ABSTRACT. In this presentation we provide an overview of our recent work in developing energy- and power-based control methods for nonlinear systems, with a particular emphasis on electrical and mechanical systems.

In the last decades different nonlinear control techniques have been developed to deal with many types of nonlinearities. However, nonlinear control design often relies on an exact description of the system dynamics. It is well-known that such a description is difficult to obtain, hence, robustness against modeling uncertainties has to be considered. This presentation deals with energy-based and power-based control design of physical systems. Both are nonlinear control design methods based on shaping the energy function and the mixed-potential function of a system, respectively, into a desired form. The energy-based control method is based on systems described in port-Hamiltonian form, originally stemming from mechanical systems considerations, while the power-based method is based on systems described in Brayton-Moser form, which is a framework that is originally developed for electrical networks. One of the contributions of this presentation is to improve the robustness of the fairly recent energy- and power-based control methods by extending them with integral and adaptive control design methods. Integral action is well-known to compensate for steady-state errors caused by unknown disturbances or model uncertainties. Adaptive control compensates for errors caused by uncertainty in the system parameters, by estimating the real parameter values. Furthermore, adaptive control offers advantages for tracking control, where the reference signal is constantly changing. The integral and adaptive control methods are described in such way that the port-Hamiltonian or the Brayton-Moser structure is preserved for the closed-loop system. Both modeling frameworks have a clear physical structure with advantages for system analysis and control design, which explains why it is desired to preserve the particular structure. Canonical transformations are shown to be a useful tool in both the Brayton-Moser and port-Hamiltonian setting.

In many cases nonlinear control also depends on full-state feedback. Mechanical systems are usually equipped with only position measurement encoders, while velocities are obtained by numerical differentiation. In this presentation, we briefly show how tracking control of mechanical systems, with only position measurements, can be realized by applying the canonical transformation theory for port-Hamiltonian systems in combination with dynamic feedback. A relation with similar results in an Euler-Lagrange setting is provided as well, and it follows from the port-Hamiltonian setting that the specific choice for the Coriolis term naturally follows from the port-Hamiltonian canonical transformation framework. The effectiveness of the described methods is shown by simulation examples, and by experiments with a two degree of freedom planar robotic arm.

Finally, some attention is given to our recent results on the embedding of the Notch and inverse Notch filter in a port-Hamiltonian setting. Such embedding allows for application of such frequency domain, and thus linear system method into a non-
linear setting, while preserving the port-Hamiltonian structure, and thus preserving passivity and stability properties.

References to our work presented here are given below, [1, 2, 3, 4, 5, 6, 7, 8].

REFERENCES


