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# Implementation and Testing of AGC SMM Control Block in NDC in Serbian TSMO within the Project of Modernisation and Upgrading of Existing SCADA/EMS System

Mirela Đurđević[1], Zoran Rudić[1], Nikola Obradović[1], Goran Jakupović[2], Ninel Čukalevski[2]

***Abstract***

*In order to maintain the frequency and power exchanges with neighbouring systems on a given (planned) values, in accordance with the rules of the European Interconnection (ENTSO – E Continental Europe), Serbian TSMO (PE EMS) is obliged to provide a reserve of active power for the needs of secondary control within the power system of Serbia. Within interconnection of Continental Europe, Transmission System Operators of Macedonia, Montenegro and Serbia form a control block, named SMM (Serbia, Montenegro and Macedonia).*

*As a coordinator of SMM Control Block EMS is obliged to calculate, in real-time, Area Control Error (ACE) of SMM Block and ACE of each control block member.*

*Within the project of modernisation and upgrading of existing SCADA/EMS system, an improved Automatic Generation Control (AGC) function has been implemented. Usually AGC system should provide the following functions: control of frequency and power exchange (LFC), planning of interchange scheduling (ITS), monitoring of reserves (RM) and performance monitoring of LFC control (PM). Additionally EMS AGC system has LFC regulator of SMM Block (SMM).*

***Keywords***

*interconnection, AGC, LFC, SMM, frequency, power, exchange, block, regulator, control.*

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## 1 Introduction

Automatic generation control (AGC) system, especially its load frequency control (LFC) part, plays very important role in continuous and secure operation of interconnected power system, and as such it is an essential part of any Energy Management (EMS) system within power utility or Independent System Operator (ISO) control centers. [3]

In this paper the implementation and testing of a new version SMM Block Regulator in National Control Center (NCC) in Serbian TSMO, as a part of renewed backup SCADA/EMS system, will be described. At the moment the first phase of the modernisation and upgrading project has been finished and the new SCADA/EMS system is in operational use since December 2014.

[1] Operational Technology Department
Serbian Transmission System and Market Operator
Vojvode Stepe 412
Belgrade, Serbia
(e-mail: mirela.djurdjevic@ems.rs, zoran.rudic@ems.rs, nada.turudija@ems.rs )

[2] „Mihajlo Pupin“ Institute, University of Belgrade
Volgina 15, Belgrade, Serbia
(e-mail: goran.jakupovic@pupin.rs, ninel.cukalevski@pupin.rs )

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## 2 SMM Control Block

The goal of connecting power systems in interconnection is to increase the reliability and stability of the system. TSOs are obligated to respect the rules of ENTSO-E interconnection. Control area is part of interconnection that is required to absorb all load changes within its territory and, at the same time, maintains the power exchanges with its neighbors and the frequency at the predefined values. Neighboring control areas often join in control blocks to make easier to comply with their obligations within the interconnection - secondary control, exchange data, calculation.

Within the interconnection of Continental Europe, Transmission System Operators of FYR Macedonia, Montenegro and Serbia formed a SMM Control Block. The organization of secondary control within the control block is possible in three ways: centralized, hierarchical and pluralistic. By agreement between the block members, it is determined that area control error has to be calculated in hierarchical and pluralistic control mode.

### 2.1 Secondary Control System (AGC)

Secondary control (AGC-Automatic Generation Control) is a system for power generation control, in order to maintain the power system frequency and TSO's power exchange with neighboring systems at the given values.

The main tasks of the AGC are:

- Maintaining a balance of production and consumption in the system;
- Maintaining the frequency on the nominal value;
- Maintaining of power exchange with neighboring systems at a given value;
- The distribution of production on the power plants in order to minimize the production costs.

AGC system should provide the following functions:

- LFC regulator of SMM Block;
- Management of frequency and power exchange (LFC);
- Planning of the power exchange;
- Monitoring of the regulating reserves;
- Monitoring of the control performance. [5]

### 2.2 Regulator of SMM Block

Regulator of SMM Block calculates ACE – area control error for each TSO member of SMM block and ACE of the whole control block. Regulator sends calculated ACEs to all transmission system operators from the Block and to his LFC controllers. Besides ACEs, AGC calculates and exchanges another values with TSOs. SMM regulator provides the following functions:

- ACE calculation for SMM Block and for each TSO;
- Modelling system – adding new and removing old control areas;
- Distributing ACEs to TSOs trough the SCADA system, using TASE2 and recently IEC 60870-5-101 protocol;
- Sending the selected ACE to LFC part of Serbian SCADA/EMS system – it is an option;
- Archiving data in SCADA archive database for calculation and accounting;
- Detection of errors in measurements, received from SCADA system;
- Calculation of values that are forwarded to ENTSO-E Energy Awareness System (EAS).

### 2.3 ACE Calculation

SMM Block Regulator allows both ways of ACE calculation: hierarchical and/or pluralistic.

In the pluralistic mode block regulator calculate ACE of each TSO member without participation block ACE:

$$ACE_k = (P_k - P_{k0}) + B_{fk}(F_1 - F_0) \quad (1)$$

but Serbian TSO follows the ACE of the whole SMM CB (Control Block).

In the hierarchical mode ACE of each block member has a component of SMM CB ACE:

$$ACE_k = (P_k - P_{k0}) + B_{fk}(F_1 - F_0) + h_k ACE_{SMM} \quad (2)$$

Where is:

$k$ – Tag of the Block member-control area-company;

$ACE_k$ - Area control error of the k control area (Company);

$ACE_{SMM}$ - ACE of the SMM Block:

$$ACE_{SMM} = \sum ACE_{k0} \quad (3)$$

$ACE_{k0}$ - Area control error of the k control area in the pluralistic mode;

$P_k$ - Actual sum of power interchanges, of the k area with the neighbouring companies;

$P_{k0}$ - Interchange scheduling with the neighbours of the k company;

$B_{fk}$ - Bias factor of the k area;

$F_1$ - Actual value of the frequency;

$F_0$ - Planning value of the frequency;

$h_k$ - Participation factor of the company in the hierarchical mode:

$$0 \le h_k \le 1, \ \sum h_k = 1 \qquad (4)$$

[6]

## 3 SMM Block Regulator Implementation

Implementation of the SMM Block Regulator includes entering and checking of all the necessary data for AGC/SMM application using. During the process of implementation it is necessary entering every data that will be used by application in the AGC/SMM database and checking quality of its value. After entering all the parameters necessary for the correct performance of AGC, the next step is creating routines to validate the functionality of application. Final phase is a real time testing, in the real time operation, when all the performances of system are setting.

System engineer entered following data:

- $B_{fk}$ - Bias factor of the k area;
- $h_k$ - Participation factor of the company in the hierarchical mode;
- Changes of generation`s units scheduling, during the hour.

### 3.1 SCADA Data used by AGC and SMM Block Regulator

AGC/SMM database contains the following information:

- AGC model;
- Parameters of SMM Block Regulator;
- Parameters of AGC Regulator;
- Following schedules: interchange, compensations, frequencies, participation of the generators power in tertiary reserves, planning generations of the regulation generator units;

Model of topology, in AGC/SMM database contains following elements:

- Companies;
- Plants, only for coordinator company;
- Generator units;
- Control generators;
- Tie lines. [6]

SCADA data used by AGC and SMM block regulator are: direct inputs from real time process, AGC/SMM control variables, AGC/SMM parameters, AGC outputs data and alarms. Considering the significance and high priority of reliably operation of SMM Block, for all real time data there is two or more redundant values. If it is technical possible, they should come from different sources and transmission paths. This is process in progress, SCADA system is developing in the direction to provide complete redundancy in all measuring points of high priority.

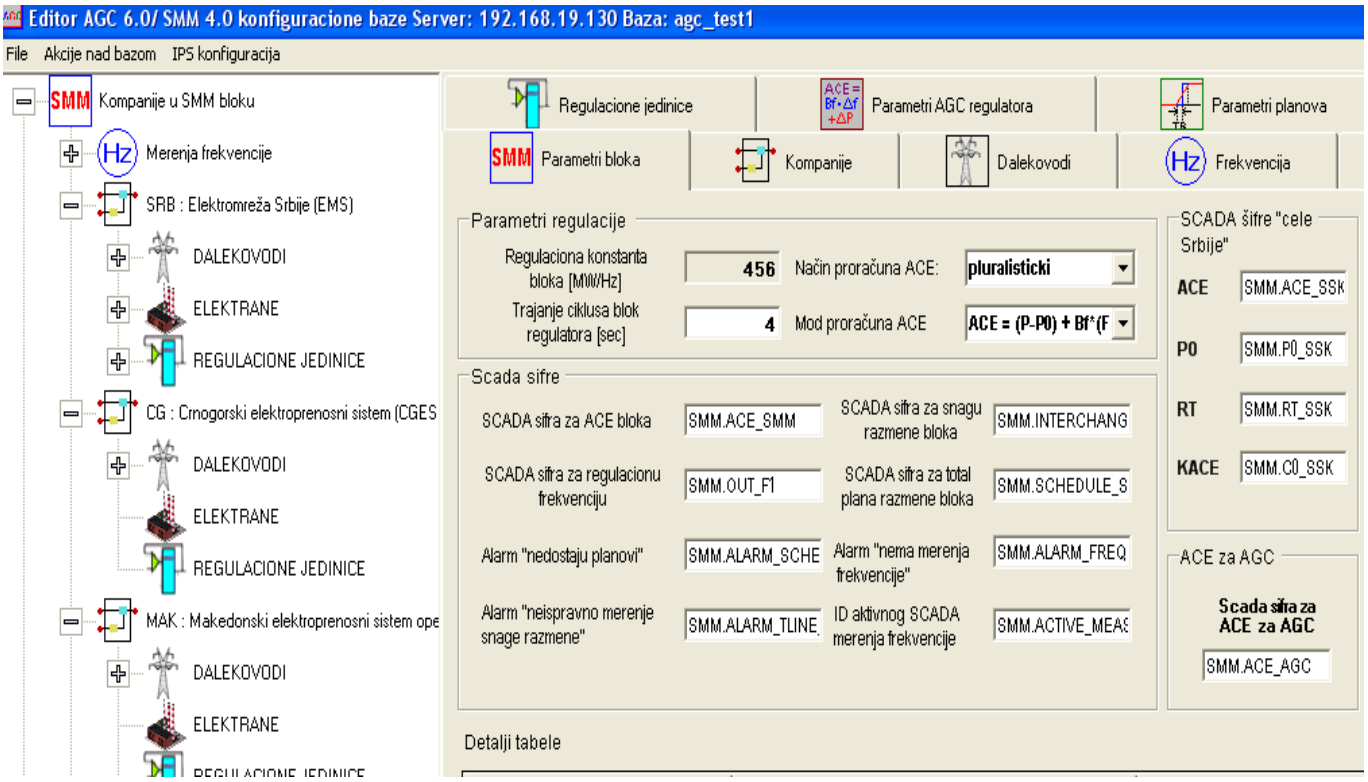


*Fig. 1* Editor of AGC/SMM Configuration Database

Data acquisition is done by SCADA communication system in the control centre. Data exchange with other parts of the power system of importance: direct communication with remote stations by IEC 60870-5-101 protocol and communication with neighbouring system operators by ICCP protocol.

A direct connection with cellular telecommunication optical path goes through over the Front End Processor (FEP) in the case of the main SCADA system, or through the communication process on IMP SCADA servers. Part of the data is transmitted by ICCP protocol via Open Access Gateway (OAG) server.

The main purpose of OAG server is the exchange of data with the other power systems in the region. This functionality is of great importance for the quality of power system control – it provides redundant measurements at interconnected lines and their switching statuses.

The set of frequency measurements consist of two measurements taken directly by specialised devices in NDC and many measurements taken from remote devices in remote stations.

### 3.2 Connection between SMM Block Regulator and Energy Accounting System

From the Energy Accounting System Block regulator receives the following data:

- Interchange schedules for the control areas – TSO members of block;
- Compensation programs for all SMM block members;
- Hourly frequency plan of the interconnected system;
- Participation of generator`s units in AGC.

There is a plan editor, in the SMM Block application, which allows manual editing and entering of all the plans for every control area and for system frequency.

## 4 Testing SMM Block Regulator

The testing process SMM Block Regulator had two phases: the testing under the SAT (On Site Acceptance Test) and the testing in a real environment. Within the SAT the functionality of the system was tested according to predetermined test plans and procedures:

- The accuracy of frequency measurement and active power exchange on the interconnection lines;
- Loading of interchange scheduling and the system frequency program;
- The accuracy of ACE calculation for each control area and for the whole SMM block, according to two modes: hierarchical and pluralistic;
- Check the export of ACE value from SMM block to the AGC application;
- Testing the editor of interchange scheduling.

For testing in real environment AGC control system was using two ACEs: from new and old SMM regulator. At the beginning, periods of working with ACE from new system was short, about one hour, and system was strictly observed with system engineers and operators. During test periods both ACEs were monitoring and SMM system was tuning according to ACE. Set of measurements is important for high quality of ACE - each measurement (system frequency and tie-lines power) has redundant value. With appropriate choice of measurements new ACE`s quality became better than old and meet criteria for operational work.

Accuracy and availability of each measurement changes during the time, this is the reason for redundant values. In the operational real - time work dispatchers change set of measurements according the conditions.

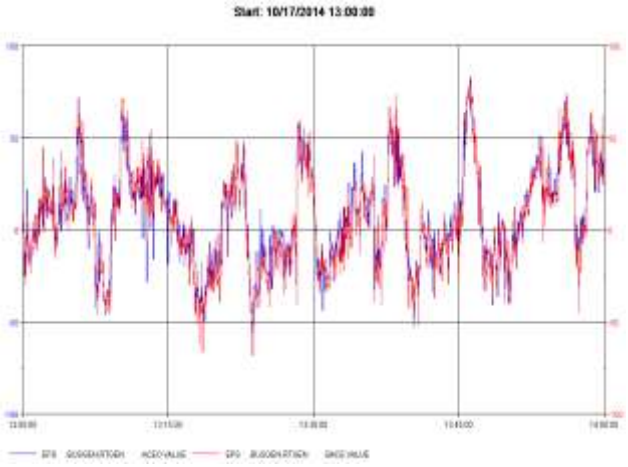

*Fig. 2* Serbian ACE for 17.10.2014.

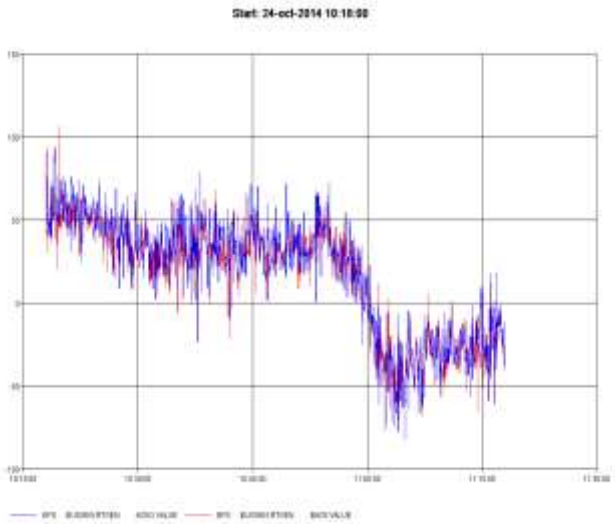

*Fig. 3* Serbian ACE for 24.10.2014.

Diagrams, on the pictures 2 and 3, are showing Serbian ACE during the test from the both systems with the same set of measurements. Blue colour, on diagrams, represents ACE from the new regulator and red colour is ACE from the old system.

## 5 Conclusion

According to the results received during the system testing and experience, it has been concluded that SMM Block Regulator provides good quality of control and monitoring of control areas within the SMM CB.

TSMO of Serbia is monitoring SMM block. Every day data and diagrams of ACE are sending to EMS staff, in goal better quality.

ENTSO-E rules are changing during the time and EMS is in touch with the AGC trends in European Interconnection. SMM block is adaptable and ready to follow all necessary changes.

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