

# Technical Feasibility of Power System Stabiliser (PSS) Compliance in Engine Power Plants

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EUGINE, the association of European engine power plant manufacturers, emphasises that the European Commission, Transmission System Operators (TSOs), and regulators, should acknowledge that, for engine power plants connecting to the high-voltage (HV) grid, demonstrating full compliance with Power System Stabiliser (PSS) requirements through testing may not be technically feasible. Therefore, clear derogation procedures or adapted requirements should be considered to ensure these units can continue safe and efficient operation without undue penalisation.

Addressing this issue is critical in maintaining a diverse and flexible energy mix, supporting decarbonisation goals and ensuring fair treatment of engine power plants technologies. Without pragmatic adjustments, units of this technology face disproportionate technical and economic burdens that could limit their contribution to the HV grid.

## Main Messages

1. Typical PSS testing methods may not be technically feasible for engine power plants because these plants exhibit inherent damping characteristics, including lower inertia compared to gas turbines and different natural frequencies.
2. The upcoming Network Code on Requirements for Grid Connection of Generators (NC RfG) should consider a PSS testing method that reflects the different damping behaviours of various technologies. A suggested amendment is [provided in Annex 1](#).
3. In the interim, Regulators and TSOs should provide adapted testing requirements or clear derogation pathways.

## Situation Analysis: Technical Limitations of PSS Functionality in Low-Inertia Units

The performance of PSS is closely linked to the inertia of the generating units, as well as to the amplitude and frequency of resulting oscillations and the short circuit power of the system. The PSS functionality is required when connecting to HV systems with a much higher short-circuit contribution capability, creating specific challenges for testing engine power plants. Gas turbines, which are much bigger in size than engine power plants, typically have significant local mode oscillations which can be effectively damped by a PSS. In contrast, low-inertia engine power plants with lower power output have difficulties demonstrating the damping of oscillations when activating the PSS function due to the low amplitude of power change compared to gas turbines.

Furthermore, the need for PSS functionality differs significantly between gas turbines and engine power plants. Low-inertia engine power plants exhibit inherently well-damped oscillations even without a PSS, as local mode oscillations in these units are already minimal. As a result, there is little room for additional damping.

## Fundamental Frequency Range Challenges

Engine power plants face a technical challenge due to their low mechanical inertia and their inherent characteristics as prime movers. This combination creates higher system eigenfrequencies compared to gas turbine-driven units. Engine power plants typically exhibit eigenfrequencies in the range of 2-5 Hz, while gas turbine systems operate in the 1-2 Hz range.

The PSS functionality must damp inter-area oscillations across a frequency range from approximately 0.3 Hz up to 5 Hz. This extended frequency range for engine power plants is substantially broader than the 0.3 to 2 Hz range typical for gas turbine systems, effectively requiring coverage of twice the frequency spectrum. The wider the frequency range that must be addressed, the more difficult the PSS tuning becomes.

PSS controllers need to provide appropriate phase shift to counteract power oscillations effectively. However, with an extended frequency range, maintaining the optimal phase relationship becomes increasingly difficult as the phase compensation cannot remain constant across the entire spectrum. At certain frequencies, the phase shift may deviate significantly from the ideal 90-degree compensation, reducing PSS effectiveness. The configuration commonly used in the industry cannot maintain optimal phase compensation across such an extended frequency range.

## Modern AVR Design and Limitations

Traditional PSS implementations utilised two lead-lag compensation stages. Modern Automatic Voltage Regulators (AVRs) from manufacturers have increased this to four lead-lag stages specifically to address the wider frequency range challenges. While this improved configuration is more appropriate for the extended frequency range of engine power plants, it represents a fundamental trade-off: the broader the frequency range that must be covered, the more complex the tuning becomes and the less effective the damping may be at specific frequencies.

Even with these updated PSS functionalities, the inherent nature of the engine power plants continues to impede optimal PSS performance. No comprehensive solution has been proposed by AVR manufacturers to fully address this fundamental limitation.

## System Noise and Verifications Challenges

Engine power plant technology exhibits higher inherent noise levels in the low-frequency range relevant for PSS demonstration. Compared to gas turbine systems, these characteristics can make testing and validation more challenging.

The verification process for PSS requires exciting the system and then demonstrating effective damping. However, when the overall system noise level is high relative to the excitation signal amplitude, it becomes difficult to clearly distinguish the PSS damping effect from the background noise. This challenge is particularly acute for engine power plants connected to power grids with high short-circuit power, where the limited response magnitude of the unit becomes obscured by the high noise floor.

In the low frequency regions where PSS verification must occur, the injected test signal must be sufficiently large to be observable above the system noise. However, operational constraints and grid connection requirements often limit the amplitude of permissible excitation signals. The combination of

a stiff grid and high system noise makes it difficult to adequately excite the system to demonstrate effective damping within acceptable operational limits.

## Excessive Damping Requirements and Grid Code Conflicts

Attempting to meet absolute PSS damping requirements, such as those specified in certain grid codes which mandate a defined damping factor relative to the first swing, often necessitates setting excessively high PSS gains. Such high gains can introduce disturbances or instability, conflicting with other operational requirements and potentially compromising overall system stability under normal operating conditions.

Simulation studies confirm that for engine power plants, increasing the PSS gain to meet specific grid code thresholds does not meaningfully improve damping and is technically unnecessary from a system stability perspective. This demonstrates that applying standard PSS requirements designed for high-inertia units to low-inertia engine power plants is both impractical and unjustified.

## Recommendations

### 1. Adapted or Alternative Requirements

Grid codes should provide alternative compliance demonstration measures or adapted requirements for engine power plants, reflecting their inherently well-damped behaviour. In this context, [please refer to the Annex](#) for EUGINE's suggested amendments to ACER's NC RfG Recommendation currently discussed within DG ENER.

### 2. Performance-Based Damping Evaluation (Instead of Absolute Gain or Damping Factor)

For engine power plants, strict test application of uniform AVR + PSS criteria may lead to technically unrealistic or unnecessary configurations. Instead of prescribing a fixed damping ratio (e.g.,  $\zeta \geq 0.1$  or a 20% increase after the first swing), the criterion should evaluate whether the PSS improves the system damping compared to the baseline without it.

### 3. Acknowledgement of Verification Methods Limitations

TSOs and regulators should recognise that engine power plants may not be able to demonstrate full compliance with PSS testing requirements due to inherent characteristics including higher system eigenfrequencies, extended frequency range requirements, elevated system noise levels, and inherently high natural damping that limits observable PSS contribution. The test methods themselves may be executed however, the key issue is their limited effectiveness in evaluating PSS damping performance in engine power plants technologies.

### 4. Encourage Further Dialogue

The European Commission, TSOs, and regulators, should continue to investigate appropriate PSS criteria for engine power plants to ensure grid stability without imposing disproportionate burdens, including consideration of alternative verification methodologies which better accommodate the technical characteristics of these units.

## Annex 1: EUGINE’s Proposed Amendments to ACER’s NC RfG Recommendation for the European Commission’s NC RfG

	ACER’s NC RfG Recommendation	EUGINE’s Recommendation
Article 19 (2)(b)(iii)	a PSS function to attenuate power oscillations, if the synchronous power-generating module size is above a value of maximum capacity specified by the relevant TSO. The PSS shall have the capability to damp inter-area power oscillations in the frequency range of, at least, 0,1 Hz – 1,0 Hz. The relevant TSO shall have the right to request and approve the tuning of the PSS by the power-generating facility owner to damp the inter-area oscillation mode based on frequency ranges specified by the relevant TSO in coordination with adjacent TSO or TSOs. The relevant TSO shall have right to request the tuning of the PSS by power-generating facility owner to damp the local oscillation mode, in which the synchronous power-generating modules is oscillating against the network.	a PSS function to attenuate power oscillations, if the synchronous power-generating module size is above a value of maximum capacity specified by the relevant TSO. <b><i>The relevant TSO shall take into account the technical characteristics of the prime mover technology when establishing capacity thresholds and verification requirements.</i></b> The PSS shall have the capability to damp inter-area power oscillations in the frequency range of, at least, 0,1 Hz – 1,0 Hz. The relevant TSO shall have the right to request and approve the tuning of the PSS by the power-generating facility owner to damp the inter-area oscillation mode based on frequency ranges specified by the relevant TSO in coordination with adjacent TSO or TSOs. The relevant TSO shall have right to request the tuning of the PSS by power-generating facility owner to damp the local oscillation mode, in which the synchronous power-generating modules is oscillating against the network.
Article 53 (2)		Proposed addition as new paragraph (d)  <b><i>(d) Where on-site commissioning tests for PSS verification are demonstrated to be technically infeasible due to inherent characteristics of the synchronous power-generating technology, compliance may be demonstrated through alternative means as agreed between the power-generating facility owner and the relevant system operator, in coordination with the relevant TSO. Such alternative means shall include simulations pursuant to points (a) to (c), supplemented by factory acceptance testing, equipment certificates from authorised certifiers, or equivalent analytical methods providing comparable assurance of PSS functionality.</i></b>

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