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Digital twins of electric machines

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Digital twins are used in industrial processes to improve and optimize physical devices using simulations and real-time data [1]. In this talk, we discuss the challenges and limitations facing the development of a digital twin for electric machines [2].

To achieve its purpose, a digital twin requires accurate and real-time simulations of the physical device. The derivation of these models from physical laws like Maxwell equations provides sound mathematical basis. However, these models generally bring a computational burden that render real-time simulations impossible. A solution to this problem is the use of model order reduction [3] to obtain simulations that are fast and accurate enough to be used in a digital twin. Alternatively, one may use surrogate and data-driven modeling to obtain fast calculation models that can be readily constructed and adapted based on the data coming from the physical asset. This results in a hierarchy of models that can be implemented in the digital twin and used based on the application.

Electric machines are multiphysics systems that involve physical phenomena from three main fields: electromagnetic, mechanical and thermal fields. Their coupling is needed to obtain an overall simulation model that preserves the physical meaning of each submodel while being computationally efficient. Port-Hamiltonian (pH) systems [4] provide such a framework that can work across different physical domains and scales. In this work, we discuss how pH systems can help in the development of digital twins for electric machines.

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