

INTRODUCTION OF THERMAL POWER PLANT “NIKOLA TESLA A” INTO AUTOMATIC GENERATION CONTROL (AGC) SYSTEM

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MAIN PURPOSE OF AGC

- To maintain power balance in the system and to make sure that system frequency is maintained
- To keep net active power interchange as near to schedule, as possible

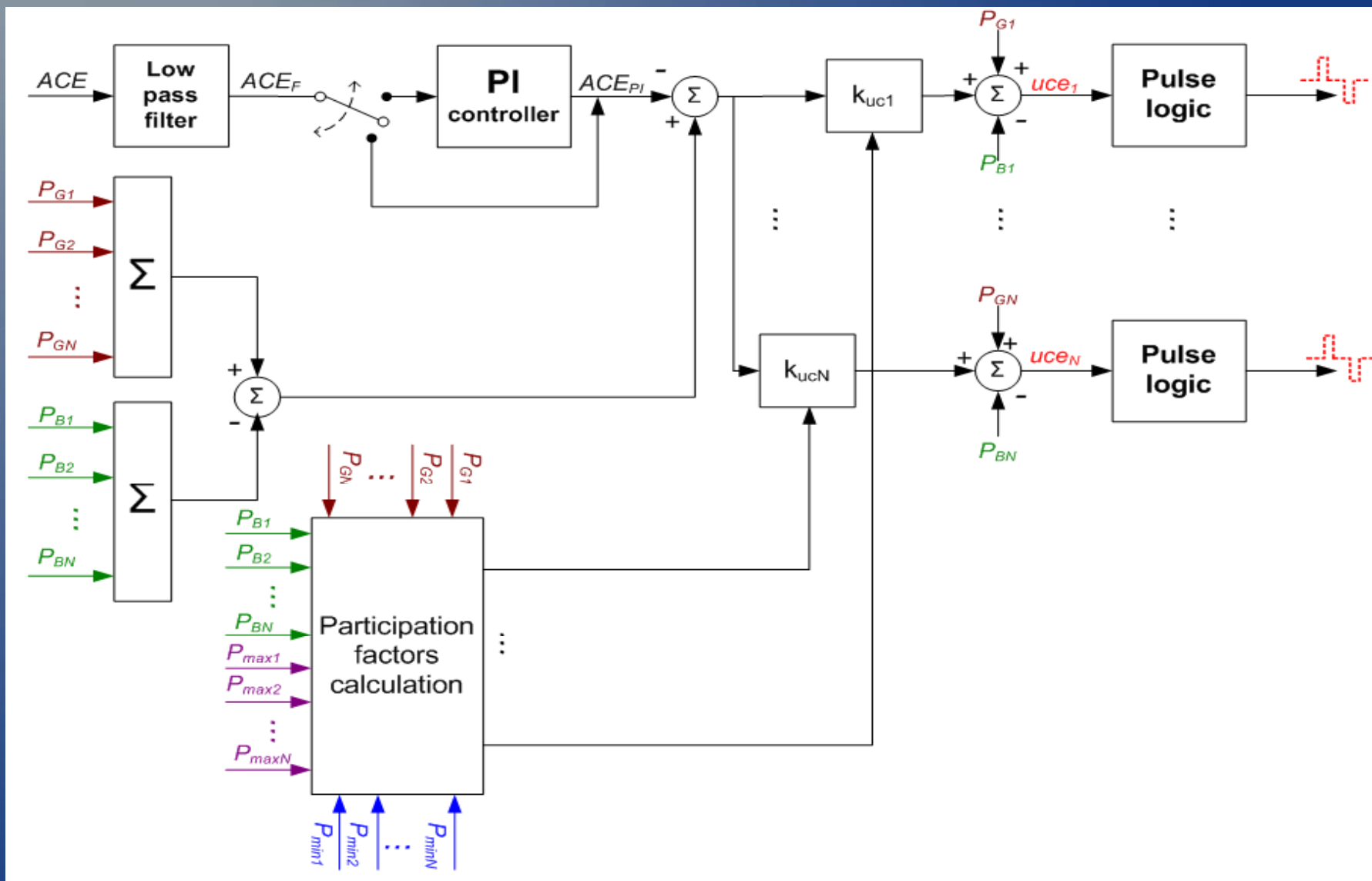
AGC OVERVIEW

- AGC control is centralized, and is performed from national or area control centers.
- AGC tries to minimize so called **Area Control Error (ACE)**, where:
 - $ACE = (P_0 - P_1) + Bf(f_1 - f_0)$
- Each control area is responsible for minimization of its ACE

AGC OVERVIEW

- AGC Control is performed by changing desired active power of plants participating into AGC
- Controls may be issued either as raise/lower pulses or as set point values

OVERVIEW OF TYPICAL AGC ALGORITHM



AGC IN SERBIA

- Responsible for AGC is Serbian transmission system and market operator – EMS
- Serbian power system is part of UCTE/ENTSO-E SMM (Serbia, Macedonia, and Montenegro) control block
- Currently only hydro power plants are used for AGC

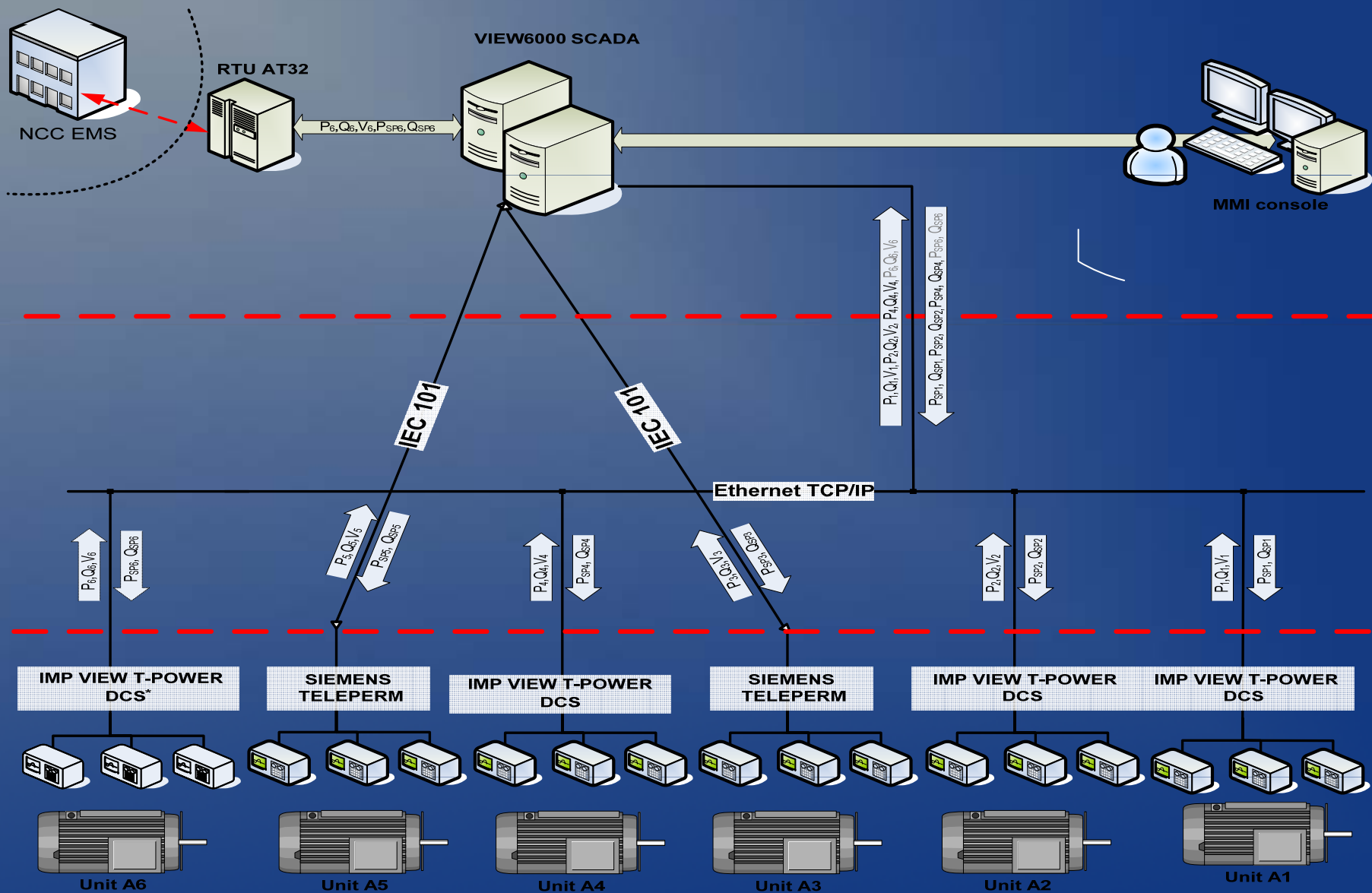
AGC IN SERBIA

- Within EMS National Control Centre there are two AGC systems available
 - AREVA *e-terra generation* (RTGEN)
 - IMP AGC 5.0 operating in framework of IMP VIEW6000 SCADA
 - Both systems are capable to operate with thermal units

MOTIVATION FOR INTRODUCTION OF THERMAL UNITS INTO AGC

- There are situations in which regulation with only hydro power units is not enough
 - *Example: State of high water when the hydroelectric power plants operate at maximum to avoid the overflow which may lead to lack of regulatory reserves and inability to perform secondary control*
- In 2009 the process of refurbishment of HPP Djerdap 1 and HPP Bajina Basta started simultaneously
- **Solution:** Introduce TPP into AGC
 - *TPP Nikola Tesla A SCADA/DCS system was recently modernized → obvious candidate for secondary control role*

OVERVIEW OF LOCAL CONTROL SYSTEM (SCADA/DCS) AT TPP "NIKOLA TESLA A"



PROCESS OF INTRODUCTION OF TENT A INTO AGC

- Each block is treated as separate control unit from point of view of AGC
- For TPP Nikola Tesla A introduction into AGC it was necessary to:
 - **At plant:**
 - Provide necessary wiring for remote commands from RTU AT32 to SCADA/DCS systems of each generating unit
 - Prepare local PLC logic to receive remote commands and execute them on local coordinated controller
 - **At EMS control centre:**
 - Modify SCADA/EMS database and model new control units
 - **Perform tuning of AGC unit control functions**
 -

AGC UNIT CONTROL TUNNING

- AGC unit control tuning is performed by observing response of the system to AGC controls and modifying tuning/model parameters to optimize performance
- Steps of tuning:
 - Measurement and control signal verification*
 - Unit Response Testing*
 - Plant controller control tuning*
 - AGC Area Level tuning*

Unit Response Testing

- Performed in **open loop** – raise/lower pulses are sent manually into series and response is recorded into Excel sheet.
- It is used to determine:

Pulse Calibration – Used to convert desired incremental MW change to millisecond contact closure control

Observed at A4: 0.91 MW/pulse (reference is block transformer MW not unit MW)

Response delay - This indicates the delay in the unit response after a signal has been sent.

Observed at A4: 352 sec

Example of unit response to series of raise/lower pulses

Unit reaches desired generation



Series of 10 raise pulses. Pulses are shown here in opposite direction due error in database.

The active power drop is due action of local coordinated control – in order to cope with steam pressure drop

Power at the start of test

Plant Controller Control Tuning

- Unit is controlled by AGC to manually entered unit-desired generation
- Desired generation is given a series of step changes
- Plant controller various parameters are adjusted
- Goal is quick unit response without sizable overshoot

AGC PLANT CONTROLLER DISPLAY

AGC Control Diagrams
ACE Allocation -- PLC Control Calculation --

SRB AGC ACE: -9 ON JRCM
Interchange - Current: S 124 Gen: 5114 Frequency: 49.985
Scheduled S 103 Load: 4990

PL: T_OBRENO Internal Mode/Priority: MAN / 1 MAN Tracking?: ACEPERM
PLC: G4 Control Status: MAN LMX: 285 LMN: 200

OPA: SRB Entered Mode/Priority: AV / 1

Per Cycle Rate
 Up: 0.000
 Dn: 0.000

PLC Tuning Chart

Regulation

Frequency Deviation: 0.035 HZ

DeadBand: 6.30 MW/1HZ

Frequency Bias: 0.035

Pending MW: 0.0

Effective: 0.0 / 0.0

Before/After: 0.0 / 0.0

Decaying: 0.0

Decrement: 0.000

% TAUREG for Wait: 100

% CAPMX for Decay Rate: 4

Change Reversal: 0 / 12

Noise Rejection: 0 / 40

Short-Term Up MW: 0 / 0

Short-Term Down MW: 0 / 0

Stored Energy Recovery Time (Up): 0

Stored Energy Recovery Time (Down): 0

Not Tracking Test Accum Deadband: 0

Not Tracking Test Accumulated MW: 0.0

Generation Last Not Tracking Test: 271.7

Pending Response Last Not Tracking Test: 0.0

	Up	Down
Calibration:	3.240	3.240
Short-Term Response Ratio:	1.0	1.0
Long-Term Response Ratio:	1.0	1.0
Short-Term Calibration Estimate:	3.240	3.240
Long-Term Calibration Estimate:	3.240	3.240

CONCLUSIONS

- First tests with TPP “Nikola Tesla A” unit A4 load frequency control, have shown satisfactory results.
- While it is significantly slower in response compared to hydro units, A4 is **fully capable** to participate into AGC
- Following steps will be to complete unit response testing and pulse calibration for units A3, A5 and A6, and then units will be introduced into test closed-loop operation

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