[DCRP_18_03_05a]

Modification

At what stage is this document in the process?

01 Modification
02 DCRP report
03 Public Consultation
04 Final Modification Report

DCRP/PC/18/01/RtA

Revision to Engineering Recommendation P28 –Voltage fluctuations and the connection of disturbing equipment to transmission systems and distribution networks in the United Kingdom

The purpose of this document is to assist the Authority in its decision to implement the proposed modifications to the Distribution Code and Engineering Recommendation P28 (subsequently referred to as EREC P28). The proposed modifications were subject to industry consultation in January 2018. Responses from this consultation show that the industry is in favour of these modifications.

Date of publication: XX XXX 2018

Recommendation

The Distribution Code Review Panel (DCRP) recommend that modifications are made to the Distribution Code and Engineering Recommendation P28, in relation to voltage fluctuations resulting from the connection of disturbing equipment to transmission systems and distribution networks in the United Kingdom that address the following:

a) Introduce requirements and planning levels for Rapid Voltage Changes (RVCs).

b) Improve definition and clarity of 'worst case operating conditions' to be used in the assessment of voltage fluctuations.

c) Include an intermediate planning level and associated flicker severity limits for supply systems with nominal voltages of 3.3 kV, 6.6 kV, 11 kV, 20 kV and 33 kV to improve co-ordination of flicker severity from higher to lower voltage supply systems.

d) Improve the definition of voltage step change.

e) Clarify information requirements for assessment and responsibilities for provision of information.

f) Include the application of transfer coefficients for determining voltage fluctuation contributions from different nodes. g) Assess voltage fluctuations caused by renewable energy and low carbon technologies.	
	The Proposer recommends that this modification should be: Submitted to the Authority for approval
	High Impact: None
	Medium Impact: New developers of embedded generation installations and existing users that make changes to existing installations with significant number of transformers that cause rapid voltage changes (RVCs) when energised, who are required to design their installations in accordance with the requirements and planning levels for RVCs in EREC P28.
	Low Impact: All Users of the Distribution System. The modifications are intended not to unduly impact on or cause interference to existing Users of public electricity systems/networks. Users that propose to connect disturbing equipment/fluctuating installations to the system, which could result in flicker, who need to carry out assessments and measurements in accordance with EREC P28.

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Document Control

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0.1	02/03/2018	ENA	Draft Report
0.2	12/03/2018	ENA	Minor Changes
0.3	19/03/2018	ENA	Timetable and implementation section modified

Timetable

Work Group Report presented to Panel	24/11/2017
Draft Modification Report issued for consultation	08/01/2018
Consultation Closed	31/01/2018
Final Modification Report available for Panel	20/03/2018
Final Modification Report submitted to Authority	05/04/2018

Any questions?

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1. Executive Summary

1.1 EREC P28 was first published in 1989 to provide recommended planning limits for voltage fluctuations for connection of equipment to public electricity supply systems in the UK. Issue 1 was primarily concerned with assessment of voltage fluctuations and associated flicker produced by traditional domestic, commercial and industrial loads.

1.2 Since EREC P28 was first published, the factors affecting development of transmission systems and distribution networks, and equipment connected to them have changed significantly. There has been a shift towards connection of distributed/embedded generation equipment powered by renewable energies and other low carbon technology equipment. These types of modern equipment are capable of causing voltage fluctuations.

1.3 Significant developments in Electromagnetic Compatibility (EMC) requirements have also taken place, which are captured in the International Electrotechnical Commission (IEC) 61000 series of Standards and technical reports. United Kingdom implementation of these Standards is captured in the various parts of BS EN 61000.

1.4 In addition to being a Distribution Code Annex 1 document, EREC P28 is referenced in the Grid Code hence a joint Distribution Code and Grid Code Working Group was established to oversee the revision of EREC P28 and associated modification to requirements for voltage fluctuation in the Distribution Code. The Terms of Reference for the Working Group can be found in Annex 9.1 to this report.

1.5 Consequently, proposed modifications to EREC P28 (subsequently referred to as EREC P28 Issue 2) and associated requirements for voltage fluctuation in the Distribution Code were developed by the Working Group. Section 4 [of this report] details the Working Group's discussions and details concerning material modifications to EREC P28.

1.6 The scope of EREC P28 has been modified to cover voltage fluctuations that are characterised as RVCs as well as those that result in flicker. The requirements in EREC P28 Issue 2 apply to new connections of customer disturbing equipment to the public electricity supply system as well as changes to existing connections, in so far as they affect voltage fluctuation. EREC P28 Issue 2 is not intended to be applied retrospectively to existing connections that have been previously assessed under Issue 1 of EREC P28 and which remain unchanged.

1.7 The proposed EREC P28 Issue 2 constitutes a full technical revision of Issue 1. The main technical modifications in EREC P28 Issue 2 include the following.

- Introduction of requirements and planning levels for RVCs.
- Improved definition and clarity of worst case operating conditions to be used in the assessment of voltage fluctuations.
- An intermediate planning level and associated flicker severity limits for supply systems with nominal voltages of 3.3 kV, 6.6 kV, 11 kV, 20 kV and 33 kV.

- Improved definition of voltage step change.
- Improved clarity concerning information requirements for assessment and responsibilities for provision of information.
- Concept of transfer coefficients for determining voltage fluctuation contributions from different nodes.
- Additional recommendations for assessing voltage fluctuations caused by renewable energy and low carbon technologies.

1.8 Distribution Code public consultation (DCRP/PC/18/01) was published on the 8th January 2018 and sought views from industry stakeholders on the proposed modification to Engineering Recommendation P28. The Consultation Pack can be found in Annex 9.2 to this report. The deadline for responses was the 31st January 2018.

1.9 A number of responses to the Distribution Code public consultation were received. All of the respondents agreed that the modification proposal:

- better facilitates the Distribution Code objectives;
- provides improved clarity of what constitutes 'worst case normal operating conditions';
- assists with co-ordination of the transfer of flicker severity from higher voltage to lower voltage supply systems through the intermediate planning level proposed.

Two respondents provided extensive comments in relation to the proposed requirements and planning levels for RVCs as provided in Figure 5, Figure 6, Figure 7 and Table 4 of EREC P28 Issue 2. The Working Group's full response can be found in Annex 9.3 to this report. A summary of the consultation responses can be found in Section 5 of this Report to Authority.

1.10 No major impacts have been identified by the Working Group.

1.11 The most significant medium impact of the modification affects those Users, who are required to assess and measure RVCs for conformance against EREC P28 Issue 2 requirements. In particular, developers of embedded generation installations with significant numbers of transformers that cause RVCs when energised, who are required to design their installations in accordance with the requirements and planning levels for RVCs in EREC P28. This modification allows for a greater number of RVCs at any point in the system in a given calendar year to facilitate disconnection and reconnection of complete customer sites with significant numbers of transformers for infrequent or very infrequent switching operations, including unplanned outages, with the ability to re-establish distributed generation more quickly after an unplanned outage, e.g. fault outage.

1.12 The assessment of the Working Group is that the proposed amendments will better facilitate the Distribution Code objectives. A more detailed commentary on the impacts and assessment of the proposed modification can be found in Section 6 of this report.

1.13 The Working Group has made a number of recommendations in Section 7 of this report, the principal one being that EREC P28 Issue 2 as it was consulted upon is approved and implemented subject to the proposed amendments.

1.14 At the meeting of the Distribution Code Review Panel (the Panel) held on 05/04/2018, the Panel unanimously agreed to the submission of the Report to Authority as the Panel agreed that the Modification proposal better facilitated the objectives of the Distribution Code.

2. Purpose & Scope of the Working Group

2.1 Purpose

2.1.1 The joint Working Group of various key stakeholders was constituted by the Grid Code Review Panel (GCRP) and the Distribution Code Review Panel (DCRP) of Great Britain (GB) to review Engineering Recommendation P28 Issue 1 1989. Facilitation of the Working Group was provided by the Energy Networks Association (ENA).

2.1.2 The purpose of the Working Group was as follows.

- To review the standards and processes employed by Distribution Network Operators (DNOs) and Transmission System Operators (TSOs) in GB for assessing voltage fluctuations and associated light flicker produced by potentially disturbing User equipment.
- To revise Engineering Recommendation P28 in light of the recommendations from the Working Group.

2.2 Scope

The scope of the Working Group included the following aspects.

2.2.1 General

a) Update references and associated recommendations in EREC P28, including standards.

b) Consider whether it is appropriate to employ different standards and/or processes for transmission compared with distribution connections.

c) Consider issues where EREC P28 is unclear and provide guidance on interpretation (e.g. which fault level to consider).

d) Consider voltage fluctuations from a wider network context and the adequacy of voltage fluctuation requirements in DPC4 of the Distribution Code.

2.2.2 Standards

a) Consider whether there are standards that could be adopted/referenced (e.g. PD IEC/TR 61000-3-7) in anticipation of the implementation of EU Network Codes. Consideration will be given to reviewing IEEE Standards, where there is no appropriate National, European or International Standard.

b) Consider whether BS EN 61000-3-3 and BS EN 61000-3-11 are effective at controlling flicker for multiple LV installations.

c) Consider whether other technical standards or recommendations would need to change as a result of any change to EREC P28.

2.2.3 Limits

a) Consider whether the planning limits for voltage fluctuations and flicker are adequate or acceptable, in particular for infrequent switching events and rapid voltage changes.

b) Consider whether changes are necessary because of the new range of lighting technologies.

c) Consider whether transformer magnetising inrush should be within the scope of EREC P28.

d) Consider requirements for guidance on the application of EREC P28 and data requirements for use in models/calculations of flicker severity, in particular, data accuracy and any initial conditions to be used.

2.2.4 Evaluation of background levels

a) Clarify the interpretation of measured background values and what duration of measurement is appropriate.

b) Consider how to progress with flicker measurements where a new substation is not yet built (i.e. how is the background level at a new substation best estimated?)

2.2.5 ‘First-come, first-served’ versus allocation of rights

a) Consider the process used to allocate the limits described in EREC P28 between different Users in similar areas including whether ‘first-come, first-served’ is the appropriate way of allocating limits or whether there are alternative methods (e.g. equal rights as per PD IEC/TR 61000-3-7) that can be justified.

b) Consider how ‘competing’ applications are dealt with and how changes to customers’ requirements may impact on their right to produce voltage fluctuations and flicker.

c) Research whether other countries have moved from ‘first-come, first served’ to ‘equal rights’ and consider whether any lessons can be learned.

2.2.6 Other technical issues

a) Develop proposals to update EREC P28 to fully cover the variety of equipment now commonly encountered.

b) Consider the best approach to co-ordinate ‘outages’ between transmission and distribution systems under fault level consideration (e.g. one transmission Supergrid transformer out at the same time as one distribution 132 kV feeder).

3. Why change?

3.1 General

3.1.1 Engineering Recommendation (ER) P28, P*lanning Limits for Voltage Fluctuations Caused by Industrial, Commercial and Domestic Equipment in the United Kingdom* was first published in 1989. Although EREC P28 has proven to be a valuable technical document that has served industry stakeholders well, many important changes affecting its scope and recommendations have taken place in the intervening period. In particular, the following aspects were identified as needing to be addressed in the revision of EREC P28.

3.1.2 Changes to standards, limits and allocation of rights

a) Standards used in Stage 1 assessments (i.e. BS 5406) are now withdrawn.

b) The EMC Directive and subsequent EMC Regulations have introduced new standards that now apply to LV equipment (i.e. BS EN 61000-3-3 and BS EN 61000-3-11).

c) BS EN 61400-21 used in disturbance assessment of large wind turbines is not referenced.

d) Stage 3 of EREC P28 involves taking background measurements of flicker but no guidance is provided on whether to use maximum values or those based on a level not exceeded for a specified percentage of time. Engineering Recommendation G5/4-1 concerning harmonics accounts for this using the 95% of time concept and a similar approach may be justified for flicker.

e) PD IEC/TR 61000-3-7 has been published and introduces new concepts that are worthy of consideration; namely:

i) Margins between ‘Planning Levels’ and ‘Compatibility Levels’ to allow co-ordination of flicker between voltage levels.

ii) Planning limits for rapid voltage changes occurring less frequently than once every 10 minutes with the limits varying with how often the changes occur. This includes indicative limits with the highest reaching 6% for rapid voltage changes occurring up to two times a day at medium voltage.

iii) Apportionment according to agreed supply capacity. NOTE: EREC P28 allows a first-comer to utilise the whole margin; consideration could be given, in cases of multiple connection applications, to use some form of apportionment according to agreed supply capacity. A similar issue is being considered for harmonics in the G5/4-1 working group.

3.1.3 Changes in networks and codes

a) Discussions are in progress with European Transmission Network Operators (ENTSO-E) concerning harmonised EU Network Codes. Documents such as PD

IEC/TR 61000-3-7 may be referenced and so the impact on EREC P28 needs to be considered.

b) The Distribution Code now includes limitation on voltage fluctuations due to transformer magnetising inrush current. A review could consider whether inrush should be included within the scope of EREC P28 and what the appropriate limit would be.

NOTE 1: This could also be linked to consideration of the PD IEC/TR 61000-3-7 rapid voltage change indicative planning limits and associated CIGRE work. NOTE 2: A separate paper - PP11/51 - related to this was presented to the GCRP by National Grid on 22/09/2011.

c) EREC P28 provides somewhat contradictory statements with regards to which fault level – normal or abnormal – should be used in Stage 2 and 3 assessments.

3.1.4 Changes in connections and lighting technology

a) Lighting technology is changing and modern lights have a different flicker performance than the 60 W tungsten filament lamp upon which the flicker limits in EREC P28 are based. Work in this area is underway at IEC level.

b) LV equipment subject to restricted connection falling within the scope of BS EN 61000-3-11 is supposed to be connected only after the customer checks that the network has sufficiently low impedance. The manufacturer is supposed to make a statement to this effect where it applies. However, in reality the manufacturer statement is often not provided or only on request and customers/installers fail to make the relevant checks. Furthermore, the impacts need to be understood of the widespread adoption of heat pumps and electric boilers, which can operate at similar times in large numbers, and the fact that BS EN 61000-3-11 allows higher levels of flicker than the EREC P28 Stage 2 limit.

c) LV equipment subject to BS EN 61000-3-3 is intended for unconditional connection. However, this standard allows higher flicker levels than the EREC P28 Stage 2 limit at the supply terminals and it may be possible to exceed compatibility levels with multiple installations (i.e. when a whole housing estate has such equipment operating at similar times).

4. Work Group Discussions

4.1 General

4.1.1 The Work Group agreed that EREC P28 should be a full technical revision and that the document should be completely restructured and formatted in line with recent ENA engineering documents.

4.1.2 It was agreed that EREC P28 would be revised so that EREC P28 Issue 2 can continue to be read as a ‘standalone’ document.

4.1.3 Appendix D of EREC P28 Issue 1, containing network impedance characteristics, was agreed to be obsolete and has been removed from the revision.

4.2 Changes to standards, limits and allocation of rights

Standards

4.2.1 The Work Group agreed that opportunity should be taken to align, wherever possible, terms and requirements in EREC P28 Issue 2 with those in the IEC 61000 series of Standards (or equivalent BS EN Standards, where they are published), where appropriate. Consequently, the Stage 1 flicker assessment in EREC P28 Issue 2 now aligns with the test requirements in BS EN 61000-3-3 and BS EN 61000-3-11, as applicable to the nature of the equipment and connection. In addition, methods for measuring and assessing voltage fluctuations from wind turbines now align with BS EN 61400-21. EREC P28 Issue 2 adopts requirements in BS EN 61000-4-15 in relation to flickermeters and BS EN 60868 for evaluation of flicker severity. Although consideration was given to IEEE Standards, the trend has been for these Standards to adopt requirements of IEC Standards in the area of voltage fluctuation, and hence reference to IEEE Standards was considered to be of limited value.

4.2.2 The Work Group reviewed how effective BS EN 61000-3-3 and BS EN 61000-3-11 are at controlling flicker for multiple LV installations. The review did not identify issues relating to planning limits being exceeded, where multiple equipment installations are installed on the same LV network, providing that individual equipment being connected complies with limits in BS EN 61000-3-3 or BS EN 61000-3-11, as appropriate, and that similar equipment is under independent control. EREC P28 Issue 2 now includes the requirement to consider the control of multiple equipment to prevent excessive voltage fluctuations.

4.2.3 The Working Group did not identify any technical standards or recommendations that would need to change as a result of any change to EREC P28 except for changes to relevant text in the Distribution Code, Grid Code and Engineering Recommendation G59 (see Section 6).

4.2.4 In light of the method in PD IEC TR 61000-3-7, planning levels and measurements of P_{st} and P_{lt} stated in EREC P28 Issue 2 are based on 95% probability values.

Limits

4.2.5 The planning levels for flicker severity at any point of the supply system are currently stated in Table 1 of Engineering Recommendation P28 Issue 1.

Table 1 of Engineering Recommendation P28 Issue 1

Supply system Nominal voltage	**Planning level**	
	P_{st}	**P_{lt}**
132 kV and below	1.0	0.8
Above 132 kV	0.8	0.6

4.2.6 The short-term flicker severity planning level (P_{st}) is currently 1.0 for supply systems with a nominal voltage of 132 kV and below. Given that the current planning level for these supply systems is the same as the low voltage (LV) compatibility level, the Working Group concluded there was opportunity to adjust the existing planning levels to improve the co-ordination of flicker transfer from higher voltage to lower voltage supply systems.

4.2.7 Table 2 of EREC P28 Issue 2 captures the Working Group's proposal for an intermediate planning level and associated flicker severity limits for supply systems with nominal voltages of 3.3 kV, 6.6 kV, 11 kV, 20 kV and 33 kV.

Table 2 of Engineering Recommendation P28 Issue 2

Supply system Nominal voltage	**Planning level**	
	P_{st}	**P_{lt}**
LV	1.0	0.8
3.3 kV, 6.6 kV, 11 kV, 20 kV, 33 kV	0.9	0.7
66 kV, 110 kV, 132 kV, 150 kV, 200 kV, 220 kV, 275 kV, 400 kV	0.8	0.6

4.2.8 This proposal is intended to improve the co-ordination of flicker transfer from higher voltage to lower voltage supply systems, which will reduce the possibility of background flicker severity levels exceeding compatibility limits at LV from the transfer of voltage fluctuations down through the supply system.

Rapid Voltage Changes (RVCs)

4.2.9 A key consideration for the Working Group was the introduction of new recommendations for assessment and limits for RVCs as distinct from separate flicker assessment and limits. Early meetings of the Working Group identified the need to address the omission of recommendations and limits for RVCs in Engineering Recommendation P28 Issue 1, particularly given the increased embedded generation connected to systems and the associated need to energise significant numbers of transformers, e.g. wind turbine transformers, with RVC characteristics from time to time.

4.2.10 The voltage envelopes for RVC events proposed by the Working Group in EREC P28 Issue 2 are replicated from EREC P28 Issue 2 (see Figure 5, Figure 6 and Figure 7). These limits take into account those in the recent GC0076 modification to the Grid Code.

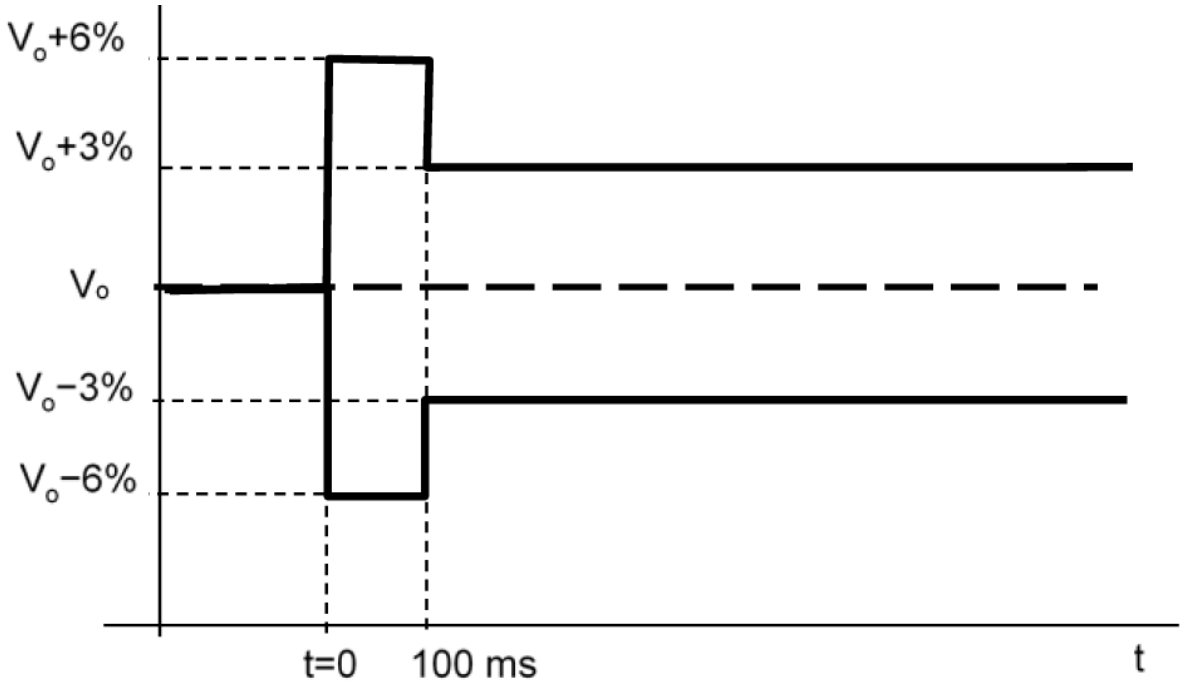

Figure 5 — Voltage characteristic for frequent events (Category 1)

4.2.11 The minimum interval between frequent events fitting within the envelope in Figure 5 is determined by conformance to flicker severity (P_{st}) limits in EREC P28.

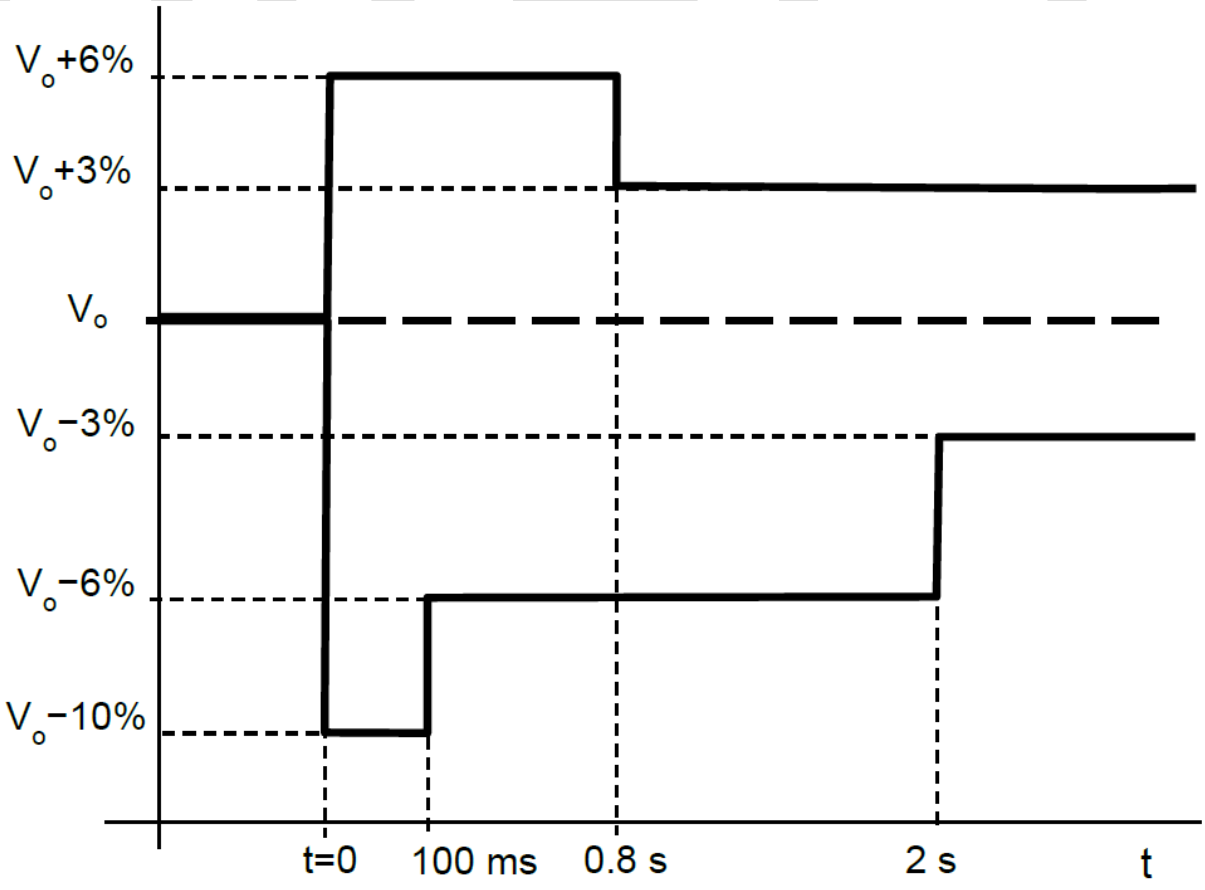

Figure 6 — Voltage characteristic for infrequent events (Category 2)

4.2.12 Up to 4 RVC events per calendar month are permitted for voltage fluctuations fitting within the envelope in Figure 6.

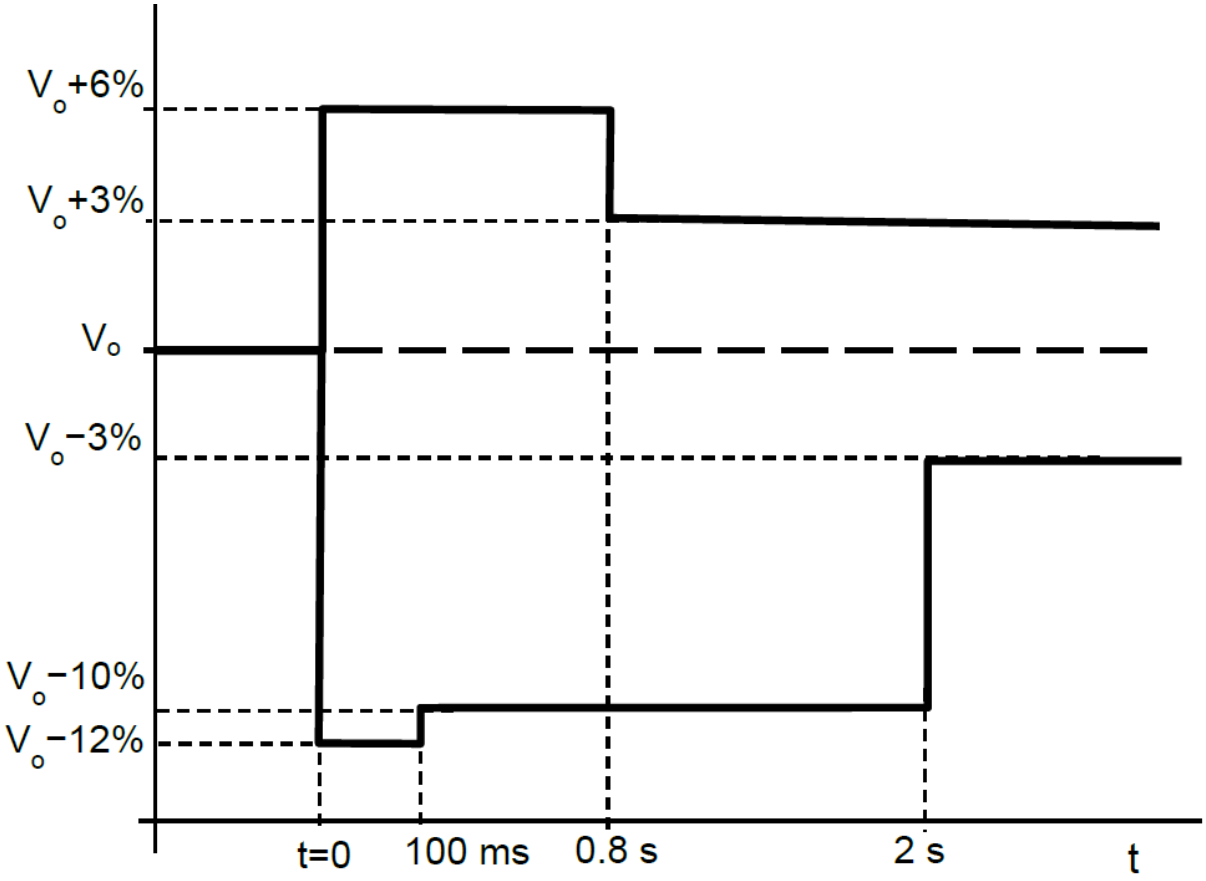

Figure 7 — Voltage characteristic for very infrequent events (Category 3)

4.2.13 The limits for RVCs proposed in EREC P28 Issue 2 take into account those in the recent GC0076 modification to the Grid Code. The key differences between the requirements in EREC P28 Issue 2 and those in the Grid Code are as follows.

- Allowable voltage changes are expressed as a percentage of nominal voltage (V_n) in P28 Issue 2 as opposed to a percentage of the initial voltage (V_o) in the Grid Code. The intention being to align with the approach taken in National and International Standards.
- For increases in voltage:
    - EREC P28 Issue 2 proposes a limit on the maximum voltage change between two steady state conditions of $\Delta V_{max} \leq 6\%$ for a maximum duration of 0.8 s from the initiation of a voltage change.
    - The Grid Code has a limit of $\Delta V_{max} \leq 5\%$ for a maximum duration of 0.5 s.
- For decreases in voltage:
    - EREC P28 Issue 2 proposes a time limit of 100 ms from initiation of a voltage change during which the maximum voltage change permitted (-12% for ‘very infrequent events’ and -10% for ‘infrequent events’) can persist.

- The Grid Code has a time limit of 80 ms from initiation of a voltage change during which the maximum permitted voltage change is -12%.

- For increases and decreases in voltage, EREC P28 Issue 2 permits a greater maximum number of occurrences for Category 3 'very infrequent' events:
  - EREC P28 Issue 2 proposes to permit up to a maximum of 4 RVCs in one day (irrespective of type of operational event causing the RVC) not more frequent than once every 3 months.
  - The Grid Code permits up to a maximum of 4 RVCs in one day (for commissioning, maintenance and fault restoration) typically not planned more than once per year on average over the lifetime of the connection.

- EREC P28 Issue 2 introduces an intermediate category of RVC (Category 2) for 'infrequent events', where up to a maximum of 4 RVCs in one day are permitted not more frequent than 4 times per month providing the $\Delta V_{max} \leq -10\%$ for ≤ 100 ms then reducing to ≤ 6% for up to 2 s after initiation of the event (see Figure 6).

4.2.14 Table 4, is replicated from EREC P28 Issue 2, which summarises the proposed categories, maximum number of occurrences within a defined time period, limits and examples of applicability for RVCs.

4.2.15 The proposed RVC limits in EREC P28 Issue 2 (and associated differences with the requirements in the Grid Code) reflect the:

- further work carried out by the Working Group and the experience of National Grid in applying RVC limits since the GC0076 modification was implemented in the Grid Code;
- limits for RVCs in Category 2 and Category 3 of Table 4 taking into account differences in the perceptibility of RVC compared with flicker associated with continuously fluctuating loads.

4.2.16 These proposals allow for a greater number of RVCs at any point in the system in a given calendar year on the basis they would be required to either be completed within a 2-hour time window or would be sufficiently spaced apart so as not to result in unacceptable disturbance. Such a modification is intended to facilitate disconnection and reconnection of complete customer sites with significant numbers of transformers for infrequent or very infrequent switching operations, including unplanned outages, with the ability to re-establish distributed generation more quickly after an unplanned outage, e.g. fault outage.

NOTE: DPC4.2.3.3 of the existing Distribution Code places a restriction of not more than one switching event per year for a single voltage change event up to 10% in magnitude. The proposal is to replace this code requirement with the planning levels for RVC in EREC P28 Issue 2.

4.2.17 The Working Group agreed that transformer magnetising inrush should be addressed in the scope of EREC P28 Issue 2. Provision for a simplified assessment of the magnitude of voltage dip caused by transformer energisation is now included in EREC P28 Issue 2. Similarly, the Working Group has provided guidance on the application of EREC P28 and data requirements for use in models/calculations of flicker severity and RVC. The intention is to highlight the sensitivity of voltage fluctuations to certain parameters and initial conditions used.

Table 4 — Planning levels for RVC

Cat-egory	Title	Maximum number of occurrence	Limits $\%\Delta V_{max}$ & $\%\Delta V_{steadystate}$	Example Applicability
1	Frequent events	(see NOTE 1)	As per Figure 5	Any single or repetitive RVC that falls inside Figure 5
2	Infrequent events	4 events in 1 calendar month (see NOTE 2)	As per Figure 6 $\lvert \%\Delta V_{steadystate} \rvert \leq 3\%$ For decrease in voltage: $\lvert \%\Delta V_{max} \rvert \leq 10\%$ (see NOTE 3) For increase in voltage: $\lvert \%\Delta V_{max} \rvert \leq 6\%$ (see NOTE 4)	Infrequent motor starting, transformer energisation, G59 [4] re-energisation (see NOTE 7)
3	Very infrequent events	1 event in 3 calendar months (see NOTE 2)	As per Figure 7 $\lvert \%\Delta V_{steadystate} \rvert \leq 3\%$ For decrease in voltage: $\lvert \%\Delta V_{max} \rvert \leq 12\%$ (see NOTE 5) For increase in voltage: $\lvert \%\Delta V_{max} \rvert \leq 6\%$ (see NOTE 6)	Commissioning, maintenance & post fault switching (see NOTE 7)

NOTE 1: ±6% is permissible for 100 ms reduced to ±3% thereafter as per Figure 5.
If the profile of repetitive voltage change(s) falls within the envelope given in Figure 5, the assessment of such voltage change(s) shall be undertaken according to the recommendations for assessment of flicker and shall conform to the planning levels provided for flicker.
If any part of the voltage change(s) falls outside the envelope given in Figure 5, the assessment of such voltage changes, repetitive or not, shall be done according to the guidance and limits for RVCs.

NOTE 2: No more than 1 event is permitted per day, consisting of up to 4 RVCs, each separated by at least 10 minutes with all switching completed within a two-hour window.

NOTE 3: −10% is permissible for 100 ms reduced to -6% until 2 s then reduced to -3% thereafter as per Figure 6.

NOTE 4: +6% is permissible for 0.8 s from the instant the event begins then reduced to +3% thereafter as per Figure 6.

NOTE 5: −12% is permissible for 100 ms reduced to −10% until 2 s then reduced to -3% thereafter as per Figure 7.

NOTE 6: +6% is permissible for 0.8 s from the instant the event begins then reduced to +3% thereafter as per Figure 7.

NOTE 7: These are examples only. Customers may opt to conform to the limits of another category providing the frequency of occurrence does not exceed the 'Maximum frequency of occurrence' for the chosen category.

Allocation of rights (Apportionment)

4.2.18 There was no evidence that the current ‘first-come, first-served’ approach in EREC P28 has resulted in any particular problems for stakeholders, e.g. voltage complaints, flicker headroom being used up.

4.2.19 Notwithstanding, the Working Group considered whether allocating flicker headroom for Stage 3 assessment, as described in PD/IEC/TR 61000-3-7, would be potentially simpler and fairer than the current approach. The pros and cons for maintaining the status quo versus a change in approach were considered. The Working Group concluded that there was no clear merit or justification for changing the ‘first come first served approach’, in particular given the low number of Stage 3 assessments carried out. The decision to retain the current policy of ‘first come first served’ was based on the following.

a) There is no compelling evidence to date that shows there are significant issues with the current ‘first come first served policy’ in practice; the application of the allocation method would appear to be a solution looking for a problem that doesn’t exist.

b) Experience in other countries that have adopted the allocation method in PD IEC/TR 61000-3-7, including Australia, suggests there are complexities and problems with applying it in practice, particularly to existing networks, and that a modified approach based on measurement of flicker background levels and allocation based on available headroom is required to address the short comings.

c) The allocation approach appears to have been taken up more in relation to transmission system operators than for distribution network operators, where there are a greater number of connections.

d) There are fairness arguments for both methods and it would be incorrect to say that the current ’first come first served’ method could be considered to be overwhelmingly unfair. There is not a compelling case to move to the allocation method on the grounds of fairness.

e) A move to an allocation method will be more complex technically and marginally more expensive commercially given that it will require more information and consideration for network operators and connectees than at present.

Background Measurements

4.2.20 The Working Group has now included guidance on background levels for flicker assessment, particularly where there is no measured data. In the absence of any data the flicker background level can be assumed to be P_{st} = 0.5 unless there is reason to believe the flicker background level might be greater than this value, in which case a direct site measurement should be carried out for the purposes of assessment.

4.2.21 The application of transfer coefficients in EREC P28 Issue 2 by the Working Group allows flicker background levels for new substations to be estimated from measurements at other locations in the electricity supply system by applying relevant transfer coefficients from adjacent nodes (see Table 3 of EREC P28 Issue 2 for typical transfer coefficients).

4.3 Changes to network codes

4.3.1 The impact of European Network Codes on EREC P28 was evaluated by the Working Group and no particular issues or conflicts were identified.

4.3.2 The Working Group recognised that EREC P28 Issue 1 provides somewhat contradictory statements with regards to which fault level should be used in Stage 2 and 3 assessments. In particular, whether planned outages of the system should be considered. The Working Group agreed that clear definitions of what should constitute normal operating conditions for assessment, should be provided including how credible outage conditions should be assessed.

4.3.3 Consequently, EREC P28 Issue 2 has been amended to provide improved clarity for the assessment of voltage fluctuations under the 'worst case normal operating condition' (see Clause 6.1.6 of EREC P28 Issue 2), which broadly aligns with the approach in PD IEC/TR 61000-3-7. Normal operating conditions for the supply system are now defined as those operating conditions, where the system/network is designed to operate and remain within acceptable/statutory limits. Table 6 of EREC P28 Issue 2 lists what should be considered normal operating conditions. These conditions include credible outage conditions (both planned and/or fault outages) consistent with securing demand as required by relevant security of supply standards, i.e. ENA Engineering Recommendation P2 for HV distribution networks and National Electricity Transmission System Security Quality of Supply Standards (NETS SQSS) for transmission systems. Notwithstanding, the limits in EREC P28 Issue 2 are not intended to apply to transient voltage fluctuations between fault initiation and fault clearance or during any reconfiguration of the public electricity supply system immediately following a fault to secure supplies.

4.3.4 The Working Group believe the improved definition of normal operating conditions in EREC P28 Issue 2 will provide a more consistent understanding and application of the network conditions by customers and system/network operators for EREC P28 type assessments and will address the lack of definition in the current EREC P28 Issue 1, which is not particularly clear in this respect and is open to interpretation. The Working Group believe the definition of normal operating conditions in EREC P28 Issue 2 are not unduly conservative and formalise good practices with respect to assessing voltage fluctuation.

4.4 Changes in connections and lighting technology

4.4.1 Although for a given voltage disturbance, illuminance variation may be less and therefore flicker may be less perceptible for certain types of modern lighting compared with traditional tungsten filament light bulbs, this response is not universal across all types of lighting technology. On this basis, the Working Group agreed that evaluation of flicker severity in EREC P28 Issue 2 should still be based on the standard flickermeter defined in IEC 61000-4-15 given there is insufficient evidence or industry consensus at present to adopt any changes to the design or function of the standard flickermeter.

4.4.2 The Working Group considered the assessment of LV equipment falling within the scope of BS EN 61000-3-11, where the customer is required to confirm that the network has sufficiently low impedance. After considerable discussions by the

Working Group the output was a revised Stage 1 assessment process in EREC P28 Issue 2, which provides the equipment manufacturer and customer with guidance and approaches to determining the value of supply system impedance and assessing whether this is sufficiently low for connection of equipment with a value of Z_{max} declared by the manufacturer.

4.4.3 The Working Group reviewed the process for assessing LV equipment subject to BS EN 61000-3-3, which is intended for unconditional connection. Although, this standard allows higher flicker levels than the EREC P28 Stage 2 limit at the supply terminals, the Working Group did not find any evidence that unconditional connection of multiple installations of similar equipment under Stage 1 in EREC P28 Issue 2 would pose an unacceptable risk of LV compatibility levels being exceeded at the point of common coupling, providing such equipment conforms to BS EN 61000-3-3 and is independently controlled. Guidance on this aspect is provided in Clause 6.3.2 of EREC P28 Issue 2.

4.5 Improved definition of voltage step change

4.5.1 The Working Group discussed the appropriateness of the general limit on the magnitude of voltage step changes of ±3%. The Working Group believes that this should not be changed to minimise the risk that voltage fluctuations will exceed statutory voltage limits.

4.5.2 However, EREC P28 Issue 2 now clarifies that the ±3% general limit relates to the voltage change between steady state conditions, referred to as $V_{steadystate}$, (see Clause 4.7 of EREC P28 Issue 2). Although EREC P28 Issue 2 does not place a limit on the time for transient decay, it requires that voltage changes must be within ±3% after 2 s from event initiation.

NOTE: Limits for voltage fluctuations in between steady state conditions (referred to as V_{max}) can be greater than ±3% for infrequent events and very infrequent events and fall under requirements for Rapid Voltage Changes in EREC P28 Issue 2.

4.5.3 The intention of this proposal is to allow a clear distinction between distinct different voltage change events.

4.5.4 EREC P28 Issue 1 was not clear whether voltage fluctuation was expressed as a percentage of the initial voltage (V_o) or the nominal voltage (V_n) of the system concerned. The Working Group discussed the need to provide clarity and agreed to align with the approach in the BS EN 61000 series of Standards, where the philosophy is to express voltage changes as a percentage of V_n. Analysis carried out by the Work Group confirms this is not expected to have a material impact on the voltage change limits in EREC P28.

5. Consultation Responses

Responses received from the Public Consultation

5.1 A Distribution Code public consultation took place from the 8th January 2018 to 31st January 2018 on the proposed modification to Engineering Recommendation P28. Industry stakeholders were invited to respond expressing their views or providing any

further evidence on any of the matters contained within the consultation document together with the rationale for their responses to the following questions.

Q1 Do you agree with the proposed requirements and planning levels for RVCs in EREC P28 Issue 2 (as provided in Figure 5, Figure 6, Figure 7 and Table 4 of EREC P28 Issue 2)?

Q2 Do you agree with the proposal for providing improved clarity of what constitutes 'worst case normal operating conditions' for the assessment of voltage fluctuations under EREC P28?

Q3 Do you agree with the proposals for an intermediate planning level to assist with co-ordination of the transfer of flicker severity from higher voltage to lower voltage supply systems?

Q4 Do you have any objections to the proposed amendments in EREC P28 Issue 2 as they currently stand? If so, please describe your concerns and if possible propose any alternatives.

Q5 Do you agree that the proposed modification proposal better facilitates the Distribution Code objectives?

Q6 Recognising that any consequential changes to the Grid Code will need to be progressed via the Grid Code governance process, the Working Group would welcome any concerns you have at this stage if the EREC P28 Issue 2 proposal was to be considered for adoption in the Grid Code?

Q7 Do you have any other comments to make on the proposed changes?

5.2 Four responses were received: 1 from a generator stakeholder, 2 from renewable energy stakeholders and 1 from a network operator stakeholder. A summary of the responses received and the subsequent response by the Working Group can be found in Annex 9.3 to this report.

5.3 Two of the four respondents were fully supportive of the proposals and had no objections to the proposed amendments in EREC P28 Issue 2 as they currently stand.

5.4 All four respondents agreed that the modification proposal better facilitates the Distribution Code objectives (see Question 5).

5.5 All four respondents also agreed with the proposals for providing improved clarity of what constitutes 'worst case normal operating conditions' (see Question 2) and the proposals for an intermediate planning level to assist with co-ordination of the transfer of flicker severity from higher voltage to lower voltage supply systems (see Question 3).

5.6 However, two of the respondents provided extensive comments in relation to the proposed requirements and planning levels for RVCs as provided in Figure 5, Figure

6, Figure 7 and Table 4 of EREC P28 Issue 2 (see Question 1). The responses to Question 1 related to the following.

a) The apparent setting of planning levels the same as operating levels for the higher categories of RVCs concerned one respondent because when the network is not operating correctly, equipment could be constrained off for long periods due to external events causing them to trip off.

   i) In response the Working Group believe there would be no realistic prospect of operation of the G59 undervoltage stage 1 protection for external RVC events that conform with the limits and requirements of EREC P28 Issue 2. Furthermore, the reference to "Commissioning, maintenance and post fault switching" in Table 4 of EREC P28 Issue 2 is an example of applicability. NOTE 7 in Table 4 states that these are examples only and that customers may opt to conform to the limits of another category providing the expected frequency of the events do not exceed the maximum frequency permitted for the chosen category. Commissioning, maintenance or post fault switching activities could be classed as Category 1, Category 2 or Category 3 events depending upon the maximum number of occurrences foreseen for those events.

      a. Subsequent to their initial response the Working Group would point out that Table 4 of EREC P28 Issue 2 refers to planning levels for RVCs, which should be used for design and planning of connections. Whilst design pre-connection should be based on an expected number of both planned and unplanned RVCs over specified time periods to comply with Table 4, it is recognised that Users do not have control of the number of actual unplanned RVC events, including G59 trips, that could occur post connection.

b) One respondent believes that the requirements in Table 4 of EREC P28 Issue 2 are more onerous than CC.6.1.7 of the Grid Code under certain circumstances and that designing for the maximum number of occurrences permitted for Category 2 and Category 3 events in EREC P28 Issue 2 could have cost implications for developers. In addition, that the maximum number of 4 RVCs per day permitted in Category 2 and Category 3 of EREC P28 Issue 2 is impractical for re-energising wind farms based on one wind turbine transformer being energised at a time.

   i) In response, the Working Group do not believe the requirements in EREC P28 Issue 2 are more onerous than Category 2 of Grid Code CC.6.1.7. The time and voltage magnitude limits for Category 3 RVCs shown in Figure CC.6.1.7 of the Grid Code when compared with Figure 7 of EREC P28 Issue 2 confirm that both the time and voltage limits in EREC P28 Issue 2 for Category 3 very infrequent events (not more than 4 RVCs in 1 day providing less frequent than once every 3 calendar months) are less onerous than those for Category 3 RVCs in the Grid Code.

   ii) Regarding the maximum number of 4 RVCs permitted per day under Category 2 and Category 3 of P28 Issue 2. The respondent has assumed only one wind turbine transformer can be energised at a time. EREC P28

Issue 2 does not preclude more than one wind turbine transformer being energised at the same time. The intention of the limits in Category 2 and Category 3 is to allow several transformers to be energised at any one time whilst complying with the applicable limits.

iii) In their response, the Working Group pointed out that the limits in Table 4 of EREC P28 Issue 2 and the associated amendments to the Distribution Code have been carefully chosen to allow a greater number and magnitude of RVC type voltage fluctuations than is currently permitted whilst not posing an unacceptable risk of voltage complaints from other customers connected to the system. It would not be acceptable to increase the RVC limits proposed for Category 2 and Category 3 events in EREC P28 Issue 2 simply to avoid the need for disturbing equipment connectees to mitigate unacceptable voltage fluctuations caused by the energisation of their equipment, where these fluctuations could cause an unacceptable risk of interference to other customers.

iv) The Working Group would also point out that the changes in EREC P28 Issue 2 are a significant relaxation compared with the current requirements in DPC4.2.3.3 of the Distribution Code, which only permits a voltage depression of -10% not more frequently than once per year for energisation of transformers, as a result of post fault switching, post maintenance switching, or carrying out commissioning tests. On this basis, the P28 Working Group is of the opinion that the requirements in Table 4 of EREC P28 Issue 2 should not be relaxed for Category 2 and Category 3 as proposed by the respondent.

5.7 In response to Question 4 concerning any objections to the proposed amendments in EREC P28 Issue 2 as they currently stand.

a) Both respondents referred to their response in Question 1 concerning the proposed requirements and planning levels for RVCs.

5.8 In response to Question 6 concerning the adoption of EREC P28 Issue 2 requirements into the Grid Code.

a) One respondent was concerned that assets could be sitting for long periods of time without generating power as indicated in answer to Q1 representing a major loss of revenue for a windfarm owner/developer.

i) The Working Group believes that the limits and maximum number of occurrences for rapid voltages changes permitted in EREC P28 Issue 2 are less onerous than those in the Grid Code. The intention of the planning levels for rapid voltage changes in EREC P28 Issue 2 are to provide more flexibility for generators, who need to energise large numbers of wind turbine transformers, than currently exists in the Grid Code. The Working Group trusts that their response to Q1 allays these concerns and that there would be no objection to ultimately adopting the relevant limits and requirements from EREC P28 Issue 2 in the Grid Code.

b) Another respondent was concerned that the categories in Table 4 of EREC P28 Issue 2 are different to those in CC.6.1.7 of the Grid Code, which could cause confusion. In particular that the permitted frequency of events for Category 3 in Table 4 of EREC P28 Issue 2 appears to be more onerous than CC.6.1.7 of the Grid Code.

i) The response from the Working Group highlights that although the categories of RVC events in EREC P28 Issue 2 and the Grid Code have similar numbers, e.g. 'Category 3', the titles, maximum number of occurrences and limits are different. This reflects the further work carried out by the Working Group and the experience of National Grid in applying RVC limits since the GC0076 modification was implemented in the Grid Code. Notwithstanding, the intention is to align the categories in the Grid Code with those in EREC P28 Issue 2, which would avoid confusion.

ii) With respect to Category 2 and Category 3 events in EREC P28 Issue 2: Under both Category 2 & Category 3, one event is permitted in a given day, where one event can consist of up to 4 separate RVCs (see NOTE 2 of Table 4). Therefore, up to 4 RVCs in a given day are allowed under both Category 2 & Category 3 of Table 4 [EREC P28 Issue 2], which is similar to the maximum of 4 RVCs per day permitted in Category 3 of the Grid Code. The difference being that the permitted occurrence of RVC events in EREC P28 Issue 2 is more frequent (less onerous) than Category 3 of the Grid Code. Category 3 of the Grid Code permits a maximum of 4 RVCs per day typically not planned more than once per year on average over the lifetime of a connection compared with 4 events (each event consisting of up to 4 RVCs) per calendar month for Category 2 events in EREC P28 Issue 2 and 1 event (consisting of up to 4 RVCs) every 3 calendar months for Category 3 events in EREC P28 Issue 2. On this basis the Working Group believes that EREC P28 Issue 2 provides for a greater number of RVCs in any given time period than is currently permitted in the Grid Code. The intention is to provide Users, including generators, with more flexibility for energising transformers than currently exists in the Grid Code.

c) A respondent was concerned that limits for the maximum number of occurrences over a particular time period as stated in Table 4 of EREC P28 Issue 2 appear to be more stringent than those in CC.6.1.7 of the Grid Code and do not allow for operational problems. The wording in CC.6.1.7 states: "…typically not planned more than once per year on average…", whereas EREC P28 Issue 2 does not have such wording.

i) With respect to the application of the wording "…typically not planned more than once per year on average over the lifetime of a connection…" in CC.6.1.7 (a) (viii) of the Grid Code. The Working Group believes the limits and maximum number of occurrences for RVCs in the Grid Code apply to both design and operation of the system. Although the requirements in EREC P28 Issue 2 primarily relate to the design and assessment of connections, the P28 Working Group does not intend for any particular difference in the application of associated aspects of EREC P28 Issue 2

and the Grid Code. The P28 Working Group would point out that EREC P28 Issue 2 acknowledges that the final decision as to whether or not disturbing equipment exceeding the limits in EREC P28 Issue 2 may be connected to the system is at the discretion of the relevant system/network operator (see Lines 276-280) in EREC P28 Issue 2.

a. Subsequent to their initial response the Working Group would like to clarify that EREC P28 Issue 2 is a planning document. Whilst design at the pre-connection stage should be based on an expected number of both planned and unplanned RVCs over specified time periods to comply with planning levels in Table 4, it is recognised that Users do not have control of the actual number of unplanned RVC events, including G59 trips, that could occur post connection; these could be greater in number than the expected number allowed for in the design. Table 4 of EREC P28 Issue 2 does not restrict the number of unplanned events that happen post-connection in the network, given network Users cannot control these events, e.g. where G59 protection trips due to voltage or frequency events in the network. However, if the number of actual events proves to be unacceptable to other network Users to the extent that 'interference' is caused then the system/network operator would be required to act under Regulation 26 of the Electricity Safety Quality & Continuity Regulation (ESQCR) and may judge that mitigation is needed in a reasonable time period.

5.9 In response to Question 7 concerning any other comments:

a) One respondent commented that is surprising after the description in the introduction [EREC P28 Issue 2] of the importance for restricting flicker to stop customer annoyance and complaints that the same requirements do not apply to all equipment by exempting licenced Distribution and Transmission Operators, given their equipment will be very similar.

i) In response the Working Group pointed out that the scope of EREC P28 Issue 1 applies to voltage fluctuations caused by industrial, commercial and domestic equipment connected to the system. The terms of reference for the revision of EREC P28 Issue 1, as set by the Joint Distribution Code and Grid Code Review Panels, was for EREC P28 Issue 2 to remain a 'customer facing' document and for any overarching application of requirements and limits in EREC P28 to be contained within the Distribution Code. Notwithstanding, the Working Group, as part of their Terms of Reference, has sought to be fair and even-handed in the application of requirements taking into account the different operating context and objectives of Users and network operators.

b) The same respondent also noted there is a reference to current version P28 figure 4 in the SQSS and EREC P28 Issue 2 replaces the original figure 4 with figure B.1.2 and asked for confirmation whether these are the same and whether the SQSS will be corrected?

i) The Working Group note the acknowledgment in the SQSS that EREC P28 Issue 1 Figure 4 was used in the derivation of Figure 6.1 'Maximum Voltage Step Changes Permitted for Operational Switching'. Figure B.1.2 in EREC P28 Issue 2 is intended to replace Figure 4 in EREC P28 Issue 1 but has been aligned with the current flicker severity curve in Figure A.1 of PD IEC/TR 61000-3-7 – except that the curve has been deliberately capped at a maximum symmetrical step voltage change of 3% once every 475 s. Consequently, the curve in Figure B.1.2 in EREC P28 Issue 2 differs from that in Figure 4 of EREC P28 Issue 1 and Figure 6.1 of the SQSS. The P28 Working Group recommend that Figure 6.1 in the SQSS is reviewed in light of the current flicker severity curve in Figure A.1 of PD IEC/TR 61000-3-7 and the aligned Figure B.1.2 in EREC P28 Issue 2.

Responses received outside the Public Consultation

5.10 A response was received outside the official public consultation process concerning interpretation of Clause 5.4 Step voltage change limit (lines 835-842). The respondent believes the clause might need re-phrasing as, unless it was intended to do so, it currently states that voltage fluctuations greater than 3% in magnitude should not cause interference where the shape of the voltage characteristic is equivalent to a step change less than or equal to 3%. In other words, a voltage fluctuation of 5% should not cause interference if the disturbing equipment is ramped up/down over a period that will correspond to a step change equivalent figure (using the shape factors) of less than 3%.

a) In response, the Working Group would like to clarify that the general limit on the magnitude of voltage step changes is ±3%. This general limit equates to the maximum change in steady state voltage ($V_{steadystate}$) from the initial voltage to the resulting voltage level. For frequent events that need to be assessed for flicker the voltage characteristic should not exceed the envelope in Figure 5 of EREC P28 Issue 2. On this basis a 5% voltage fluctuation that is ramped up/down over a period but it expected to occur frequently would not be acceptable even though the equivalent step voltage change derived using the appropriate shape factor corresponds to an equivalent step voltage change of less than 3%.

In order to avoid misinterpretation with the requirements in EREC P28 it is proposed to delete lines 840 to 842 inclusive of EREC P28 Issue 2

~~840 Voltage fluctuations greater than 3% in magnitude should not cause interference where the~~
~~841 shape of the voltage characteristic is equivalent to a step voltage change less than or equal to~~
~~842 3% (see 6.3.3.4) or is of sufficiently low frequency of occurrence (see 5.2.2).~~

6. Impact & Assessment

6.1 Impact on the Distribution Code and Grid Code

6.1.1 The revision of EREC P28 Issue 2 materially affects DPC4.2.3.2 (Voltage Disturbances) and DPC4.2.3.3 (Voltage Step Changes) of the Distribution Code. The Working Group recommends the changes to the legal text of the Distribution Code, Issue 32 – 01 August 2018 contained in Annex 9.4 of this report.

6.1.2 The Working Group also recommend that the requirements of CC.6.1.7 of the Grid Code are aligned with those in EREC P28 Issue 2. The Grid Code Review Panel are proposing the legal text changes to the Grid Code as a separate code modification.

6.2 Impact on Distribution Code Users

6.2.1 The proposed modification provides Users with improved clarity of requirements concerning assessment and measurement of voltage fluctuations, in particular, the definition of what constitutes 'worst case normal operating conditions' for assessments. The respective responsibilities of Users and system/network operators in the assessment process are better defined, which is expected to allow for a more consistent application of EREC P28 requirements by system/network operators.

6.2.2 The proposed planning levels for RVC, whilst allowing for a greater number and magnitude of RVC type voltage fluctuations than is currently permitted is not considered to pose an unacceptable risk of voltage complaints from other Users connected to the system.

6.2.3 The proposal for an intermediate planning level and adjustment of associated flicker severity limits for supply systems with nominal voltages of 3.3 kV, 6.6 kV, 11 kV, 20 kV and 33 kV will improve the co-ordination of flicker transfer from higher voltage to lower voltage supply systems. This is expected to reduce the possibility of background flicker severity levels exceeding compatibility limits at LV from the transfer of voltage fluctuations down through the supply system.

6.2.4 The modifications are intended not to unduly impact on or cause interference to existing Users of public electricity systems/networks.

6.3 Impact on embedded generators

6.3.1 The proposed modification to the Distribution Code will allow embedded generators to plan for a greater number of RVCs at any point in the system in a given calendar year than currently exists in EREC P28 Issue 1 and the Distribution Code. The intention of the modification is to facilitate disconnection and reconnection of complete customer sites with significant numbers of transformers for infrequent or very infrequent switching operations, including unplanned outages, with the ability to re-establish distributed generation more quickly after an unplanned outage, e.g. fault outage.

6.4 Impact on National Electricity Transmission System (NETS)

6.4.1 The proposed changes to the RVC voltage envelopes arising from Figure 5, Figure 6 and Figure 7 of EREC P28 Issue 2 are expected to have a minimal impact on the NETS compared with those in CC.6.1.7 of the Grid Code. Under EREC P28 Issue 2 the maximum no. of occurrences of RVCs would change from typically 4 RVCs in one day (for commissioning, maintenance and fault restoration) typically not planned more than once per year on average over the lifetime of the connection to 4 RVCs in one day not more than once per three months. Whilst this increases the number of planned RVCs permitted per year these will be sufficiently spaced apart so as to minimise any potential disturbance to customers connected at PCCs. No impact is

foreseen regarding notification of Category 3 events, which still require notification to NGET.

6.4.2 The NETS SQSS uses EREC P28 Issue 1 Figure 4 in the derivation of Figure 6.1 'Maximum Voltage Step Changes Permitted for Operational Switching'. Figure B.1.2 in EREC P28 Issue 2 replaces Figure 4 in EREC P28 Issue 1 so that the curve has been deliberately capped at a maximum symmetrical step voltage change of 3% once every 475 s compared with once every 600 s previously. The Working Group would recommend that Figure 6.1 in the NETS SQSS is reviewed in light of the current flicker severity curve in Figure A.1 of PD IEC/TR 61000-3-7 and the aligned Figure B.1.2 in EREC P28 Issue 2. If the SQSS were to be subsequently modified on this basis it would permit more voltage step changes of a given magnitude of 3% over a given time period than is currently allowed now.

6.5 Assessment against Distribution Code Objectives

6.5.1 The proposed amendments would better facilitate the following applicable Distribution Code objectives:

(a) permit the development, maintenance, and operation of an efficient, co-ordinated, and economical system for the distribution of electricity.

i) The proposals provide improved clarity of voltage fluctuation requirements for Users wishing to connect to public electricity supply systems. The proposals facilitate improved co-ordination of planning levels for flicker related voltage fluctuations and RVCs down through voltage levels to minimise the risk of compatibility levels being exceeded at LV.

ii) The proposals allow Users to have a greater number and magnitude of RVC type voltage fluctuations over a year than is currently permitted in P28 Issue 1 and the Distribution Code. This provides Users with greater flexibility on how they design their equipment/connection to meet voltage fluctuation limits and how they can avoid costs with providing additional equipment to reduce the magnitude of voltage fluctuations.

(b) facilitate competition in the generation and supply of electricity

i) The proposals are expected to facilitate connection of embedded generation, which may otherwise not be connected to the system because of the limits on the magnitude and number of voltage fluctuation events permitted in DPC.4.2.3.3 of the current issue of the Distribution Code, in relation to the energisation of complete sites with a significant presence of transformers.

(c) efficiently discharge the obligations imposed upon distribution licensees by the distribution licences and comply with the Regulation and any relevant legally binding decision of the European Commission and/or the Agency for the Co-operation of Energy Regulators.

i) The proposals align requirements in EREC P28 Issue 2 with provisions for voltage fluctuations in the relevant series of BS EN 61000 standards. so

far as considered relevant and suitable by the Working Group. The proposals are intended to comply with the requirements for voltage fluctuations in the proposed European Network Codes.

(d) promote efficiency in the implementation and administration of the Distribution Code.

i) The proposals allow detailed requirements in DPC.4.2.3.3 of the Distribution Code concerning fluctuations to be addressed in EREC P28 Issue 2. The intention is to avoid any conflict between the Distribution Code and EREC P28.

6.6 Impact on core industry documents

6.6.1 The proposed modifications to EREC P28 and the Distribution Code impacts on requirements in clauses 9.5.7 to 9.5.11 inclusive of Engineering Recommendation G59. These clauses refer to limits and requirements in EREC P28 that have been modified under these proposals. In essence, minor text changes are required to align with EREC P28 Issue 2.

6.6.2 In addition, Clause 3.2 of Engineering Recommendation G59 will need to be amended to reflect the modified title of EREC P28.

6.6.3 As stated in 6.4.2 of this report Figure 6.1 'Maximum Voltage Step Changes Permitted for Operational Switching' in the NETS SQSS is possibly impacted should the decision be taken to align this with the new Figure B.1.2 in EREC P28 Issue 2.

6.6.4 The proposed modification does not affect any other core industry documents.

6.7 Implementation

6.7.1 The Working Group confirms there are no reasons why implementation should be unduly delayed and recommends that the proposed changes be implemented from 1st August 2018, or other such date as the Authority might agree to. The proposed date for implementation has been chosen to follow other modifications that pre date EREC P28 Issue 2 and to coincide with proposed Issue 32 of the Distribution Code.

6.7.2 In accordance with DGC11.2 of the Distribution Code:

(a) the proposed changes in EREC P28 Issue 2 are not intended to apply retrospectively to Equipment already existing at the date of implementation of the Distribution Code change.

(b) any material changes to Equipment after the date of implementation will need to comply with the requirements of EREC P28 Issue 2.

7. Working Group Recommendations

7.1 The recommendations of the Working Group are as follows.

a) EREC P28 Issue 2 as it was consulted upon is accepted subject to the following specific amendments.

i) Clause 5.3.2 Planning Levels (Line 765-767):

"The planning levels in Table 4 define absolute limits of maximum voltage change (ΔV_{max}) and steady state voltage change ($\Delta V_{steadystate}$) for RVCs according to the maximum number of occurrences ~~permitted~~ expected within a specified time period."

ii) Table 4 Note 7:

"These are examples only. Customers may opt to conform to the limits of another category providing the frequency of occurrence ~~does~~ is not expected to exceed the 'Maximum frequency of occurrence' for the chosen category."

iii) Clause 5.4 Step voltage change limit (Lines 840-842)
~~"Voltage fluctuations greater than 3% in magnitude should not cause interference where the shape of the voltage characteristic is equivalent to a step voltage change less than or equal to 3% (see 6.3.3.4) or is of sufficiently low frequency of occurrence (see 5.2.2)."~~

b) The proposed requirements and planning levels for RVCs in EREC P28 Issue 2 (as provided in Figure 5, Figure 6, Figure 7 and Table 4 of EREC P28 Issue 2) are implemented.

c) The definition of 'worst case normal operating conditions' and associated requirements for assessing these conditions in EREC P28 Issue 2 are accepted.

d) The intermediate planning level and associated flicker severity limits for supply systems with nominal voltages of 3.3 kV, 6.6 kV, 11 kV, 20 kV and 33 kV is accepted to improve the transfer of flicker severity from higher voltage to lower voltage supply systems.

e) The proposed changes to the legal text of the Distribution Code, Issue 32 – 01 August 2018 as documented in Annex 9.4 to this report are implemented.

f) The relevant clauses in Engineering Recommendation G59 that refer to limits and requirements in EREC P28 are aligned with the proposed amendments in EREC P28 Issue 2.

g) Proposed changes to the legal text of the Grid Code are drafted and progressed via the Grid Code governance process to align with the proposals in EREC P28 Issue 2.

h) Figure 6.1 in the NETS SQSS is reviewed in light of the current flicker severity curve in Figure A.1 of PD IEC/TR 61000-3-7 and the aligned Figure B.1.2 in EREC P28 Issue 2.

8. Distribution Code Review Panel Recommendation

8.1 At the meeting of the Distribution Code Review Panel (the Panel) held on 05/04/2018, the Panel unanimously agreed to the submission of the Report to Authority as the Panel agreed that the Modification proposal better facilitated the objectives of the Distribution Code.

9. Annexes

9.1 Working Group Terms of Reference

Please see the separate attachment to this report titled ‘Annex 9.1_DCRP/PC/18/01/RtA’

9.2 Public Consultation Pack for Revision of EREC P28

Please see the separate attachment to this report titled ‘Annex 9.2_DCRP/PC/18/01/RtA’

9.3 Responses to the Public Consultation for Revision of EREC P28

Please see the separate attachment to this report titled ‘Annex 9.3_DCRP/PC/18/01/RtA’

9.4 Proposed changes to the legal text of the Distribution Code

Please see the separate attachment to this report titled ‘Annex 9.4_DCRP/PC/18/01/RtA’