Energy based network modeling, numerical simulation, and control of multi-physics systems

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Most real world dynamical systems consist of subsystems from different physical domains, modelled by partial-differential equations, ordinary differential equations, algebraic equations, combined with input and output connections. To deal with such complex system, in recent years the class of dissipative port-Hamiltonian (pH) systems has emerged as a very efficient modeling methodology. The main reasons are that the network based interconnection of pH systems is again pH, Galerkin projection in PDE discretization and model reduction preserve the pH structure and the physical properties are encoded in the geometric properties of the flow as well as the algebraic properties of the equations. Furthermore, dissipative pH system form a very robust representation under structured perturbations and directly indicate Lyapunov functions for stability analysis.

We discuss dissipative pH systems and describe how many classical models can be formulated in this class. We illustrate some of the nice algebraic properties, including local canonical forms, the formulation of an associated Dirac structure, and the local invariance under space-time dependent diffeomorphisms.

We illustrate the results with some real world examples.