Engineering Recommendation G5/4-1 – Planning Levels for Harmonic Voltage Distortion and the Connection of Nonlinear Equipment to Transmission Systems and Distribution Networks in the United Kingdom

A proposal for a review by National Grid

Paper to the DCRP

Summary

It is National Grid's view that it is timely to undertake a review of Engineering Recommendation G5/4-1, and this paper outlines that case for change and proposes a terms of reference for such a review.

Background

Engineering Recommendation G5/4-1 deals with the assessment of harmonic distortion. Over the years this document has been developed by relevant parties within the electricity industry. ER G5/4-1 is referenced in both the Distribution Code and Grid Code, and hence is the 'industry standard' for all the harmonic assessments that are undertaken in Great Britain for distribution and transmission connected customers.

Current position

In recent years there has been a significant increase in the number of polluting loads that have applied to connect to the transmission system together with a similar increase in small domestic and essentially unregulated polluting loads connected to LV. These connections include offshore windfarms, onshore wind farms, traction loads, and HVDC connections. National Grid fully expects that these types of applications for connection will continue to increase as the generation mix changes (with a predominance for renewables), the number of interconnectors increases, HVDC is integrated into the transmission system, and we see further developments on the rail network.

National Grid is currently required, and does, adhere to G5/4-1 for all harmonic assessments that are being progressed relating to relevant applications to connect to the England and Wales transmission system.

Case for Change

Up until reasonably recently, harmonic assessments undertaken in accordance with G5/4-1 were relatively infrequent (e.g. assessment for the Cross-Channel Rail Link and West Coast Main Line upgrade). There were also a whole plethora of National Grid owned SVCs during late 1980's and 1990s that were subject to G5/3 (predecessor to G5/4) type assessments. These assessments tended to be independent (from both a timescale and location point of view). The processes described within G5/4-1 are well suited to this type of one-off harmonic assessment.

As explained above, there has been (and will continue to be) a significant change in the numbers and types of connection to the electricity system in recent years. We are faced with real situations where there are offshore windfarms, HVDC interconnectors, and HVDC systems that form part of the main integrated transmission system that are all planning to connect at geographically (and electrically) close locations and in similar timescales. These applications are competing for the available harmonic headroom, and the application of G5/4-1 is becoming increasingly difficult, and does not appear to be sustainable, when faced with these types of circumstances.

The current G5/4-1 process allocates available headroom on a 'first-come, first-served' basis. Thus a heavily polluting connection could take all the available headroom in a particular area, meaning that all subsequent connections would have to provide some kind of extreme mitigation. Indeed harmonic limits available for one user will be influenced by the actions of another user. National Grid is aware that several potential users of the transmission system have raised concerns about this aspect of the process.

Put simply G5/4-1 does not adequately deal with circumstances where different connection applications are effectively competing for the available harmonic headroom.

With the advent of the offshore transmission regime, a new type of Transmission Company (the offshore transmission owner – OFTO) will be required to undertake harmonic assessments. This has the potential to further complicate the existing process and National Grid believes that it is timely to undertake a full review of the roles and responsibilities of all the different stakeholders.

The increasing number of offshore windfarms, with their associated lengthy AC cable connections has highlighted that the background level of harmonic distortion at the onshore point of connection are also affected by the proposed connection. The method of addressing this is not currently defined in G5/4-1. A detailed recommended assessment methodology needs to be drawn up for this type of connection.

G5/4-1 specifies harmonic levels (planning levels and compatibility levels) up to the 50th harmonic. A review of these levels should be undertaken to determine whether they are still appropriate, as well as an assessment of whether the effects at orders above the 50th harmonic should be included. National Grid is increasingly required to assess connection applications with harmonic current injections above the 50th harmonic, and believes that there should be some standard relating to these.

Further difficulties have also been encountered where a new substation is being built solely to accommodate a new connection. It is not currently clear how the background level at the new substation is estimated in the absence of measurements.

Discussions are in progress with European Transmission System Operators (ENTSO-E) relating to the creation of harmonised EU Network Codes. These codes are mandated as part of the 3rd package of energy regulations. It is likely that international standards will be extensively referred to in these codes, and indeed the relevant IEC standard (IEC 61000-3-6) relating to harmonic distortion is referred to in the pilot code that has been developed for generation connections. Great Britain will have to fall into line with these proposals, so any review of G5/4-1 should consider whether it would be simply more appropriate for us to adopt an existing international standard (such as IEC 61000-3-6) at this stage or form a UK specific version of an existing international standard by amending it where necessary in a similar manner to Australian and New Zealand approach (IEC 61000-3-6 to AS/NZS 61000-3-6 example).

Proposal for a review and Recommendations

Given the reasons explained above, National Grid believes that there is a compelling case for change.

Any changes to G5/4-1 (or the adoption of a different standard) will impact on network operators and potential users of these networks along with equipment manufacturers.

National Grid therefore recommends that:

- The DCRP **agrees** with the case for change contained within this paper; and

- The DCRP agrees that a joint GCRP/DCRP WG is the most appropriate method to undertake a review of G5/4-1 in line with the proposed terms of reference that are consistent with the case for change presented above and are attached to this paper (Appendix A).

Appendix A

Proposal for a review of Engineering Recommendation G5/4-1

Draft terms of reference for joint GCRP/DCRP review

Proposed by National Grid

It is National Grid's view that it is timely to undertake a review of Engineering Recommendation G5/4-1 (Planning Levels for Harmonic Voltage Distortion and the Connection of Nonlinear Equipment to Transmission Systems and Distribution Networks in the United Kingdom). The main drivers for this review are:

- A significant increase in the number of polluting loads that are connecting to the transmission/distribution system;
- Interactions between these connections i.e. connecting at same/proximate nodes and in similar timescales; and
- Concerns raised by some customers that the principle of allocating rights to emit on a 'first-come, first-served' basis may not be appropriate.

Such a review of ER G5/4-1 should consider:

- Whether there are international standards that could be adopted or referenced (e.g. IEC 61000-3-6) in anticipation of the implementation of EU Network Codes.
- A general review of the technical processes used to calculate allocated harmonic emission levels
- The roles and responsibilities of the different stakeholders in the process (e.g. Transmission Owners, Offshore Transmission Owners, Distribution Network Owners and users connected to these systems)
- Are the harmonic levels in the current version of G5/4 adequate or acceptable?
- Should harmonics levels above the 50th harmonic be included within G5/4?
- How to progress with harmonic assessments where a new substation needs to be built i.e. how is the background level at the new substation estimated?
- The process used to allocate the limits described in G5/4 between different users in similar areas including:
    - Whether 'first-come, first-served' is the appropriate way of allocating limits
    - How 'competing' applications are dealt with, and how changes to customers requirements may impact on their right to emit harmonics
    - Clarification on the process used to measure and predict the applicable level of background distortion to be used in an assessment
- Whether there are 'non-technical' changes that need to be introduced into other codes (e.g. CUSC, DCUSA).