

Grid Code Review Panel

Voltage Fluctuations

A paper by National Grid

Summary of Issue

1. The Grid Code sets out criteria relating to Voltage Fluctuations at a Point of Common Coupling within CC.6.1.7. These include references to step changes, voltage excursions and a cross reference to Engineering Recommendation P28 for the transmission system in Scotland. The current text can be misinterpreted and would ideally be modified for the sake of clarity.
2. CC.6.1.7 (a) states that voltage excursions other than steps may be allowed up to a level of 3%. This requirement applies regardless of the impact of an excursion, either in duration, frequency or repetitiveness of occurrence. Excursions of greater than 3% have been observed coincident with the energisation of transmission user transformers. These excursions have been short-lived and occur infrequently.

Grid Code, SQSS and Engineering Recommendation Context

3. The voltage change criteria applicable to the National Electricity Transmission System (NETS) are set out in a number of documents.
4. The SQSS sets out step change limits applicable to operational switching and to secured events (ie faults) which the NETS needs to be designed and operated within. A 3% limit applies to operational switching, with 6% and 12% applied to secured events. The SQSS also includes a cross reference to Engineering Recommendation P28.
5. The Grid Code applies criteria on Voltage Fluctuations to be applied "at a Point of Common Coupling with a fluctuating Load" in CC.6.1.7. Voltage fluctuations are changes in voltage which can follow a number of different patterns including dips, ramps and steps. Steps and ramps are normally caused by a transition from one set of steady state conditions to another, whilst small dips (a sub-category of 'voltage change') can be caused by events such as motor starting for example.
6. Note that the Voltage Fluctuation criteria within CC.6.1.7 includes Flicker, but it is not considered necessary to review this as the treatment of flicker is well defined in IEC documentation and the Grid Code is consistent with this.
7. The Grid Code also sets out requirements on transmission users to ride through faults, including events where voltage goes to zero for up to 140ms.

Impact of Voltage Fluctuations

8. Voltage Fluctuations of limited magnitude, duration and frequency affect power quality but do not have a direct impact on the safety and security of a network. Their impact can be observed on perceived levels of electric lighting for example.

9. Beyond a certain point Voltage Fluctuations can impact adversely on the operation of network customers' equipment (eg motors, computing equipment), including generating station auxiliaries. Some industrial processes are known to use low voltage relays to protect the equipment concerned. There is therefore a continuing need to manage Voltage Fluctuations.

Impact of the Current Grid Code Criteria

10. CC.6.1.7 imposes an absolute ceiling on the magnitude of voltage excursions. The requirement as drafted is equally applicable to events which occur frequently (eg a number of times per day) or occur once or twice a year, and events which are short lived or events which have a semi-permanent effect.
11. Additional equipment can be needed in order to make sure that the 3% limit can be met under all circumstances. Mitigation measures can include Point on Wave controlled switching equipment, additional switchgear and reconfiguration of the transmission network.

Discussion

12. This table below summarises the voltage change criteria applied to the NETS alongside an assessment of how often or regularly the applicable event would occur.

	Type of Event	Frequency of Occurrence
1	Network faults will occur on occasion, where voltage can dip locally by up to 100% for a short period (100s of ms). Smaller excursions caused by remote faults will be observed more frequently.	1 in >30 years for severe dips
2	Secured events (as defined in the SQSS) can trigger step changes of up to 6% and up to 12%	1 in >10 years
3	Infrequent or occasional planned events can trigger steps or fluctuations of up to 3% subject to local conditions	1 in > 1month
4	Routine operational switching (as defined in the SQSS) can trigger step changes of up to 3%	A number of times per day
5	Planned events which occur frequently can trigger step changes or fluctuations of up to 3% as pre current practice and as per ER P28	A number of times per day
6	Repetitive operations (eg tap changing) can triggers steps up to 1%	A number of times per day
7	Perceived Flicker levels are managed within Short Term and Long Term limits	Continuous

13. The table illustrates how criteria are applied to events which occur at different frequencies and regularities. Generally, more severe events are tolerated where they are expected to not to occur very often.

14. However, it can be seen that the 3% change criteria applies equally to events which occur a number of times in a day and to events that occur at frequencies of less than once per month. Also, there is no differentiation between voltage fluctuations which last a number of milliseconds and longer events, including step changes where voltage does not return to its previous level.
15. The Panel is therefore asked to consider the criteria that should be applied to short voltage excursions other than steps caused by infrequent or occasional, non-repetitive planned events. Given the technical complexity of the issue it is recommended that a working group should be established involving representatives of Generators, Network Operators and, if possible, equipment manufacturers.
16. In developing any amendment proposals, the working group should consider:
 - a) the ability of affected equipment to withstand voltage excursions;
 - b). International standards relating to voltage fluctuations;
 - c) the need to define voltage excursions in terms of time, magnitude and frequency of occurrence;
 - d) the need for an absolute limit in the magnitude of a voltage excursions;
 - e) the costs of any mitigation measures; and
 - f) changes required to CC.6.1.7, excluding paragraph (b), to make the Grid Code Voltage Fluctuation criteria clearer.

GCRP Recommendation

17. The GCRP is invited to establish a working group to review the Grid Code criteria on Voltage Fluctuations set out in CC.6.1.7.

Attachment 1

Grid Code Text

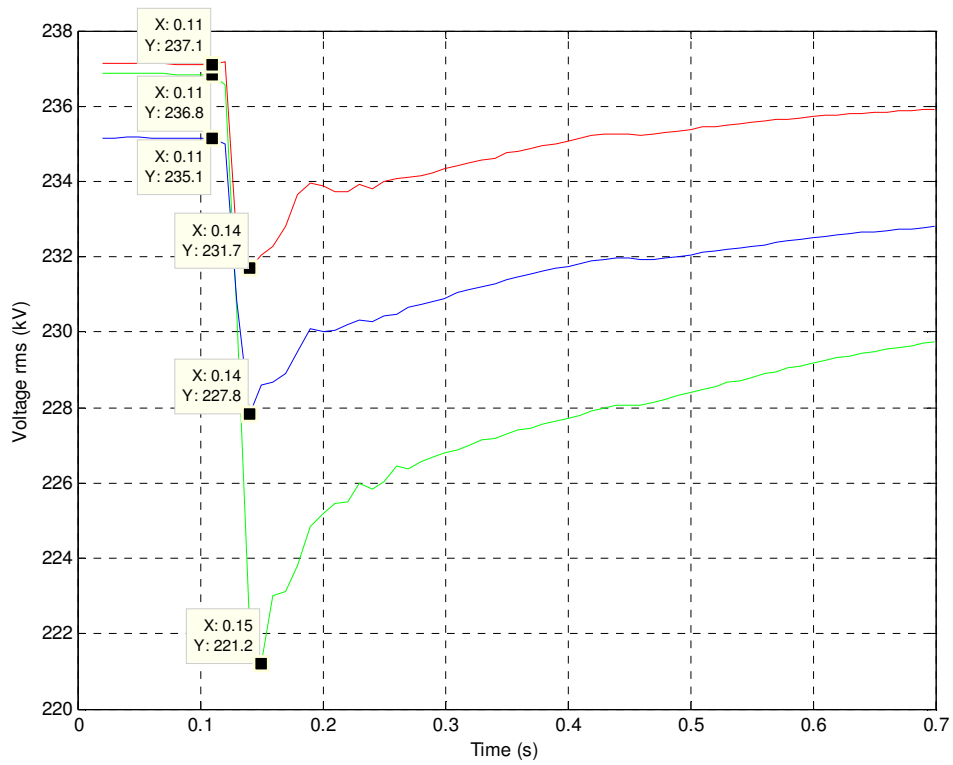
"Voltage Fluctuations

CC.6.1.7 Voltage fluctuations at a **Point of Common Coupling** with a fluctuating **Load** directly connected to the **Onshore Transmission System** shall not exceed:

- (a) In England and Wales, 1% of the voltage level for step changes which may occur repetitively. Any large voltage excursions other than step changes may be allowed up to a level of 3% provided that this does not constitute a risk to the **National Electricity Transmission System** or, in **NGET's** view, to the **System** of any **User**. In Scotland, the limits for voltage level step changes are as set out in **Engineering Recommendation P28**.
- (b) For voltages above 132kV, **Flicker Severity (Short Term)** of 0.8 Unit and a **Flicker Severity (Long Term)** of 0.6 Unit, for voltages 132kV and below, **Flicker Severity (Short Term)** of 1.0 Unit and a **Flicker Severity (Long Term)** of 0.8 Unit, as set out in Engineering Recommendation P28 as current at the **Transfer Date**."

Attachment 2

Example Measurement Data from transformer energisation.



Attachment 3

Voltage Fluctuations Working Group [Draft] Terms of Reference

Governance

1. The Voltage Fluctuations Working Group is established by Grid Code Review Panel (GCRP).
2. The group shall formally report to the GCRP.

Membership

3. The Voltage Fluctuations Working Group shall comprise a suitable and appropriate cross-section of experience and expertise from across the industry, which shall include:
 - National Grid
 - Grid Code Users
 - [Equipment Manufacturers]

Meeting Administration

4. The frequency of Voltage Fluctuations Working Group meetings shall be defined as necessary by the Voltage Fluctuations Working Group chair to meet the scope and objectives of the work being undertaken at that time.
5. National Grid will provide technical secretary resource to the Voltage Fluctuations Working Group and handle administrative arrangements such as venue, agenda and minutes.
6. The Voltage Fluctuations Working Group will have a dedicated section under the Grid Code part of National Grid's website. This will enable information such as minutes and presentations to be available to a wider audience.

Scope

7. The scope of this group is limited to the Voltage Fluctuation requirements set out in CC.6.1.7.
8. The group will consider:
 - a. The information available on the ability of affected equipment to withstand voltage excursions, where affected equipment includes distribution connected customer equipment and transmission connected equipment such as generating station auxiliaries;
 - b. International standards relating to voltage fluctuations including the terms steps, ramps, sags, swells and dips;
 - c. The need to define voltage excursions in terms of time, magnitude and frequency of occurrence;

- d. The need for an absolute limit in the magnitude of a voltage excursions; and
 - e. The costs of any mitigation measures
9. The scope of the group shall not include the requirements set out in CC6.1.7 (b).

Deliverables

10. The Group will provide updates and a Working Group report to the Grid Code Review Panel which will:
 - Detail the findings of the Group;
 - Draft, prioritise and recommend changes to the Grid Code and associated documents in order to implement the findings of the Group; and
 - Highlight any consequential changes which are or may be required.

Timescales

11. It is anticipated that this Group [tba]