Discussion on the paper "Energy shaping of port-Hamiltonian systems by using alternate passive input-output pairs" by A. Venkatraman and A. van der Schaft

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The paper further elaborates on a passive output that was constructed in [3] with the purpose of providing an energy-balance (EB) interpretation for basic interconnection and damping assignment (BIDA [6, 7]). Such output has its roots in power shaping [4], an alternative method to stabilize nonlinear RLC circuits subjected to the dissipation obstacle [6]. It has been recently shown in [5] that this particular output is also useful in the context of control by interconnection (CbI [8, 6]).

The output constructed by *swapping the damping* (also called the *power shaping* output) is without doubt worth investigating, as it plays an important role in a somewhat convoluted interplay between: energy-balance, interconnection and damping assignment, control by interconnection and the dissipation obstacle (see [5] for details).

Venkatraman and van der Schaft study the power shaping output and its connection to the set of achievable Casimir functions from the more general perspective of Dirac structures [2]. Among other things, the authors show that the process of generating new passive outputs can be understood as a 'decomposition' and further 're-composition' of the plant's Dirac and resistive underlying structures.

Pros

The abstraction to Dirac structures offers some advantages. One of them is the possibility to use an interconnection structure $\mathcal{D}_I$ which results not only in a different output, but also in a different input[1]. This degree of freedom can be exploited, for example, to incorporate a state feedback component in the controller (recall that in its present form, control by interconnection is essentially a dynamic output feedback scheme).

The Dirac setting also offers the prospect of working with implicit or singular port-Hamiltonian models described by the generalized Dirac structures introduced in [2].

Contra

The main drawback of the approach taken by the authors is that one does not *derive* the power shaping output using a clear criterion. This special output is selected *beforehand*, leaving the questions

> (i) What are the distinctive features of this output, what is so particular about it?

and

> (ii) Are there any other outputs that enlarge the class of achievable Casimir functions?

unanswered. The importance of answering this questions becomes apparent with the negative example regarding the MEMS optical switch, where after failure of the power shaping output one still has to look at

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[1] That is, using a $\mathcal{D}_I$ that satisfies (40)-(43) but not necessarily (53)-(56).

the achievable Casimirs *for all* possible passive outputs (i.e., for all $\tilde{J}_1$, $\tilde{J}_2$ and $\tilde{J}_3$).

In the approach taken in [1], on the other hand, it is first shown that energy-balance is equivalent to the invariance of the output and dissipation functions under the action of the controller. If $J(x) - R(x)$ is non singular, then the power shaping output is *uniquely* chosen as the output which is invariant under the action of basic interconnection and damping assignment — This result becomes relevant to the present discussion by recalling the equivalences

$$\text{EB} \iff \text{CbI}$$

and

$$\text{BIDA} \iff \text{CbI w/o the dissipation obstacle}$$

that have been established in [5]. The key property of the power shaping output is thus identified in terms of invariance with respect to the control action (cf. question (i)). Because of the second equivalence, we can conclude that the class of Casimir functions can not be enlarged with other passive outputs.

References

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