INTRODUCTION OF TERMAL 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

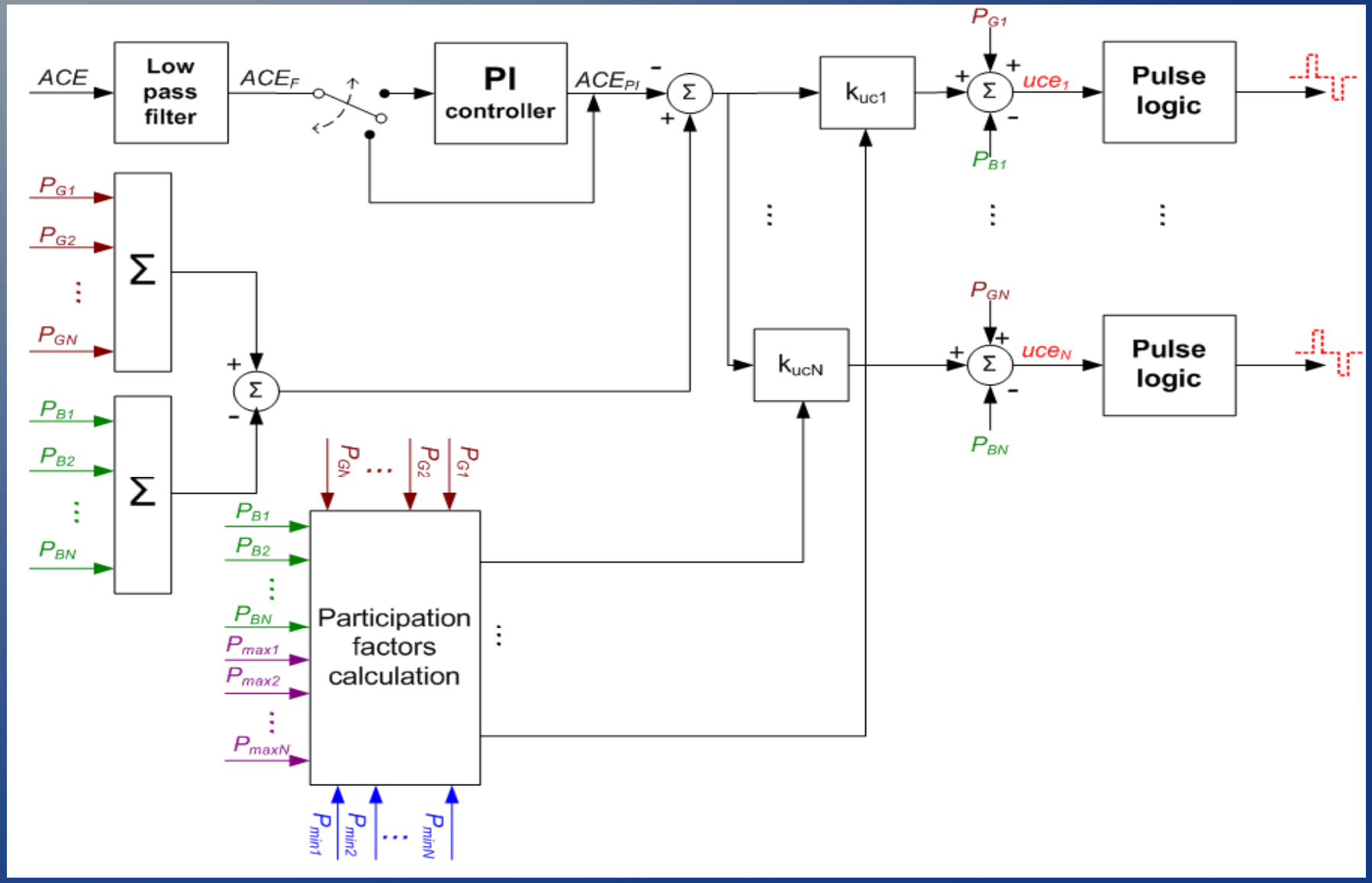
AGC OVERVIEW

- 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

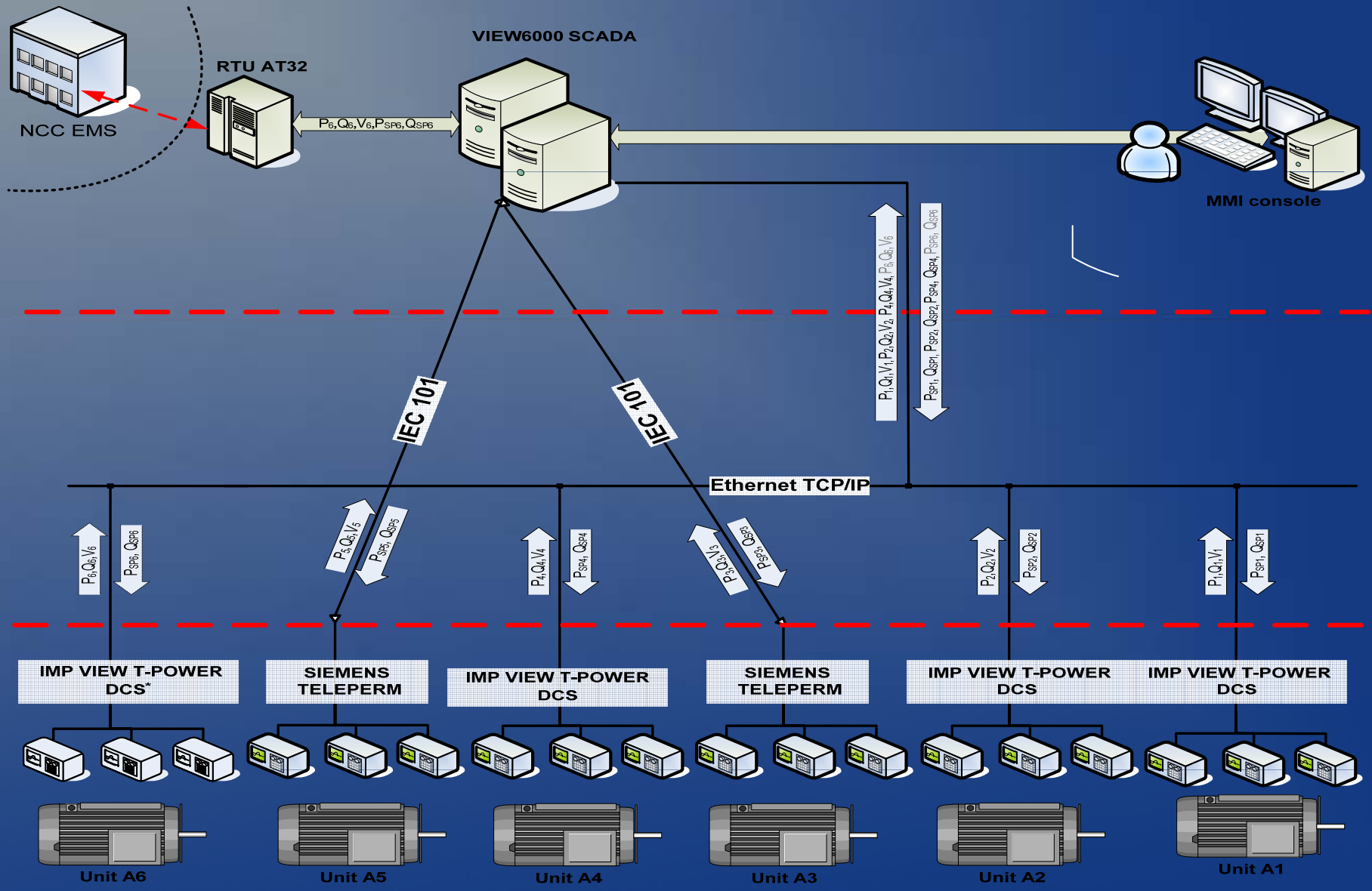
AGC IN SERBIA

- 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

Tuning Worksheet for TENT A4

AGC control cycle =		4		Pulse control				PLC name				Max MW= 285		MW/min= 2,1					valid tests		
TEST #	Pulse Width (msec)	# of Pulses	Total Pulse (sec)	Start Time	hour	min	sec	Start MW	Stop Time	hour	min	sec	Finish MW	Delta MW	MW per pulse	Observed Average Rate	Pulse Calib (MW/sec)	TAU MW	TAU MW Time	hour	min	sec	Resp Delay (sec)	Keep test 1 = Yes	Resp Delay (sec)	Pulse Calib (MW/sec)
1	-500	**6**	-3,00	21 sep 2010	11	50	32	269,5	11	53	0	263,6	-5,9	0,98	2,39	1,967	**265,8**	11	52	0	76	**1**	76	1,967
2	500	**10**	5,00		11	56	9	263,6	12	4	30	272,6	9	0,90	1,08	1,800	**269,3**	12	4	0	451	**1**	451	1,800
3	-500	**10**	-5,00		12	14	36	272,4	12	19	45	262,1	-10,3	1,03	2,00	2,060	**265,9**	12	18	30	214	**1**	214	2,060
4	500	**10**	5,00		12	22	24	262,1	12	35	23	269,2	7,1	0,71	0,55	1,420	**266,6**	12	33	52	668	**1**	668	1,420
5																										
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13																										
14																										
15																										
														Avg	**0,91**	1,504	1,812					352	4	**352**	**1,812**
do not delete gray areas																								Number of valid tests	Resp Delay (sec)	Pulse Calib (MW/sec)

PLC RESPONSE TESTS

	P initial	BP	Delta MW	Start Time	hour	min	sec	Stop Time	hour	min	sec	Finish MW	Delta MW	Delta time	MW/min
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															

Notes:

21.09.2010.

Test odziva A4 sa prepodesenom promenom po impulsu od 1MW umesto 2 MW.

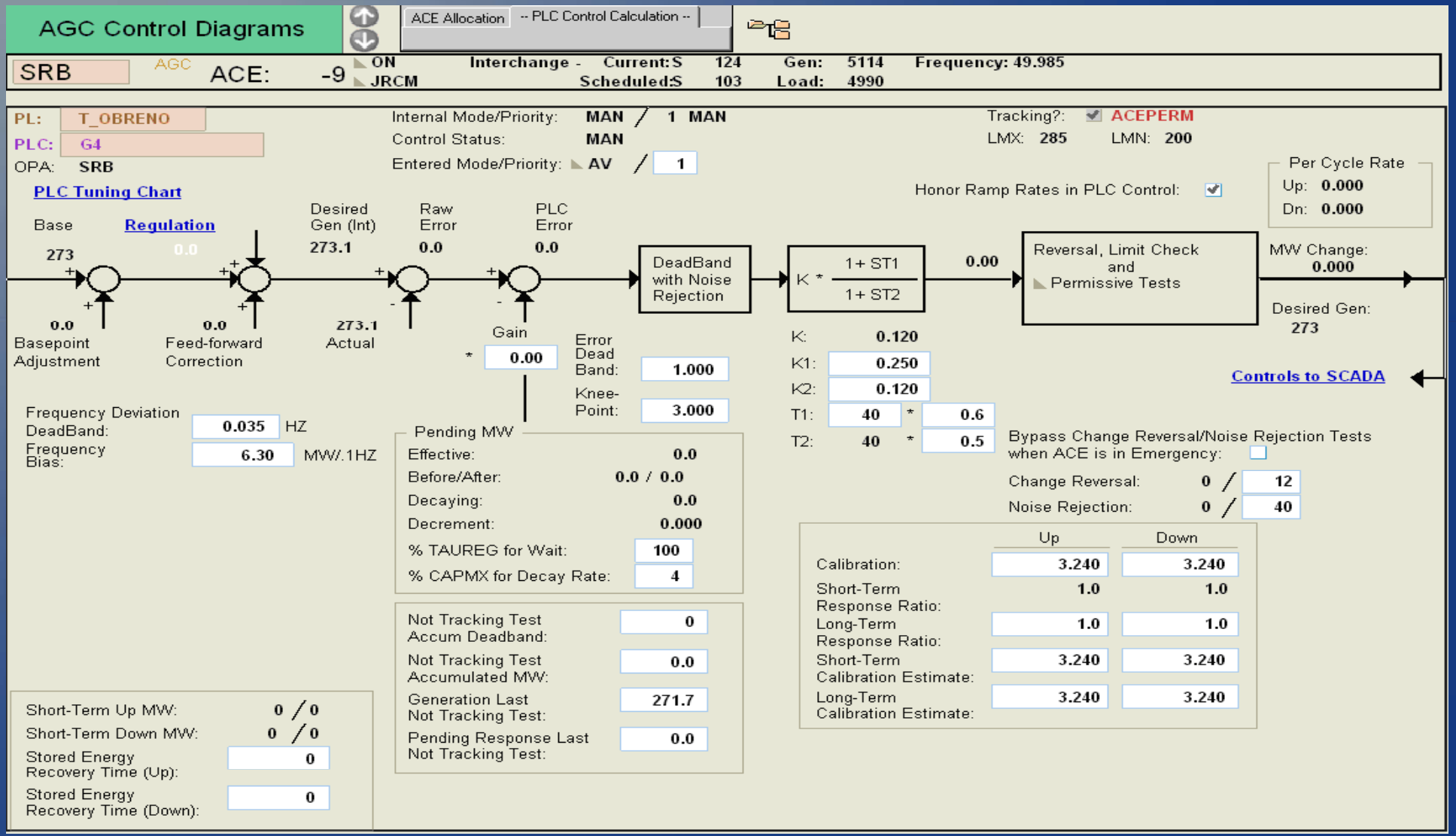
Vazno: test je radjen sa kontrasmerom

Example of unit response to series of raise/lower pulses

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



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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