A note on decoupling

Karin Eriksson [a], Claes Breitholtz [a] Anders Karlström [b]

[a] *Department of Signals and Systems, Chalmers University of Technology, SE-412 96 Göteborg, Sweden*

[b] *Chalmers Industrial Technology Foundation, Chalmers Science Park, SE-412 88, Göteborg, Sweden*

Abstract

Decoupling is a well established approach to decentralized control of linear time-invariant MIMO-systems having an equal number of control inputs and control outputs. Among applications in the area of process control, distillation columns have to be mentioned, see for example Luyben [1] and Waller [2]. In later years, decoupling control has also been applied to other systems such as thermodynamical pulping processes, see Berg [3]. However, with the exception of various distillation applications, so far the recognition of decoupling control seems rather limited in process engineering, see Waller et al. [4].

Among recent development, interesting methods are described by Nordfeldt and Hägglund [5], and by Cai et al. [6]. However, the results presented by these authors focus on the 2×2 case which is insufficient for some applications. Taken together, there are indications that besides previous research achievements, further work within the area of decoupling is needed.

In this paper, some notes on realizability and stability of filters providing so called simplified decoupling are made. The 3×3 case is emphasized and in addition, a few general conclusions are drawn. Note however that decoupling control for, lets say, 10×10 systems is not really interesting from an engineering point of view (mainly due to the curse of dimensionality).

$$\begin{bmatrix} G_{11} & G_{12} & G_{13} \\ G_{21} & G_{22} & G_{23} \\ G_{31} & G_{32} & G_{33} \end{bmatrix} \begin{bmatrix} 1 & F_{12} & F_{13} \\ F_{21} & 1 & F_{23} \\ F_{31} & F_{32} & 1 \end{bmatrix} = \begin{bmatrix} P_{11} & 0 & 0 \\ 0 & P_{22} & 0 \\ 0 & 0 & P_{33} \end{bmatrix}$$

Email addresses: `ke@chalmers.se` (Karin Eriksson), `claesbr@chalmers.se` (Claes Breitholtz), `anders.karlstrom@cit.chalmers.se` (Anders Karlström).

Sample data control of linear time-invariant MIMO-systems, are considered here, implying that the models used are MIMO-transfer functions in the complex z-domain. One advantage of this approach is that all elements of the MIMO-transfer functions can be expressed as fractions between polynomials $Q_{ij}(z)$ and $P_{ij}(z)$. This strongly promotes a more systematic analysis, compared to cases with continuous-time models, especially when the real MIMO-system includes delays. In addition, to cope with problem related to model uncertainties, an approach to robust control employing decoupling is briefly outlined.

References

[1] Leuyben, W.L. (1970): Distillation decoupling, AIChE J. 16, 198-203.

[2] Waller, K.V. (1974): Decoupling in distillation, AIChE J. 20, 592-594.

[3] Berg, D. (2005): A comprehensive approach to modeling and control of thermomechanical pulping processes, Licentiate thesis, Chalmers University of Technology, Göteborg, Sweden.

[4] Waller, M., Waller J.B. and Waller, K.V. (2003): Decoupling revisited, Ind. Eng. Chem. Res. 42, 4574-4577.

[5] Nordfeldt, P. and Hägglund, T.(2006): Decoupler and PID controller design of TITO systems, J. Process Control 16, 923-936.

[6] Cai, W.-J., Ni, W., He M.-J. and Ni, C.-Y. (2008): Normalized decoupling -A new approach for MIMO process control system design, Ind. Eng. Chem. Res. 47, 7347-7356.