of the actual terminal voltages, currents and power flows at an appropriate measurement point

SGRE Item 1.21.

At this point in time we do not want to add a synthetic ROCOF test as drafting this in a standard way for all **Users** if probably impossible.

The initial system validation can be carried out on a system of a realistic rating in a test facility.

For scale ROCOF testing is really only practical by observing what a system produces when a real event occurs.

With all the new interconnectors it is likely that a reasonable test condition will occur several times per year

This is why we have specified the signals in ECC.6.6.3.2

SGRE Item 1.22.

Your comment relates to the Workgroup Consultation data and your proposed changes can be made in the updated Workgroup Report.

SGRE Item 1.23.

Your comment relates to the Workgroup Consultation data and the full data on virtual impedances should be a topic covered by the **Best Practice Guide** that should be starting very soon.

SGRE Item 1.24.

It is essential that to get the Grid Code approved that any and all topics that are secondary to the basic principle of GBGF technology are dealt with in the **Best Practice Guide**

Your comment relates to the Workgroup Consultation data and the full data on harmonics and unbalanced performance should be a topic covered by the **Best Practice Guide** that should be starting very soon.

This data and other similar topics will provide the guidance to NGESO and **Users** on the full details of the GBGF technology.