Efficient Design of Dynamic Smart Structures by Combining Network Methods with Finite-Element Methods

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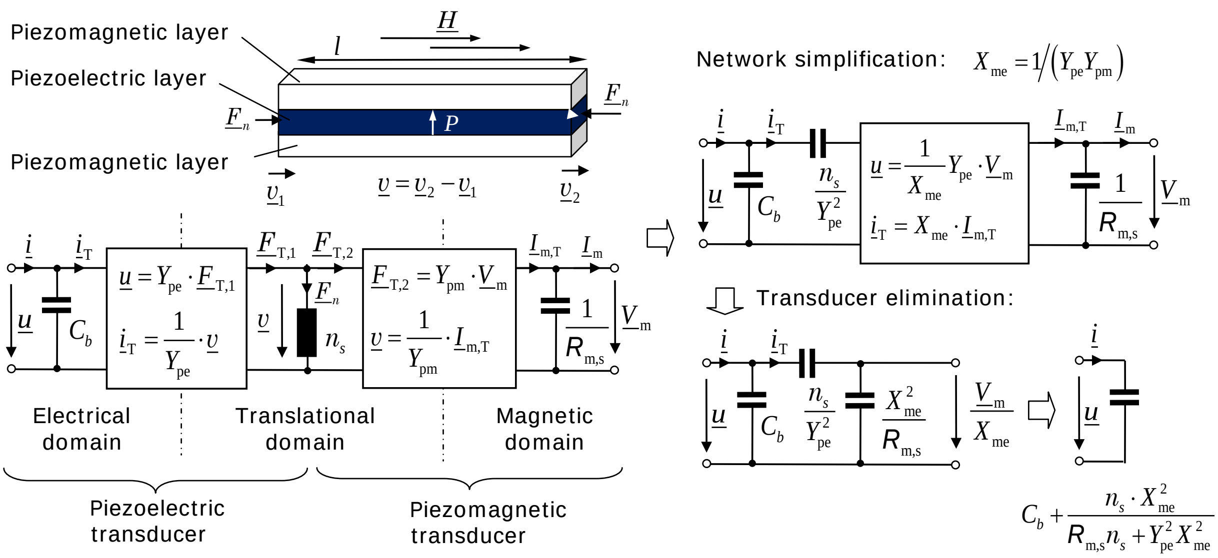
The modeling and simulation of smart structures and systems involves coupled field calculations which requires currently high computational costs. Especially time and frequency analyses of sensor or actuator constructions described by equation systems with 10,000 to several 100,000 degrees of freedom demand efficient design methods. A successful approach to solve this problem is to increase the abstraction in a model hierarchy by switching to macro models. In the talk the merits of multi-physics network models applied as macro models are discussed. The main advantage is the significant reduction of the degree of freedom and the transition to ODEs from PDEs. Another important aspect appreciated by design engineers is the structural graphical system representation offered by networks. Particularly, feedback mechanisms, e.g. from acoustic subsystems into the mechanical subsystem, can be overviewed. Moreover, linear time-invariant (LTI) multi-physics networks allow the transformation of network elements from one physical domain into another domain. As a consequence transducers can be eliminated and thus the network be simplified. Besides this, passive LTI systems are reciprocal. This property is the basis of precise measurement techniques.

The example below shows the network model of a magneto-electric transducer and the transformations of the compliance and magnetic reluctance into the electrical domain in order to calculate analytically the resulting capacitance. More examples are discussed in detail in [1].



[1] U. Marschner, R. Werthschützky: Aufgaben und Lösungen zur Schaltungsdarstellung und Simulation elektromechanischer Systeme – In Mikrotechnik und Mechatronik, Springer-Verlag Berlin Heidelberg 2015