To Whom It May Concern,

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In response to AEMO's "Consultation on NER S5.2.5.10 Guideline - Protection to trip for unstable operation" please find below EPEC Groups feedback to the key questions asked:

1. **Opportunities and/or challenges that exist for implementing a suitable protection system to meet the S5.2.5.10 access level requirements, for example, available technology and areas requiring further development.**

Following EPEC's review of proven technology locally and abroad we have been unable to identify a broad implementation of a protection system to trip plant for unstable operation, especially for asynchronous generating units. The early adoption of this system will require a collaborative approach between the market operators, network service providers and generators/developers. It is important to manage the implementation of this new technology and mitigate the impact on project schedules, (for example, by not binding the implementation to specific project milestones).

From our literature review between 2007 to 2021 worldwide, there were 19 subsynchronous oscillation incidents in power grids with high penetrations of inverter-connected sources, according to available publications. This statistical data indicates this area needs further investigation. There are known implementations using phasor measurements to identify oscillations in power systems dominated by the synchronous generating units. The frequency of oscillation in those systems was lower compared to oscillation noticed in a system dominated by asynchronous generating units. During some incidents, the oscillations were noticed in instantaneous voltages and currents with frequencies of 37 Hz, 63 Hz and 82 Hz. In our opinion a broad solution to the problem (development of the protection to trip plant for unstable operation) needs to incorporate an addition to the existing RMS-based identification of the oscillation and identification in instantaneous voltages and currents.

Accuracy and processing time has been found to be a dominant problem of existing systems (RMS based) for identifying undamped small signal oscillations. The complexity of the technology will increase with the need for processing the instantaneous voltages and current.

2. **Clarity of the S5.2.5.10 access standard requirements, including how unstable operation is defined, conditions that are considered unstable and how they are assessed in accordance with the Power System Stability Guidelines.**

Clarity of clause S5.2.5.10 Protection to trip plant for unstable operation needs to be improved. There is no definition of unstable operation in the Glossary - National Electricity Rules. Consequently, understanding the unstable operation is open to different interpretations. At the same time, the definition needs to be implemented in Power System Stability Guidelines. We noticed that the definition still is missing in the Draft Power System Stability Guidelines.

Instead of the unstable operation, we suggest using the term adequately damped. This term is defined in the Glossary of the National Electricity Rules. Definition of the adequately damped is also suitable for

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meaningful scaling of the level of the negative impact of the noticed undamped oscillations on the power system and generating unit.

The frequency at the connection point of the generator needs to be measured in addition to the voltage, active and reactive power.

The frequency could be used in conjunction with active power to confirm that the broader power system event initiates the oscillation of the active power and that the generator only contributes to damping the oscillations of the existing frequency in the system.

This is very similar to the analysis of the interaction recommended for voltage and reactive power of the generating unit.

Definition of 'adequately damped' published in Glossary of the National Electricity Rules does not consider the amplitude of the oscillations.

Very often, the oscillating component of the frequency, voltage, active power and reactive power have very small amplitudes compared to the amplitude of the entire signal. In the case of active and reactive power, it could be a tenth or a hundredth part of the MW or MVAr compared to hundreds of MW, MVAr of the entire signal. In the case of frequency, some known modes usually have amplitude in the domain of mHz.

The minimum amplitude of the undamped oscillation must be agreed upon to ensure that noticed oscillations are not artefacts of the measurements or calculation methodology. Undamped oscillations below the agreed value should be neglected.

The S5.2.5.10 minimum access standard does not appear to be aligned to the automatic access standard requirements. The NER still refers to AS/NZS 61000.3.7:2001 which was superseded some time ago, the current standard is AS/NZS 61000.3.7:2012.

According to the S5.2.5.10 clause and AS/NZS 61000.3.7:2001, minimum access is defined as emission limits for voltage changes with the number of changes listed per hour. The clause's definition for the highest frequency of voltage change, <1000 changes per hour (<0.27Hz), limits the changes' amplitude to 1% of the nominal voltage, for example.

These shortfalls of the existing clause S5.2.5.10 leave it open to different interpretations of the clause and broad misalignment of interpretation and intent within industry.

3. **The approach to develop, agree, implement and commission a suitable protection system with the NSP and AEMO, including consideration of nearby plant and their interaction/contribution (desired or undesired) to unstable operation.**

The complexity of the renewable generating units makes them more susceptible to a broad spectrum of oscillations. Oscillations could originate at any stage of the energy conversion from tracking the maximum power extraction point, controlling active, reactive power or supporting power system. Differently from synchronous generating units, high harmonic components originating in instantaneous voltage and currents could interact with RMS values of the positive sequence. While there is a high potential risk of development of the oscillations, there is no rich history of the incidents in this domain.

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The protection system should not cause unnecessary tripping or should not cause an excessive considerable number of false alarms.

While during the development and commissioning of renewable plants, there are more cases of undamped oscillations seems that most of the issues have been resolved before final acceptance and putting the generator into service.

A suitable protection system needs to be developed and tested intensively before broad implementation to ensure that the protection system is not a new, more significant source of problems.

The National Measurement Institute (NMI) is Australia's peak measurement body with capabilities to test and evaluate characteristics of the protection systems; it seems very useful to involve the Institute in developing and prototype testing the novel protection system.

AEMO and NSP should prepare the improved S5.2.5.10 access standard requirements as the first step for developing the future protection device. The improved version of the S5.2.5.10 clause should clearly define the requirements and characteristics of the protection device, avoiding multiple interpretations and understanding of the clause.

While there is the potentially broad availability of devices with capabilities and characteristics which could be used as the foundation for the protection device, none of the devices was tested for specific tasks and conditions required by clause S5.2.5.10.

It seems that most of the needed components for the protection devices already exist, and there is no need for pioneering in the development of a new methodology; however, integrating the different elements to achieve the accuracy and response time of the protection device could be challenging.

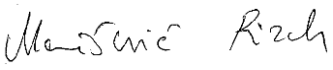
It is worth mentioning that small signal oscillations have some similarities with this issue; there is a long history in this domain, and some of the experiences from this domain should be used and implemented in the solution of this problem.

The protection device should use all means to minimise unnecessary tripping or alarming. Consequently, a comparison of the angles between voltage reactive power, frequency and active power should be used to distinguish generating units that are generating oscillations from those that are damping oscillations.

Analysis of interaction between nearby plants in real-time will require costly fast communication networks and could be hard to gain broad support.

However, there is a genuine need to make data captured during contingencies or periods when some oscillations were noticeable in the power system available to all involved plants, generators or loads.

Kind regards,



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