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Editors: M. Thoma, F. Allgöwer, M. Morari

Ali Khaki-Sedigh and Bijan Moaveni

Control Configuration Selection for Multivariable Plants

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Authors

Prof. Ali Khaki-Sedigh

Faculty of Electrical and Computer Engineering
Department of Control Engineering
K. N. Toosi University of Technology
Tehran, 14317-14191
Iran
E-mail: sedigh@kntu.ac.ir

Dr. Bijan Moaveni

School of Railway Engineering
Iran University of Science and Technology
Tehran, 16846-13114
Iran
E-mail: b_moaveni@iust.ac.ir

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Preface

Control of multivariable industrial plants and processes has been a challenging and fascinating task for researchers in this field. The analysis and design methodologies for multivariable plants can be categorized as centralized and decentralized design strategies. Despite the remarkable theoretical achievements in centralized multivariable control, decentralized control is still widely used in many industrial plants. This trend in the beginning of the third millennium is still there and it will be with us for the foreseeable future. This is mainly because of the easy implementation, maintenance, tuning, and robust behavior in the face of fault and model uncertainties, which is reported with the vast number of running decentralized controllers in the industry. The main steps involved in employing decentralized controllers can be summarized as follows:

- Control objectives formulation and plant modeling.
- Control structure selection.
- Controller design.
- Simulation or pilot plant experiments and Implementation.

Nearly all the textbooks on multivariable control theory deal only with the control system analysis and design. The important concept of control structure selection which is a key prerequisite for a successful industrial control strategy is almost unnoticed. Structure selection involves the following two main steps:

- Inputs and outputs selection.
- Control configuration selection or the input-output pairing problem.

This book focuses on control configuration selection or the input-output pairing problem, which is defined as the procedure of selecting the appropriate input and output pair for the design of SISO (or block) controllers. An improper input-output pairing selection can be detrimental to closed loop stability and performance. The main objective in selecting an appropriate control configuration is to minimize the loop interactions. This will facilitate the single input single output independent design that is the basis of many industrial control systems.

This book reviews the main control configuration selection methods available in the literature. The seminal work of Bristol, the Relative Gain Array (RGA) introduced in 1966 is the first method proposed for input-output pairing. This empirical method is the most widely control configuration selection strategy used in the practical designs of process control systems. During the nearly 4 decades after introducing the RGA, there are now many extensions and generalizations to the conventional RGA methodology.

Moreover, input-output pairing selection from other viewpoints such as the state space, passivity and soft computing has been introduced. Other approaches include, control configuration selection for nonlinear multivariable plants and pairing problem in the face of time varying parameters or plant uncertainties.

This book is the first monograph to deal in depth with the issue of control configuration selection. It is designed and written to serve the needs of a wide audience working in the area of decentralized control systems both in the academia and industry. The engineers and students interested in control configuration selection techniques, engineers already acquainted with the basic concepts and willing to be familiar with the more advanced strategies and postgraduate students who in addition to the aforementioned points want to get to the frontiers of research in the field may find this book useful.

The book achieves these objectives by reviewing and explaining the concepts involved in the techniques, starting with the RGA and to the latest methodologies available in the literature. Worked examples and simulation results are also available to further explain and clarify the main points. This book will also be useful to process control engineers, postgraduate students in process, electrical, and mechanical engineering disciplines. It is assumed that the reader is acquainted with a basic knowledge about linear and nonlinear system theory, analysis and design of linear multivariable control systems.

Most of the numerical examples are solved using MATLAB software and are available over the internet. Also, corrections and comments can be accessed from the authors' homepages:

- <http://saba.kntu.ac.ir/eecd/khakisedigh>
- http://webpages.iust.ac.ir/b_moaveni

Feedback from our readers will be appreciated and will help in improving the materials in this book. Please send any questions and comments you may have to authors email addresses: sedigh@kntu.ac.ir and b_moaveni@iust.ac.ir.

Finally, we would like to acknowledge the support of all the people who in some way helped us during the preparation of this book. In particular, we would like to thank our colleagues and graduate students at K. N. Toosi University of Technology, Shahid Rajaee Teacher Training University, and the staff of the Springer-Verlag for their support. The whole manuscript has been revised by our post graduate student Mr Nima Monshizadeh Naini and his technical comments and proof reading the draft chapters of the book is very much appreciated. Last, but not least, we would like to sincerely thank our families for their encouragement, support and patience during the holidays and evenings devoted to this book, the moments that truly belonged to them.

Tehran
July 2009

Ali Khaki-Sedigh
Bijan Moaveni

List of Abbreviations

ARMA	Auto Regressive Moving Average
BRG	Block Relative Gain
CSTR	Continuous Stirred Tank Reactor
DBRG	Dynamic Block Relative Gain
DIC	Decentralized Integral Controllability
Digraph	Direct Graph
DIOPM	Dynamic Input-Output Pairing Matrix
DMRS	Decentralized Model Reference Schemes
DRGA	Dynamic Relative Gain Array
ERGA	Effective Relative Gain Array
GBDD	Generalized Block Diagonal Dominant
GDRG	Generalized Dynamic Relative Gain
GNI	Generalized Niederlinski Index
HIIA	Hankel Interaction Index Array
HSV	Hankel Singular Value
IC	Integral Controllability
ICI	Integral Controllability with Integrity
IM	Interaction Measure
IMC	Internal Model Control
LFT	Linear Fractional Transform
MIMO	Multi-Input Multi-Output
NBRG	Nonsquare Block Relative Gain
NDBRG	Nonsquare Dynamic Block Relative Gain
NI	Niederlinski Index
NRGA	Nonlinear Relative Gain Array
NSRG	Nonsquare Relative Gain
NSRGA	Nonsquare Relative Gain Array
PM	Participation Matrix
PRG	Partial Relative Gain
PRGA	Performance Relative Gain Array
QBDD	Quasi Block Diagonal Dominance
RG	Relative Gain Array
RIA	Relative Interaction Array
RLS	Recursive Least Square
SIMO	Single-Input Multi-Output
SISO	Single-Input Single-Output

SSE	Sum Squared Error
SSV	Structured Singular Value
STR	Self Tuning Regulator
SV	Singular Value
upper-LFT	Upper Linear Fractional Transform

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