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| Title | 結合・分離がおこるシステムに対するコントローラの設計に関する研究 |
| Author(s) | 浅田，幸則 |
| Citation | |
| Issue Date | 1997-03 |
| Type | Thesis or Dissertation |
| Text version | author |
| URL | http://hdl.handle.net/10119/1002 |
| Rights | |
| Description | Supervisor:示村 悦二郎，情報科学研究科，修士 |

# Controller for systems under connection and disconnection

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February 14, 1997

**Keywords:** connection, disconnection, subsystem, overall system , parallel interconnection structure, series interconnection structure , Turn Over Method.

Recently, systems under connection and disconnection are becoming very important, and stability and reliability are an essential and important requirements in those systems. For example, future space flight programs, such as the international space station program, promise a new era of space stations and spacecraft activities in the special area. During the assembly phase of the space station as well as later on, when full operational use will have begun, the U.S.Space Shuttle and other spacecrafts will serve as transfer vehicles between earth and space. For the period of their stay in space, spacecrafts will be docked with the space station. Consider that the space station and spacecrafts are subsystems, then they are regarded as the system under connection and disconnection. For the space station and spacecrafts, automatic control systems are required to guarantee desired motions on its orbit.

Another example can be found in the high density train system. If we consider trains as subsystems, this is also an example each of system under connection and disconnection. To achieve the reliable high density transportation by trains on railway, it is necessary to control them as one system.

It can be regarded that the connection and disconnection of the subsystems in our problem is a simultaneous stabilization problem or a large-scale systems problem. However, most of available literature does not address the question of 'how to design a stabilizing controller' - they mainly focus on the question 'whether or not such a controller exists'. Furthermore, these ideas can not take interconnection structure into account corresponding to the particular situation. In the case of a space station and spacecrafts, the interconnection structure is parallel, whereas it is serial in a railway transportation system. structure is serial.

If we take thought of interconnection structure, it can be expected to obtain the controller with higher performance.

A central question of control engineering interest arising in this context is:

How to design controllers for systems under connection and disconnection such that

1) each of the disconnected subsystem is stabilized by controllers that attain desirable input-output responses.

2) the overall interconnected system with interconnection structure (parallel interconnection structure, series interconnection structure) which is built by any combination of subsystems is stable.

First, this thesis provides a frame work to describe the parallel interconnection structure and the series interconnection structure between subsystems via mathematical. Second, we propose the following four methods of designing a controller that stabilizes the overall system each of the two interconnection structure.

Design method 1: the high gain control with a common gain multiplier,

Design method 2: the high gain control with a separate gain multiplier,

Design method 3: the control with a common parameter of turn over method,

Design method 4: the control with a common parameter of turn over method.

The design methods 1 $\sim$ 4 apply the Turn Over Method to locate poles of the closed loop system in a specified region for fast and non-oscillatory responses of the closed loop system as well as for its stability. An advantage of the method lies in its easiness in calculating a feedback gain. It is only necessary to solve an algebraic Riccati equation for once.

Now, we make the assumption that the subsystem can breed equivalent interference input from other subsystems by way of operation input itself. In that case, we can consider that the overall system is stablized by high gain controller.

As design methods 1 and 2, we apply the Turn Over Method to design of each subsystem. We obtain high gain condition to stabilize the overall system. We obtain the common high gain condition in design method 1, and separate high gain condition in design method 2.

On the other hand, in design methods 3 and 4 we obtain a parameter condition of Turn Over Method that stabilize both the overall system and subsystems. By using this method, we can locate poles of the closed loop system in such area that is desired for the good response of the closed loop subsystem as well as for its stability. Furthermore, controllers can avoid to be high-gain. We obtain the common parameter condition of Turn Over Method in design method 3, while separate parameter condition of Turn Over Method in design method 4.