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Tuning the Control Penalty Factor of a Minimum Variance Adaptive Controller

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Abstract This paper presents a startup and tuning procedure for an adaptive control system based on a minimum variance controller, proposing a successive dual setting of the control penalty factor (ρ) which weights the influence of the control variance in a cost criterion function. The main idea consists in a differentiated approach of the transient startup regime (including the following steps: open-loop initialization of the parameter estimates, initial tuning of the controller parameters, closing the loop, synchronization between the controller and the plant, retuning of the control penalty factor), respectively of the stable steady-state regime reached by the control system, by tuning the controller using two distinct values of factor ρ. Firstly, in the control system startup phase, characterized by strong transient regimes which could destabilize the system, a high value of ρ factor is chosen. Such a value of ρ ensures a strong penalization of the control and, at the same time, smoothes the transient responses, leading the control system to a stable steady-state regime. However, a too high value of ρ factor is not proper for an efficient rejection of disturbances which perturb the plant during this stable state. Based on these considerations, a retuning of the controller is required through a significant decrease of the ρ factor, thus increasing the dynamic of control, which becomes able to provide an efficient rejection of the disturbances acting on the plant. The new proposed startup and tuning procedure was tested and validated for the case of an excitation control system of an induction generator connected to a power system. The novelty of the paper consists in this dual setting of the control penalty factor (ρ).
Keywords: adaptive control; minimum variance controller; control penalty factor; tuning procedure; induction generator.

1. Introduction

The topics of adaptive control based on minimum variance strategy are widely treated in the technical literature and no longer presenting an absolute novelty (Åström, & Wittenmark, 1989; Wellstead & Zarrop, 1991). Also, industrial use was demonstrated by a substantial number of today's available applications (Åström, & Kumarb, 2014). The basic idea consists in minimizing a criterion function defined as the sum of two quadratic terms: the first represents the controlled output variance (practically, the quadratic output error), and the second term represents the control variance (controller output variance). This second term is weighted in the criterion function through a commonly named control penalty factor (ρ), leading to a suboptimal control (Åström, & Wittenmark, 1989). The controller output variance becomes more important in the criterion function by increasing this control penalty factor (Ambady, & Kazner, 2001). In the technical literature the control penalty factor is set as a constant, being a fixed parameter of the controller (Bobal, at al., 2005; Meng, et al., 2010; Mikles, & Fikar, 2007; Mu, 2004). However, if per units are used for the controller design, the value of this tuning parameter of the controller is usually chosen in the range