Transmission Capital

Application of P28 in Operational Timescales

1 INTRODUCTION

The purpose of this short paper is to seek the STC Panel's guidance on the requirements for compliance with Engineering Recommendation P28 in operational timescales, particularly where energising cable circuits.

P28 is entitled "Voltage fluctuations and the connection of disturbing equipment to transmission systems and distribution networks in the United Kingdom". This document was first issued by the ENA in 1989 and has been extensively updated, with revision 2 being issued in May 2019. P28 is incorporated into the Grid Code as CC6.1.7.

STC Section D, Part 1 Clause 2.2.6 requires that in **planning and developing** its Transmission System, each Transmission Owner (which includes Offshore Transmission Owners) shall ensure that its Transmission System complies with the minimum technical, design and operational criteria and performance requirements set out or referred to in Connection Conditions 6.1, 6.2, 6.3 and 6.4. This is also referenced in STC Section K 1.2.

Hence TOs must plan / design their systems to be compliant with P28. TOs should also plan and develop their transmission systems to be compliant with the SQSS. The ESO's Licence Condition C17 also requires that at all times it shall "co-ordinate and direct the flow of electricity onto and over the national electricity transmission system, in accordance with the National Electricity Transmission System Security and Quality of Supply Standard"

The point in question is whether P28 is an operational standard and hence applicable in all timescales or only used in design / planning timescales.

Why is this important? It is important because the two documents deal with voltage fluctuation from circuit energisation in different ways. CC6.1.7 essentially establishes an absolute limit from t=0, allows no transient overshoot, and considers no automatic mitigating actions to limit the size of the step change; as such the size of the step change is essentially driven by the size of the uncompensated element of cable being switched in; and, the system fault level. The SQSS on the other hand considers the step change at the end of the transient time phase; after the action of fast acting automatic controls such as generator AVRs and SVC controllers.

Transmission Capital has been in discussion with ESO regarding the future operation of an OFTO connection to a particularly weak area of the onshore transmission system. The offshore system has been designed to be compliant with CC6.1.7. However, it is possible to foresee circumstances where under operational conditions such as outages or low system fault levels, energisation of an export cable may not be compliant with CC 6.1.7, but would be perfectly acceptable when applying the SQSS criteria, providing that local SVCs and other fast acting devices are in service.

The STC Committee is asked to provide guidance on whether the requirements of STC Section D, Part 1 Clause 2.2.6 in regard to the application of CC6.1.7 should be met in operational timescales or whether there by inference the criteria of SQSS Section 6 should be applied.

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2 ENGINEERING RECOMMENDATION P28 AND GRID CODE CC6.1.7 – A DESCRIPTION.

Energisation of an export cable is classified as a very infrequent event in terms of CC6.1.7.

The requirements are set out in the diagram below:

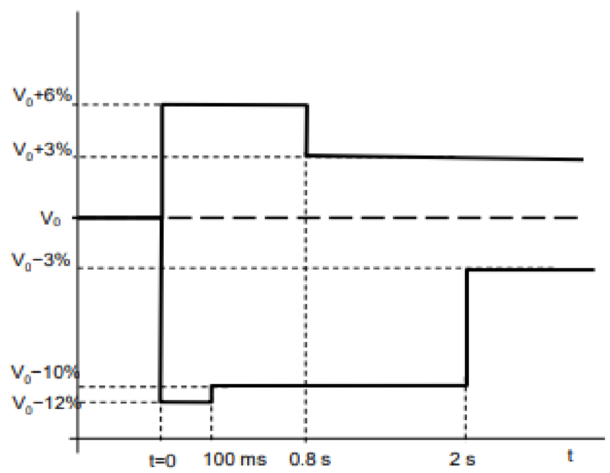

Figure CC.6.1.7 (3) — Voltage characteristic for very infrequent events

As can be seen, for energisation, the +6% upper limit is absolute, there is no relaxation (unlike the transient -12% for 100mS). This means that the response of fast acting devices such as AVRs or SVC controllers cannot be considered, as there will always be some finite time for the controller to react. (even though these devices typically react in <50mS). Energisation of highly capacitive circuits (this could also include MCSs) is therefore very onerous when considered against CC 6.1.7. Whilst mitigations such as point on wave switching will help, the step change is largely driven by the net capacitance and system fault level. Unlike the ER G5 Harmonic Voltage Distortion standard, P28 contains no compatibility levels to deal with operational conditions encountered which are outwith the design criteria.

Offshore transmission systems frequently have long cable circuits which are compensated by teed shunt reactors, such that the MVAr gain of the cable seen at energisation is reduced. The design of offshore networks is complex, both in terms of the need to meet STC Section K at the onshore interface, but also to optimise the means of meeting the static and dynamic reactive power requirements internally to the system. Long export cables, particularly at 220kV, can generate in excess of 300MVArs and it is usual to compensate at least partially with shunt reactors. Siting all the shunt reactors onshore can lead to high export cable loadings at the shore landing, (which is often the deepest buried section and hence has the lowest rating), hence this can drive significant export cable costs. Siting reactors offshore helps this at the expense of a larger and heavier platform to accommodate the reactor(s). Utilising the WTG converters to absorb MVArs is often beneficial as the capability

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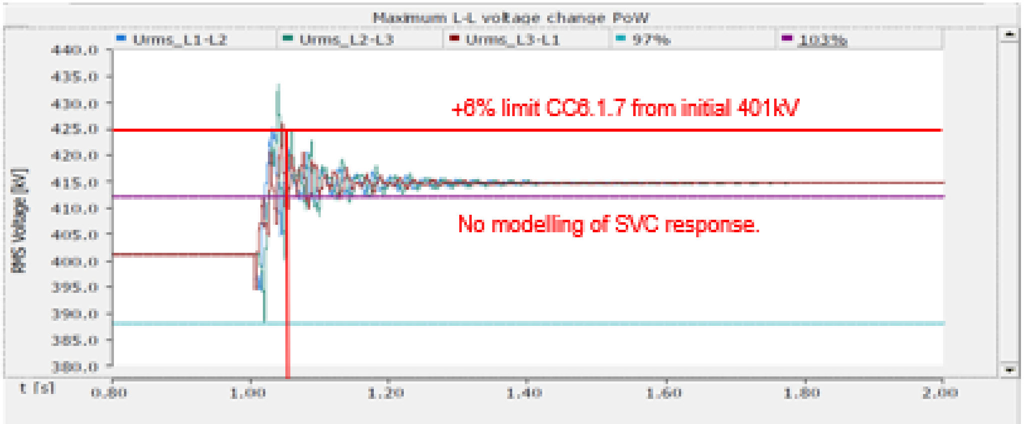
is inherent, but it isn't available during energisation. Highly compensated export cables present a very onerous duty on switchgear due to the "missing zero" phenomenon. Hence significant optimisation is needed to derive the overall most economic / technical solution, but it should be considered that the cost of this equipment is many tens of million pounds.

As the purpose of ER P28 is principally to address the irritation to Users caused by observed flicker and does not impinge on any equipment or system technical capabilities, the implications of potentially incurring many millions of pounds of additional capex to mitigate a very infrequent and very short duration exceedance needs very careful consideration. It should also be considered that applying the P28 criteria in operational timescales will also bring the requirement for specialist time domain power system studies, which are not normally considered practical in such timescales, due to the complexity of the model and specialist skills required to run them.

An example an energisation that is non-compliant with CC 6.1.7 is shown below:



It can be seen that the exceedance is very short lived.

Looking at a trace from a real-life energisation (in this case CC6.1.7 would just be met) the mitigating effects of local fast acting voltage control plant can be seen. The instantaneous step is 5.4%, but the voltage is only above 3% for 23mS, within 40mS the voltage has returned very close to the pre-switching level.

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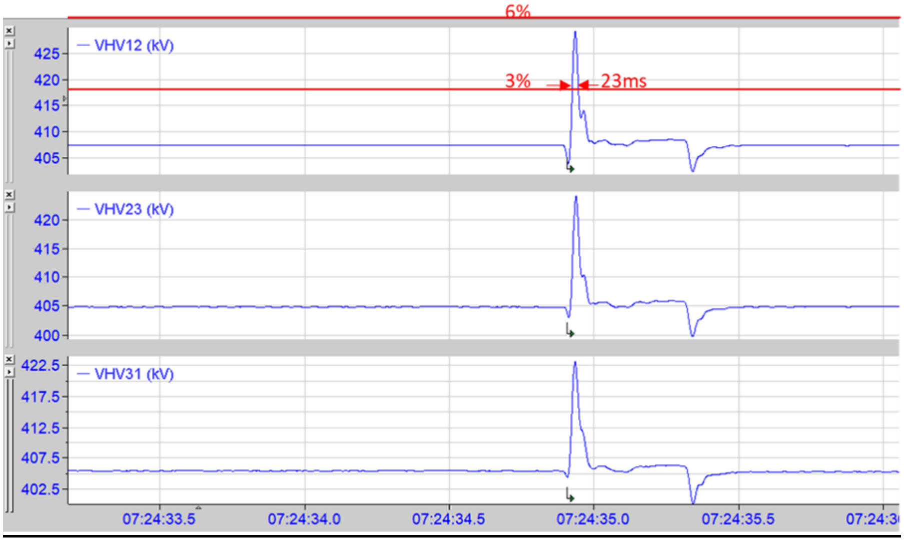

3 THE SQSS

Chapter 6 of the SQSS covers the voltage limits in planning and operating the onshore transmission system. Whilst the energisation concerns an offshore transmission system, it is the impact on the onshore transmission system that is being considered. The steady state voltage limits as set out in SQSS Chapter 10 Voltage Limits in Planning and Operating an Offshore Transmission System are all met.

The SQSS step change allowance for infrequent operational switching is +6% onshore at an interface with a User. In the case in consideration, there is currently no user connected, so under the SQSS, no specific limits would apply, provided steady state voltage limits could be maintained. However, should a User connect in future, Step Change is defined as after the transient time phase, in other words after the impact from all fast, automatic response. This definition for Step Change is understood to be a long-standing definition presumably based on a sound technical basis of the impact on equipment or Users.

Table 6.5 Voltage Step Change Limits in Planning and Operational Timescales

Type of Event	Voltage Fall	Voltage Rise
(a) At substations supplying *User Systems* at any voltage		
1. Following *operational switching* at intervals of less than 10 minutes	In accordance with Figure 6.1	
2. Following *operational switching* at intervals of more than 10 minutes, 3. except for *infrequent operational switching* events as described below	-3%	+3%
4. Following *infrequent operational switching* ***(Notes 8, 9)***	-6%	+6%
5. In planning timescales, following a *fault outage of a double circuit supergrid* overhead line ***(Note 10)***	-6%	+6%

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Voltage Step Change	The difference in voltage between that immediately before a *secured event* or operational switching and that at the end of the *transient time phase* after the event.
Transient Time Phase	The time within which fault clearance or initial system switching, the transient decay and recovery, auto switching schemes, *generator* inter-tripping, and fast, automatic responses of controls such as *generator* AVR and SVC take place. Load response may be assumed to have taken place. Typically 0 to 5 seconds after an initiating event.

It is understood GSR0025 is anticipated to implement the P28 issue 2 changes into the SQSS (Go-live April 2021), but no change on the allowable step change is proposed or revision to the SQSS methodology regarding study at the end of the transient time phase.

One can see through these definitions how a step change could be comfortably compliant with SQSS in operational timescales but not meet CC6.1.7 for the same event.

4 ARE THE GRID CODE CCS A DESIGN AND OPERATIONAL REQUIREMENT?

STC Section D 2.2.6 requires that:

Without limitation to Section C, Part One, paragraph 2.2, in **planning and developing** its Transmission System, each Transmission Owner shall ensure that its Transmission System complies with:

2.2.6.1 the minimum technical, design and operational criteria and performance requirements set out or referred to in Connection Conditions 6.1, 6.2, 6.3 and 6.4 and in Planning Code 6.2 and/or 6.3 as applicable; or

2.2.6.2 such other technical criteria or requirements as apply to any relevant part of its Transmission System by virtue of a current Transmission Derogation; and in the case of an Offshore Transmission System, each Transmission Owner shall also ensure that:

2.2.6.3 its Transmission System meets the minimum technical, design and operational criteria and performance requirements set out or referred to in Section K of this Code;

STC Section C 2.2 states:
Each Transmission Owner agrees with NGET to provide Transmission Services and to plan, develop, operate and maintain its Transmission System in accordance with its Transmission Licence and this Code, subject to any Transmission Derogations from time to time. In the case of Construction Projects that involved OTSDUW, it is acknowledged that a User may have undertaken some or all of the original planning

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and/or development of the Transmission System.

Hence it is reasonable to conclude that compliance with CC6.1.7 is not a requirement in operational timescales. This is consistent with the decision reached by the Committee regarding compliance with Section K in Operational Timescales in June 2013.

5 VIEWS OF THE STC MODIFICATION PANEL

The views of the STC Modification Panel are requested to confirm that the following understanding is correct.

a) STC Section D 2.2.6 applies to a TO in planning and developing its Transmission System, hence the requirements of CC 6.1.7 and P28 apply as design and not operational standards.
b) Therefore, by inference, the requirements of the SQSS in respect of voltage limits for infrequent switching apply in operational timescales.