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PID pitch attitude control for unstable flight vehicle in the presence of actuator delay: tuning and analysis. (English) Zbl 1393.93110

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Summary: In the realm of flight control, proportional-integral-derivative (PID) control is still widely used in practice due to its simple structure and efficiency. The robustness and dynamic performance of PID controller can be evaluated by stability margins. Based on the empirical knowledge about the unstable flight dynamics, the analytical tuning formulas of the PID pitch attitude control with actuator delay are derived with the help of several proper approximations. These tuning formulas can meet the increasing Gain and Phase Margins (iGPM) requirement and avoid time-consuming trial-and-error tuning process. The feasible iGPM area is established in 2-D plane subject to several conditions, especially taking the decreasing gain margin into account, wherein the numerical polynomial solving approaches are employed. The relationship between an existing PD tuning scheme and the proposed PID tuning method is also revealed. The applicable area of the tuning rule is then investigated on the basis of a crucial assumption. Furthermore, the achievable decreasing gain and phase margins (dGPM) area is obtained when the decreasing gain margin is critical; and another tuning rule is derived according to the dGPM specifications. The effect of the actuator delay on the achievable GPM area is demonstrated in a straightforward manner such that the reasonable criteria can be specified. Finally two numerical paradigms are presented to validate the proposed method; and the robustness and dynamic performance of the PID control are also reexamined for unstable flight dynamics.

MSC:

93D99 Stability of control systems
93C95 Application models in control theory

Keywords:

PID pitch attitude control; unstable flight vehicle; increasing gain and phase margins (iGPM)

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