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The Synthesis and Analysis by the Inverse Describing Function

Niro TAKATSUKA*

In this paper, the synthesis of general nonlinear control system, using the inverse describing function is described.

Firstly, the realizable nonlinear control system separated into the linear part and the nonlinear part is considered. For the stabilization of the system, a minor feed back loop with equivalent nonlinear gain H is added. Based on the stability criteria with respect to the nonlinear control system, the critical value of H which stabilizes the system, depends on the input to the minor feedback loop. Between the critical value of H and its input, there exists a certain relation for a particular nonlinearity. The relations were calculated for commonly used nonlinearities, and found to be some pattern. As the gain of feedback loop is desired to be as small as possible, the gain H should be close to the desired gain and the boundary of the critical gain is ordinarily approximated by an algebraic expression. The element which has the input-output characteristic for the algebraic expression is obtained by using the inverse describing function. As this expression is calculated by separating into several segments, the obtained input-output characteristic curve is not continuous but piecewise linear. Based on the piecewise linear curve, the precise tendency of the input-output relations may be obtained approximately.

In this paper, one numerical model is studied as an example, and the input-output relation is calculated both for small number and large number of segments. The former is obtained by manual calculation and the latter by digital computer. These results are shown in the paper and the nonlinear characteristic is similar to the static characteristic of the thermister.

As a conclusion, we might say that the stabilizing method using local feedback through nonlinear element of this type is useful for nonlinear automatic control systems.

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