CLASSICAL DESIGN METHODS FOR CONTINUOUS LTI-SYSTEMS

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Contents

Summary:

Classical control methods are introduced and put into perspective.

1. Introduction

As the 19th century came to an end, the works of Routh and Hurwitz formed the basis for understanding system stability and for designing controllers to provide desirable performance. Control application included various mechanically activated devices. In the early decades of the 20th century, interest focused on newly invented electrical devices, in particular those that involved telephone, telegraph, radio and television. The ingenuity of Nyquist and Bode was a major impetus to the improvement of amplifiers. It was observed that feedback greatly improved disturbance rejection and rendered the system more robust to unexpected and unpredictable changes in the very transfer function upon which design is based. Later, their work had direct application to aircraft and automobile performance. Ziegler and Nichols provided leadership in selection of compensators to produce desirable time response for various electromechanical systems driven by a proportional-integral-derivative (PID) compensator. It is said that the idea for PID compensation followed from observation of a helmsman steering a boat, an appropriately time domain operation. Another useful design and analysis tool is the root locus introduced by Evans in 1948. The composite wisdom (drawn from these pioneers and many others too numerous to mention in this brief introduction) formed the basis for classical control methodology, based on the use of the transfer function to describe a single-input single-output system. To put classical methods into perspective, consider Figure 1. The classical control system consists of a controller, plant and feedback device in a loop driven by an input R(s), producing an output Y(s). The control system input is generated by an outer guidance system, which examines measurements drawn from the control system. The guidance system creates the appropriate system input. For example, a person driving an automobile acts as a guidance system while the automobile forms the controlled system. A guidance system causing a missile (the control system) to intercept a target is another example.

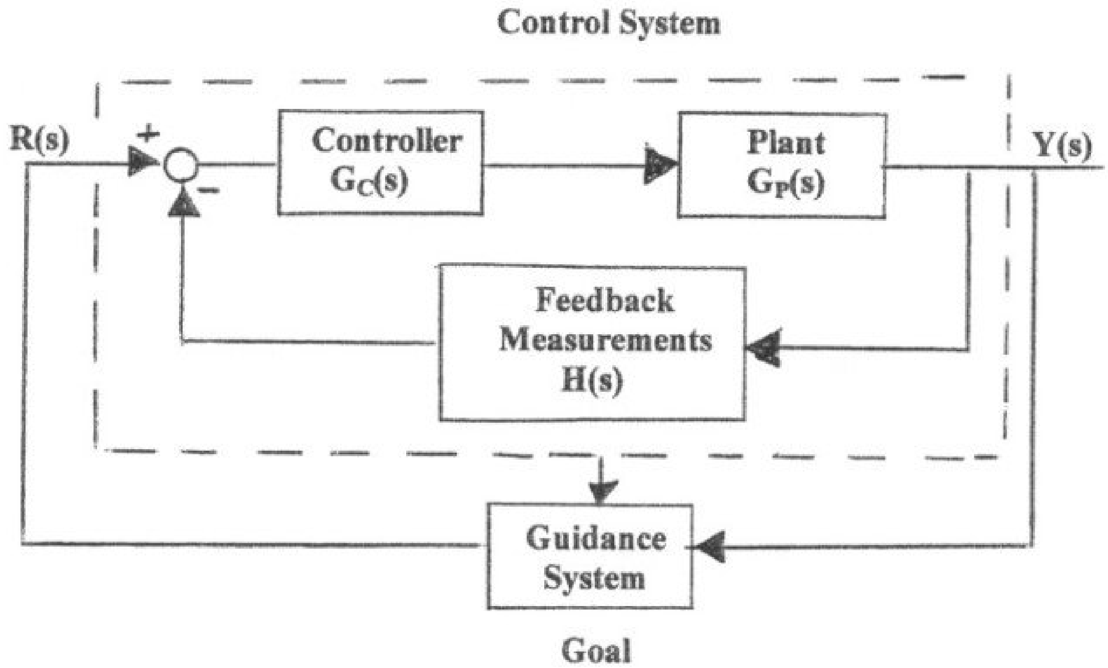

Figure 1.Classical Guidance and Control System

Certainly, a control system should respond quickly and smoothly to a guidance system (the driver of the car expects prompt acceleration and braking with short time constants). Conversely, the input from the guidance system varies slowly compared to the response of the controlled system (the driver does not brake and accelerate all the time so the driver's time constants are much longer). As a result, interest can focus on step and ramp inputs, which simulate a wide range of relatively slowly varying guidance commands.

In classical control, activity can be divided into three parts (excluding production, which is not covered here).

1. model
2. design
3. test

Each part may be accomplished in either the frequency domain or the time domain. For example, a step input could be applied in the time domain and a model (transfer function) can be found which follows the observed step response. The design could follow using Bode plot (frequency response) methods. The device could then be tested to operate in the time domain, for various step and ramp inputs.

Conversely, a sinusoidal input could be applied to obtain magnitude and phase data versus frequency. The transfer function model could be selected to fit frequency response data. Design could follow from time domain strategies applied to the model. The design could be a communication system, which is tested so as to operate for various frequency inputs.

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Biographical Sketch

Dr. Raymond T Stefani is a professor of electrical engineering at the California State University, Long Beach (California, USA). His teaching assignments include circuit analysis and control systems at both undergraduate and graduate levels. His electrical engineering research includes classical and modern compensator design, stability analysis and observer design. His coauthored control system textbook is entering its fourth edition. Other research interests include statistical analysis of Olympic winning performances in athletics (track and filed) swimming, weightlifting and rowing. He is also interested in rating and ranking systems. He has published a book chapter on predicting the outcome of sporting events.