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Passivity Based Control of Continuous Bioreactors

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Abstract: In this paper, a passivity based model of a general set of bio-reactions in open reactors with new energy functions is derived. A change of coordinates is done, based on the stoichiometric invariance principle, which simplifies the number of equations to be taken care of and shows directly the passivity of the system. The passivity based control will be obtained in terms of systematic controller design techniques. The energy functions can be said to be in close proximity with the Gibbs free energy function used in port-Hamiltonian model of enzymatic reactions and are far from the traditional non-physical quadratic functions.

Keywords: *Port-Hamiltonian systems; passivity; nonlinear control; bioreactors.*

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1 Introduction

Passivity is a fundamental property of physical systems which are able to transform and dissipate energy. For such systems, passivity balances the energy of a system quantifying the external input and generated output. Hence, passivity is also related to the stability of the system by the fact that the system is said to be passive if the input energy is always more than or equal to the stored energy (closed systems) or output energy (open systems). Port-Hamiltonian (PH) modelling has been one of the most physical passivity based modelling technique which has inherent structural properties clearly defining the interconnection and dissipation of energy. Bond graph (BG) modelling technique can be considered as the graphical representation of the PH models . However, it is possible to propose only quasi-port-Hamiltonian representations for chemical and enzymatic systems using different energy functions and subsequent controllers (entropy, enthalpy, Gibbs free energy, etc., see e.g. [1], [2]) or pseudo bond graph models, e.g. [3].

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