TAMING THE POWER
ABB Review series

Taming the power

Advanced control is achieving high availability and performance by mastering complex instability

ALF ISAKSSON, SILVIA MASTELLONE – A modern-day power system represents an increasingly complex engineering process – from generation, across transmission, distribution and power conversion, to the loads that convert the electric energy into a useable form. Every link of such a network contains heterogeneous dynamic subsystems that interact in complex ways. Predicting and controlling their individual and collective behavior is a major challenge, yet one that needs to be mastered in order for the network to be operated at an optimum defined by economic, reliability and safety requirements. ABB Review presents a series of articles looking at potential instabilities that arise in different stages of the electromechanical power system and the role of computation methods in controlling them.

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Many fields of technology are experiencing an extraordinary increase in complexity being brought about by technological advances. The electromechanical power system is no exception. Once a system has been successfully designed, its operational boundaries are pushed for even higher performance.

Rising complexity in this context manifests itself primarily in two ways: (i) the high degree of interconnectivity of components and (ii) the heterogeneous nature of the components and the diverse timescales of their behaviors. These effects are compounded by the increased demand for faster dynamics, as well as the reduced size and weight of components brought about by technological advances.

To yield a stable operation, the hardware and control design are normally performed at the individual subsystem level. However, once the subsystems are interconnected the stability properties do not necessarily carry over to the whole system.

In fact, interactions between subsystems may lead to a poorly damped system response as well as undesired oscillatory behavior.

Such instability may express itself in ways ranging from mild derating of performance to severe system-wide shutdown.

For example, operational instability in the electrical network of an oil and gas plant may lead to a plant-wide trip that results in an irrecoverable loss in production. Another example relates to power oscillations in the transmission grid that can lead to extreme consequences, including a total power blackout.

It is precisely these complex scenarios that call for detailed, system-wide analysis and control designs meeting high performance criteria. In fact, an intelligent control design enables optimal system-wide operation at the physical limits without introducing any additional physical inertia that would slow down the system response and increase costs.

A key aspect that leads to smarter control design is the ability to perform detailed system analysis and develop a deep understanding of the system behavior in a steady state as well as during dynamic transients. Moreover, the available computational resources and actuation capabilities need to be taken into account. Traditionally, advanced methods required substantial computational resources that often prevented their applicability. However, with ongoing progress in the computational capabilities of control platforms, these advanced methods can now be applied.

ABB Review is launching a series of articles looking at electrical and mechanical oscillations and the advanced numerical methods of taming them across the entire electromechanical power network. The series will include the areas of power generation, distribution, low- and medium-voltage conversion, and mechanical loads and processes. This series is furthermore intended as an update on the research and development activities performed by ABB to enable continuous power availability and enhanced productivity.

The following article looks at oscillations in medium-voltage power converters. Further articles in upcoming issues of ABB Review will explore the other stages of the electromechanical power network.

Title picture

Oscillations are inherent in every technical system of a certain complexity. Engineers need to understand their behavior to ensure the stability of the overall system is maintained. The title picture shows the Golden Gate Bridge (United States).

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