Chapter 12
An Adaptive Framework for Power Components Dynamic Loadability

Antonio Piccolo
University of Salerno, Italy

Pierluigi Siano
University of Salerno, Italy

Gerasimos Rigatos
Industrial Systems Institute, Greece

ABSTRACT

In electrical competitive markets, where deregulation and privatisation have determined changes in the organizational structures of the electricity supply industry as well as in the operation of power systems, utilities necessitate to change dynamically the loadability rating of power components without penalizing their serviceability. When assessing network load capability, the prediction of the Hot Spot Temperature (HST) of power components represents the most critical factor since it is essential to assess the thermal stress of the components, the loss of insulation life and the consequent risks of both technical and economical nature. In this chapter a general adaptive framework for power components dynamic loadability is proposed. In order to estimate the effectiveness of the adaptive framework, based on grey-box modelling, a specific case study, concerning the problem of forecasting the HST of a mineral-oil-immersed transformer, is presented.

INTRODUCTION

Adaptive modelling is generally used in order to make the system to model less sensitive to unmodeled system dynamics and to changes in its parameters. Even if many non-linear systems can be approximated by reduced-order models, possibly linear, these models may be suitable only within certain specific operating ranges and, because of changed operating conditions or changed system model parameters,

DOI: 10.4018/978-1-61520-849-4.ch012

adaptive models may be necessary. This problem has been solved to a great extent by the advent of artificial intelligence methods, such as neural networks and adaptive fuzzy systems, that may contribute in the area of non-linear control problems.

On the other hand, the new multifunction intelligent electronic devices, with increased processing capabilities, used in companies and industries, can be accessible from the outside in order to communicate and to interact with humans or computers. The recent tendency is to integrate these programmable devices through inexpensive network-based infrastructure that provides an immediate, cost-effective and efficient large-scale system required for the construction of an adaptive control. As side effect of this trend, the complexity increases as control and autonomy are decentralized and heterogeneous, therefore the definition of general control-based frameworks able to cope with this reality is required. This trend is particularly significant in competitive markets for electricity, where deregulation and privatisation have effected sustained changes in the organizational structures of the electricity supply industry, as well as in the operation of power systems. Following a "doing more with less" strategy, utilities try to balance overloading of power components against extending their life and maintaining system reliability. These conflicting needs can only be satisfied by implementing real time estimation of components' dynamic loadability rating, allowing the maximum load possible without causing thermal and mechanical damages to the equipment itself. The adoption of a dynamic loadability rating strategy can allow an additional overload performance capability in emergency conditions, which implies lower lost revenues or costly upgrades for utilities and industries. From previous experiences (Ippolito & Siano, 2004), it was derived that for the accurate and reliable prediction of the thermal behaviour of power components it is essential to achieve high accuracy in the results, both during load cycling and in presence of overload conditions.

Among other power components, power transformers and power cables represent the bottlenecks in networks load capability and their monitoring would have a noticeable effect on transmission and distribution networks, especially during emergency conditions. The use of adaptive frameworks for power components monitoring can significantly contribute to reduce the development time required to model highly complex non-linear systems and to implement monitoring and control using less expensive chips and sensors. Obviously, the introduction and spread of this new modelling philosophy in power system application require a substantial independency from low-level constraints of devices functioning (Acampora et al., 2004). Therefore, a general adaptive framework, for power components dynamic loadability is proposed. The adaptive framework, based on grey-box modelling, represents a major improvement of previous works (Ippolito & Siano, 2004). It allows designing a grey-box model that can estimate the power transformers Hot Spot Temperature (HST) only on the basis of measured load current and that can adapt to changes in power transformer's parameters.

BACKGROUND

System abnormalities, loading, switching and ambient condition normally contribute towards accelerated aging and sudden failure of power components. In the absence of critical components monitoring, the failure risk is always high. For early fault detection and real time condition assessment, online monitoring system would be an important tool. On-line monitoring of power components can also provide a clear indication of their status and ageing behavior. Analysis of the collected data allows prudent asset management, foresighted investment budgeting as well as operation closer to or, for certain time periods, even above limits.

Related Content