Lecture Notes
in Control and Information Sciences 175

Editors: M. Thoma and W. Wyner

E. Rogers, D.H. Owens

Stability Analysis for Linear Repetitive Processes

Springer-Verlag
Berlin Heidelberg New York
London Paris Tokyo
Hong Kong Barcelona Budapest

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Authors

Eric Rogers
Advanced Systems Research Group
Dept. of Aeronautics and Astronautics
University of Southampton
Southampton, SO9 5NH
United Kingdom

David H. Owens
Centre for Systems and Control Eng.
School of Engineering
University of Exeter
Exeter, EX4 4QF
United Kingdom

ISBN 3-540-55264-2 Springer-Verlag Berlin Heidelberg New York
ISBN 0-387-55264-2 Springer-Verlag New York Berlin Heidelberg

Typesetting: Camera ready by authors
Offsetprinting: Mercedes-Druck, Berlin; Bookbinding: B. Helm, Berlin
60/3020 5 4 3 2 1 0 Printed on acid-free paper

PREFACE

Repetitive, or multipass, processes are characterised by a series of sweeps, or passes, through a set of dynamics which in the simplest case is both linear and known. On each pass an output, or pass profile, is produced which acts as a forcing function on, and hence contributes to, the next pass profile. This so-called unit memory property is a special case of the more general situation where it is the previous M passes which contribute to the current one. The integer M is termed the memory length and such processes are simply termed non-unit memory. Industrial examples include long-wall coal cutting and certain metal rolling operations.

This interaction between successive pass profiles is the basic source of the unique control problem for these processes. In particular, it is possible to generate oscillations which increase in amplitude from pass to pass. Such behaviour is clearly totally unacceptable and hence appropriate control action is required.

The concept of a multipass process was first introduced in the early 1970's as a result of work at the University of Sheffield on the modelling and control of long-wall coal cutting operations. This, in turn, led to systematic attempts at controller design for these and several other industrial examples based, essentially, on appropriately modifying existing standard linear systems techniques such as Nyquist diagrams. As the number of examples increased, however, it gradually became clear that this general approach was, at best, valid only under quite restrictive conditions. Hence the need for a rigorous control theory, where stability is an obvious essential item of any such theory.

Using previously published work as a basis, this monograph presents a rigorous control theory, and associated tests, for repetitive processes with linear dynamics and a constant pass length. This is based on an abstract representation formulated in functional analysis terms by, in effect, regarding the pass profile as a point in a Banach space. All linear dynamics constant pass length examples are special cases of this abstract representation but this work concentrates on so-called differential and discrete non-unit memory linear repetitive processes which are of direct industrial relevance.

Three computationally feasible sets of stability tests are developed together with some associated properties. These then lead to some preliminary results on feedback control which are included with the general aim of stimulating further research. A central theme in the work reported here is the use of structural links with other classes of linear dynamic systems.

The work reported in this monograph was undertaken during periods when one or both of the authors were on the staff of The University of Sheffield, The Queen's University of Belfast and The University of Strathclyde. It follows on from the original work of John Edwards at Sheffield to whom we owe a great debt of gratitude

as the pioneer of this area. A number of former colleagues have also made very useful suggestions, particularly Derek Collins and Ian Willson in the early days at Sheffield. Finally, we must thank Miss Yvonne Fleming for typing the final manuscript.

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