Informative Note on Motivation and Drivers for TSOs' Requirement for Electromagnetic Transient Models

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Note on Electromagnetic Transient Models

This document has been prepared following discussions at the Joint Grid Code Review Panel where members requested information on the TSOs' requirement for electromagnetic transient (EMT) capable models. The document aims to identify the events that the TSOs consider to require EMT study. The document is intended to inform the User of the motivation and drivers for requiring EMT models of the Users Plant.

As specified in Grid Code, the User must provide models suitable for balanced, root mean-square, positive phase-sequence, time-domain studies and unbalanced, three-phase, electromagnetic transient (EMT) simulations. The model for three-phase EMT simulations shall represent phenomena that materially affect the Voltage and Frequency at the Connection Point over timeframes of sub-cycles up to 500 cycles. The model shall not require a simulation time step of less than 0.1ms.

The motivation for requiring an EMT model is to ensure stability of the Users Plant for unbalanced phenomena including single-phase and unbalanced short circuit faults, equipment energisation and ferroresonance. Recently the TSOs have had to perform such studies more frequently than has been traditionally been required. A reason that the requirement for such analysis has increased is partly due to the connection of non-conventional power electronic driven generation such as modern Wind Farm Power Stations (WFPS) and Interconnectors. Types of events and phenomena that require EMT study that the TSOs consider are described below.

Energisation and Switching Studies

At times during the operation of the system the TSOs are required to energise transmission equipment such as long overhead lines, cables, transformers or capacitor banks. Similarly, at the planning stage the TSOs need to assess the impact of introducing equipment to an area which may result in transient events on the system. Energisation of such equipment can result in transients on the system that may materially affect the performance and stability of a Users Plant. This may be of particular concern when the equipment in question is in close proximity to the Users Plant.

Phenomena that may result from energisation of transmission equipment are temporary over-voltages, temporary under-voltages and ferroresonance. All of these phenomena can affect and be effected by the equipment in a Users Plant and therefore to ensure safe and secure planning and operation of the Power System the TSOs must perform the relevant simulations. In such analysis unbalanced, three-phase, EMT simulations are required.

Power System Restoration Analysis

The TSOs of Ireland and Northern Ireland are tasked with restoring the All-Island Power System in the event of a disturbance causing complete or near complete blackout of the Power System. Power System Restoration is the method that the TSOs follow in the event of such an incident occurring. The TSOs prepare for this process through the testing of relevant Generators and equipment. Such tests include the energisation of equipment along an isolated path which begins at a particular Generator and typically concludes with energising block load or a subsequent Generator.

Prior to performing restoration tests on the real system it is of paramount importance for the TSO to perform technical analysis. This analysis typically involves investigating the stability of particular generators during the energisation of equipment along the restoration path. This analysis is typically concerned with phenomena including those mentioned above.

Time Domain Unbalanced Disturbance Studies

System disturbances on the system and their potential impact on the stability of system are of particular interest to the TSOs. Unbalanced system disturbances are much more common than balanced faults and they also pose their own challenges to the system. Examples of unbalanced disturbances include single-phase to ground, phase-phase and phase-phase to ground faults.

Simulations to investigate the impact of unbalanced disturbances can be performed to investigate the stability of the Users Plant to such events. It is also of importance to the TSO to monitor the contributions of Plant when interrogating unbalanced faults on the system. Dynamic performance of system protection relays is a further area that must be analysed by the TSO and in order to perform such analysis unbalanced, three-phase, simulations are required. The dynamic performance of relays used for differential, impedance and anti-islanding protection can be assessed through unbalanced, three-phase simulations.

Another unbalanced disturbance that must be considered by the TSO is lightning impulse events. Events of this nature must be analysed using unbalanced EMT simulations. This analysis is usually conducted to determine the ratings required for equipment such as surge arrestors at the planning stage.

Circuit Breaker Re-closing and System Islanding Studies

The Transmission System has a number of circuit breakers and protection schemes that allow for re-closing of the breaker after a fault has been cleared on the system. The purpose of such schemes is to return the system to a normal mode of operation as quickly and safely as possible once the fault has been cleared. In addition to three-phase circuit re-close systems there are also single-pole re-close systems being introduced across the system. In order to assess the impact of such schemes on the stability of a particular Users Plant it is required that unbalanced, three-phase simulations are performed.

In particular areas of the network it is possible that at certain times some Units may be temporarily isolated from the system in an island fashion during a system disturbance and these events can cause instability of the Unit if a breaker were to re-close. Therefore, it is also important to consider the effect that islanding and subsequent re-closing may have on the stability of the Unit.