Model-in-the-loop Testing of Flexible-Bus Conductors Interconnecting Substation Equipment

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Seismic performance of electrical substation equipment is of paramount importance to avoid power outages and economic losses, and to ensure efficient post-earthquake response. Significant progress had been made towards improving seismic performance of such equipment through the development of recommended practices for design, such as IEEE 693 and IEEE 1527, and by implementation of seismic protective systems such as base isolation. However, there are still unresolved questions pertaining to dynamic response of substation equipment, one of which is the influence of interconnection through flexible bus conductors. Dynamics of flexible conductors are highly nonlinear, and not well understood. Current recommended design practices to account for interaction are therefore developed to be very conservative, and often become impractical for the power industry to follow. This work is part of a larger project aimed at quantifying flexible conductor dynamics and interaction of interconnected equipment.

The scope of this work, within the larger project, is to develop a model-in-the-loop (MIL) test system to represent substation equipment interconnected by flexible conductors. The conductor is tested physically, while the equipment are represented by computer models running in real-time. The interface conditions are enacted by a specially-designed equipment simulation. The main contribution of this work is application of a new algorithmic approach that makes such a test system feasible. MIL enables performing an extensive parametric study by varying dynamic characteristics of equipment, so that mathematical models of conductor nonlinear dynamics can be validated over a broad range of conditions.