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An original approach for load–frequency control—the winning solution in the Second UCTE Synchronous Zone

Branko Stojkovic*

Electric Power Company of Montenegro, National Dispatching Center, Podgorica, Novaka Miloseva 46, Podgorica, Montenegro (Serbia and Montenegro), Yugoslavia

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Abstract

This paper describes a specific approach to resolving problem of load–frequency control (LFC) in the power system of Montenegro (Serbia and Montenegro). The complete LF controller was developed and implemented on the single PC computer. The extremely high "in-field" efficiency of the proposed method was achieved by compact design of the controller as well as by implementing algorithm for efficient control error filtering (comprising a PI-filter, too), algorithm for minimizing of regulating units movement and uniform regulating power allocation as well as feed-back algorithm for permanent adjustment of the tie-lines power measurements. Details on the above-mentioned algorithms are given. The entire LF controller as well as SCADA system that lies in its background, were developed, coded and implemented "from zero" by the Power Company's staff in a fast, feasible and cost-effective manner. Finally, the last but the most important issue—official field results for the 2 months exploitation of the system were reported and analysed, which have confirmed the top regulating success in the Second UCTE Synchronous Zone.

Keywords: Load–frequency control (LFC); SCADA; Area control error (ACE); Control area (CA); Energy management system (EMS); Secondary regulation

1. Introduction

The European Power System at the moment consists of two *Union for Coordination of Transmission of Electricity* (UCTE) synchronous zones, which operate separately. The Second UCTE Synchronous Zone comprises seven national power systems located in the southeastern part of the European continent: Romania (TEL), Bulgaria (NEK), Albania (KESH), Serbia (EPS), Greece (HTSO), Montenegro (EPCG) and Macedonia (ESM). The reason for separate operation of these two zones is transimission network destruction due to civil war in ex-Yugoslavia. The power system we are talking about is system of Montenegro.

Among all the classical control functions of an energy management system (EMS), the load–frequency control (LFC—so-called secondary regulation of power and frequency) is the most important one, because the most severe requirement of the surrounding interconnection is permanent satisfying of frequency and active power interchange schedules. The main requirement is to achieve this goal with a minimum of unit movement, i.e. minimum of generator's "wear and tear".

At the level of the Second Synchronous Zone the "pluralistic" principle of load–frequency control is in the force [1–3], with a loose coordination and accounting at the upper level (Electricity Coordinating Center (EKC) in Belgrade) but with the full LFC regulation at the lower level (individual control areas).

By the end of the next year (2003), the reconnection of the two European Zones is going to happen. An additional set of stringent requirements must be satisfied by each Control Area—at the first place regarding the obligation on complete and strict self-regulating of loads and adequate participating in power system frequency regulation.

The power system of Montenegro has never had its own LFC system, but it has permanently bought that service from the contiguous power system of EPS (Electric Power Company of Serbia). An average monthly invoice for this service was in the range of € 60,000–90,000. The price (€/(MW h)) for invoice forming was based on the cost for the reserved

* Tel.: +381-81-244-820.
E-mail address: vibas@cg.yu (B. Stojkovic).

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regulating capacities (depending on the season—from 15 to 22 MW), and the cost of regulating energy employed. For example, this price for March 2002 was 4,6458 (€/(MW h)). Amount of realized regulating energy is calculated by multiplying the total hours of correct operations of rented LFC resources, and the square root of the hourly peak load.

How this problem can be timely overcome in an efficient, fast, feasible and cost-effective way? It has been already shown how classical approaches to this problem resolution have failed [4]. In the same paper, an alternate, original approach was presented. It was proven at the same place why such an approach is preferable, especially compared with some huge, expensive projects of this kind. So, for the purpose of power system monitoring the compact SCADA system was developed and put into operation. It is characteristic of the compact SCADA system that it was completely developed and implemented by inside the Power Company (by the Company's staff) in an extremely efficient, cost-effective, fast and viable manner. In [4], it can be found that the overall cost of the system development and implementation was up to US$ 10,000. This amount compared with just 1-month invoice for LFC rent is self-explanatory regarding cost effectiveness! System's viability is proven by the realized availability for the past 3-years' exploitation period. Namely, just four outages were recorded, with the complete "out-of-operation" duration of 85 min. As of January 2003, the second (redundant) SCADA computer is in the operation, too.

Furthermore, apart from monitoring of common parameters of the power system, the SCADA provides a very good overall observability of some "exotic" power system features, such as momentary Net Transfer Capacities (NTC's) at the both main Power System *flowgates*, momentary overall energy import/export/transit as well as real-time power losses, etc. Those are important data due to ensuring fluency of South East European Electricity Market (SEEEM), that is

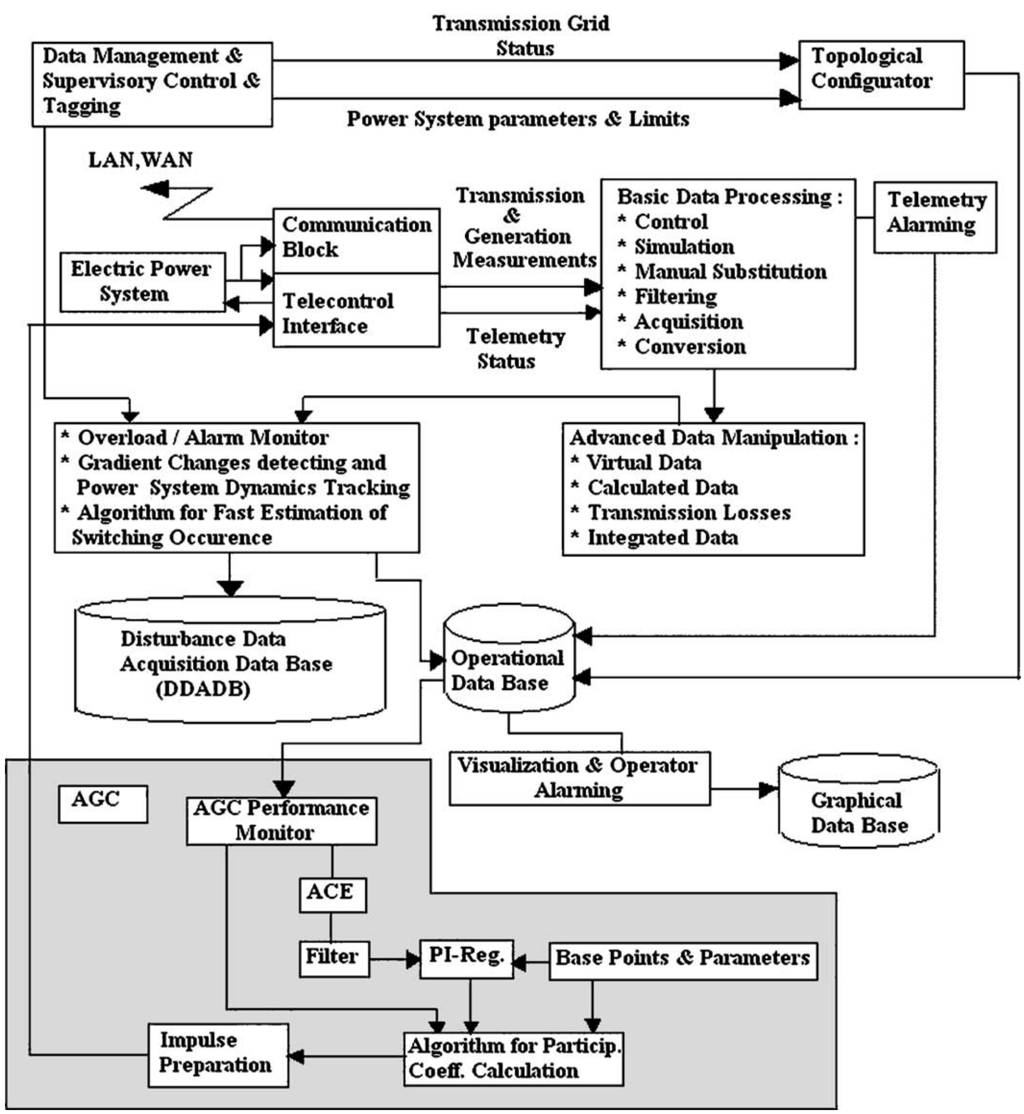

Fig. 1. Diagram of SCADA & AGC system.