CEN WORKS ON REAL TIME SIMULATION

SIMÓN VELOSO

COORDINADOR ELÉCTRICO NACIONAL (CEN, CHILEAN'S ISO)

USER SPOTLIGHT SERIES BY RTDS Technologies

CONTENTS

- Background
- Infrastructure
- Projects
  - Testing of System Integrity Protection Scheme (SIPS)
  - Chilean HVDC Model
  - Parameter Identification (standard models)
  - Hybrid Simulations

BACKGROUND

- According to a law modification in 2018, *"the Chilean ISO will have permanent resources to develop and to coordinate research in energy matters aiming to enhance the real time operation of the power system"*.

Specific goals to fulfil what was mandated by law:

- To contribute with new technologies
- To study the behaviour of equipment and to de-risk its operation before putting it in service
- To train employees in the theory and use of new technologies
- To promote research through collaboration with universities, study centers and consulting groups.

INFRASTRUCTURE

- NovaCor with 4 licensed cores
- GTNETx2 card
  - Port 1: 104, GOOSE, PLAYBACK, PMU, Socket
  - Port 2: DNP3, MODBUS, Socket
- Synchronizer
- Scope
- 2 amplifiers

- SEL-3555 (RTAC)
- SEL-2240 Axion

INFRASTRUCTURE

DSATools™ Powertech

- PSAT (Static)
- TSAT (RMS)
- TRI (TSAT-RTDS Interface)

PROJECTS: SIPS

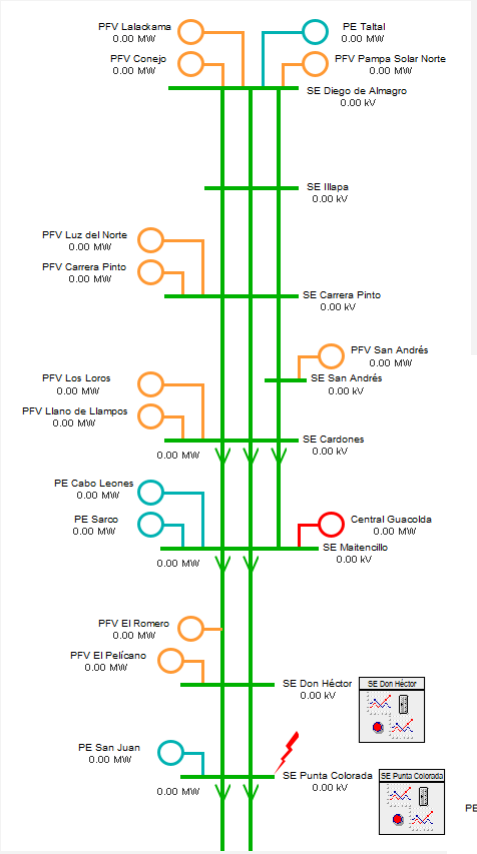
System Integrity Protection Scheme

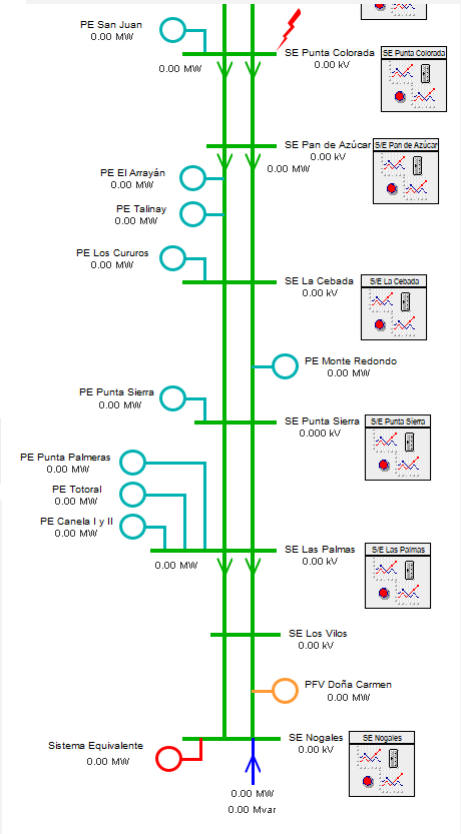
Also known as Remedial Action Scheme (RAS) by NERC

Equipment RTAC SEL-3555

Programming software SEL AcSELerator RTAC

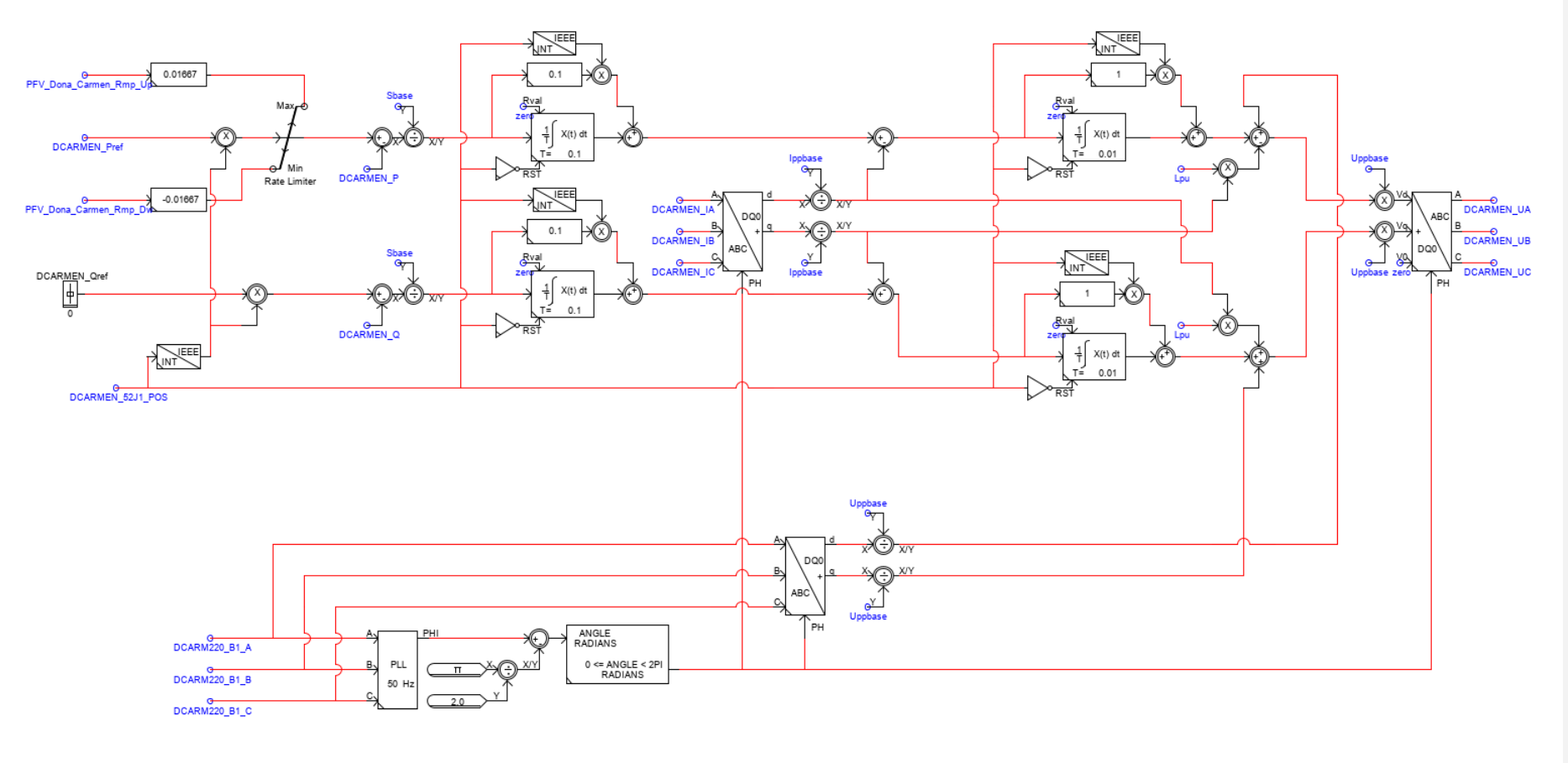
GTNETx2 DNP3 port



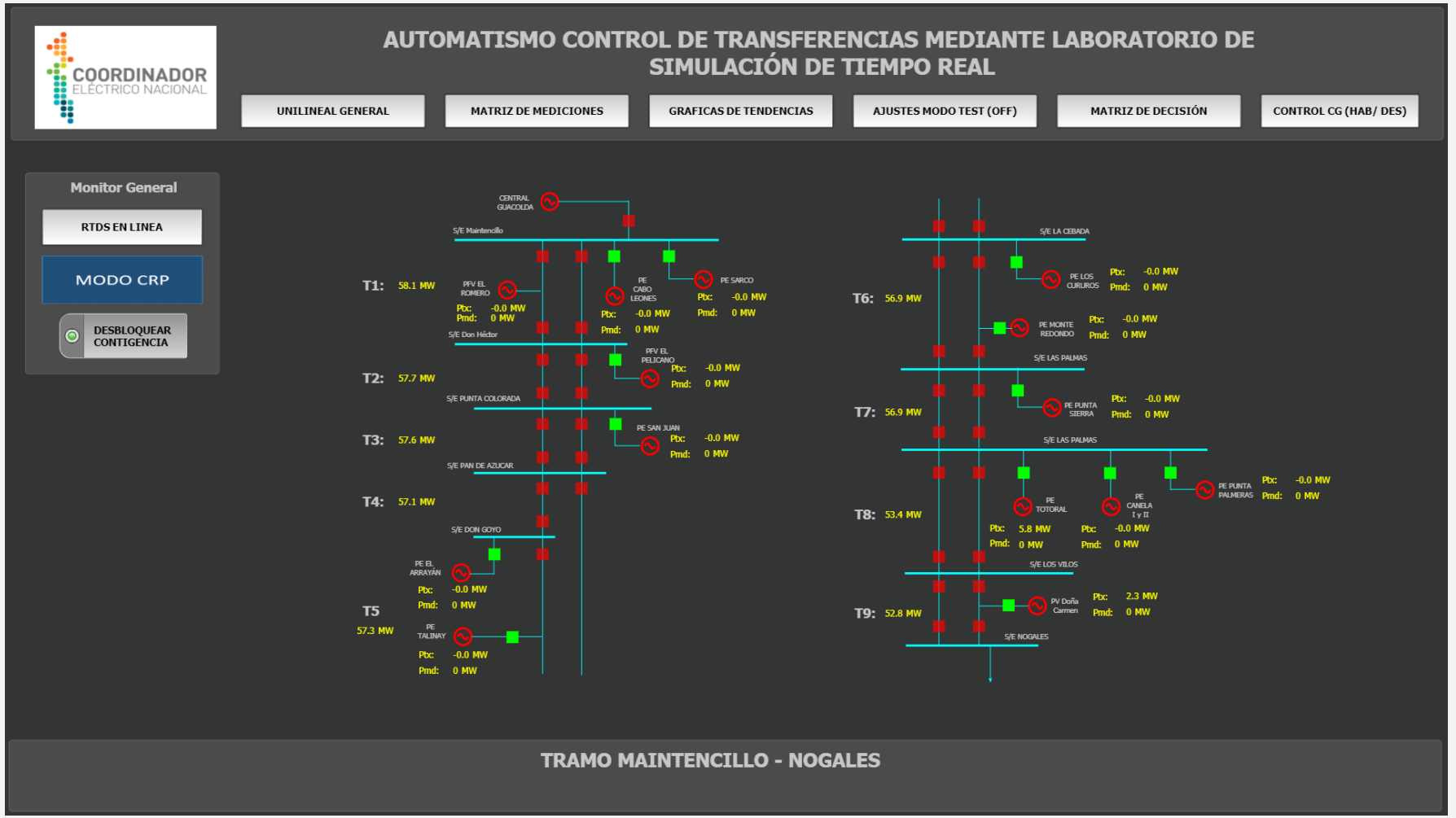


PROJECTS: SIPS

- Renewable power plant simplified model



PROJECTS: SIPS



PROJECTS: SIPS

AUTOMATISMO CONTROL DE TRANSFERENCIAS MEDIANTE LABORATORIO DE SIMULACIÓN DE TIEMPO REAL

UNILINEAL GENERAL | MATRIZ DE MEDICIONES | GRAFICAS DE TENDENCIAS | AJUSTES MODO TEST (OFF) | MATRIZ DE DECISIÓN | CONTROL CG (HAB/ DES)

MATRIZ DE MEDICIÓN

	PE Taltal	PE Cabo Leones	PE Sarco	PE San Juan	PE Arrayan	PE Talinay	PE Los Cururos	PE Monte Redondo	PE Punta Sierra	PE Totoral	PE Canela	PE Punta Palmeras	PFV Conejo	PFV Pampa Solar Norte	PFV Lalackama	PFV Luz del Norte	PFV Carrera Pinto	PFV San Andres	PFV Los Loros	PFV Llano de Llampos	PFV El Romero	PFV El Pelicano	PFV Dona Carmen	CT Guacolda
Potencia Generada (PGi)	-0.0	-0.0	11.3	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	5.8	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	4.3	-0.0	-0.0	9	-0.0	2.3	61
Generación disponible (MGDi)	0	0	156.6	0	0	0	0	0	0	-5.8	0	0	0	0	0	0	0	45.6	0	0	186.9	0	-2.3	688.9

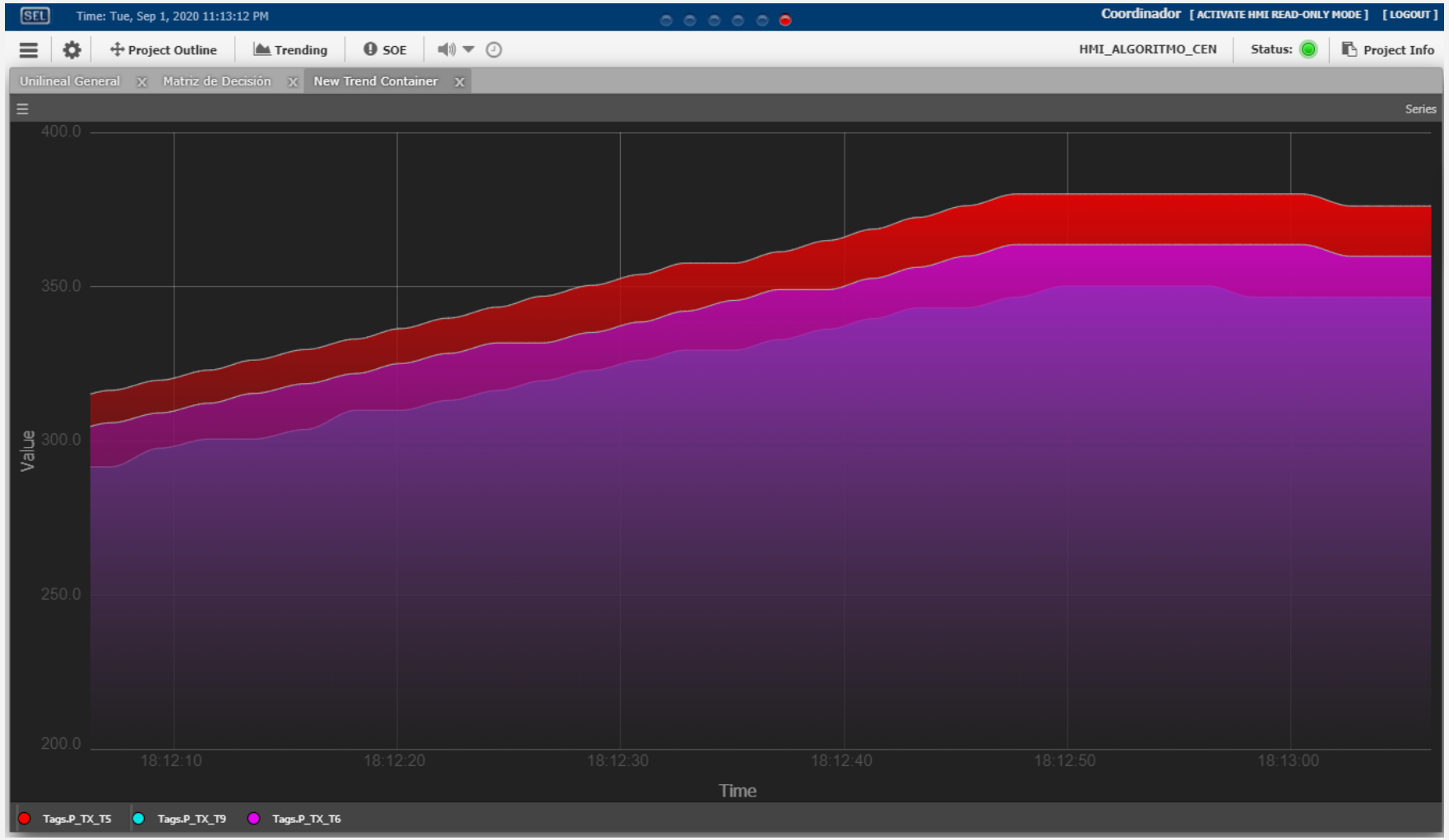
MATRIZ DE DECISIÓN

TRAMO						SOLAR			EOLICO		MARGENES INDIVIDUALES																							
		TX	LO	MTD	DAG?	GSN	GDTSN	MDGSN	GEN	MDGEN	PE Taltal	PE Cabo Leones	PE Sarco	PE San Juan	PE Arrayan	PE Talinay	PE Los Cururos	PE Monte Redondo	PE Punta Sierra	PE Totoral	PE Canela	PE Punta Palmeras	PFV Conejo	PFV Pampa Solar Norte	PFV Lalackama	PFV Luz del Norte	PFV Carrera Pinto	PFV San Andres	PFV Los Loros	PFV Llano de Llampos	PFV El Romero	PFV El Pelicano	PFV Dona Carmen	CT Guacolda
1	Maitencillo - Don Héctor	61.2	395	333.7	0	2	145	241	7	160	0	0	188.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0
2	Don Héctor - Punta Colorada	62.4	395	332.5	0	4	241	241	7	160	0	0	91.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0
3	Punta Colorada - Pan de Azúcar	62.6	395	332.3	0	4	241	241	7	160	0	0	91.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0
4	La Cebada - Don Goyo	61.7	395	333.2	0	2	120	241	3	160	0	0	425.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0
5	La Cebada - Pan de Azúcar	62.3	448	385.6	0	2	120	241	3	160	0	0	530.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0
6	La Cebada - Punta Sierra	61.8	448	386.1	0	4	241	241	7	160	0	0	144.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0
7	Punta Sierra - Las Palmas	61.8	448	386.1	0	4	241	241	7	160	0	0	144.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0
8	Las Palmas - Los Vilos	57.6	448	390.3	0	4	241	241	7	160	0	0	149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0
9	Los Vilos - Nogales	57	448	390.9	0	4	241	241	7	160	0	0	149.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.9	0	0	191.3	0	0	0

	PE Taltal	PE Cabo Leones	PE Sarco	PE San Juan	PE Arrayan	PE Talinay	PE Los Cururos	PE Monte Redondo	PE Punta Sierra	PE Totoral	PE Canela	PE Punta Palmeras	PFV Conejo	PFV Pampa Solar Norte	PFV Lalackama	PFV Luz del Norte	PFV Carrera Pinto	PFV San Andres	PFV Los Loros	PFV Llano de Llampos	PFV El Romero	PFV El Pelicano	PFV Dona Carmen	CT Guacolda
Margen Definitivo (DFi)	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47.9	0	0	189.3	0	0	0
Orden de Desconexión (DAGFi)	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

Vectores definitivos de Márgenes de Inyección y Órdenes de desconexión en Régimen Permanente

PROJECTS: SIPS



PROJECTS: SIPS

Busbar Frequency

Individual Renewable Power Plants Inputs

- Available power (wind speed or sunlight radiation)
- Load rate of change limiter [MW/s]
- Enabler of remote control
- Manual braker closing

Local synchronous machine control

PROJECTS: SIPS

Equivalent Machine

RMS Model (Hybrid Simulation)

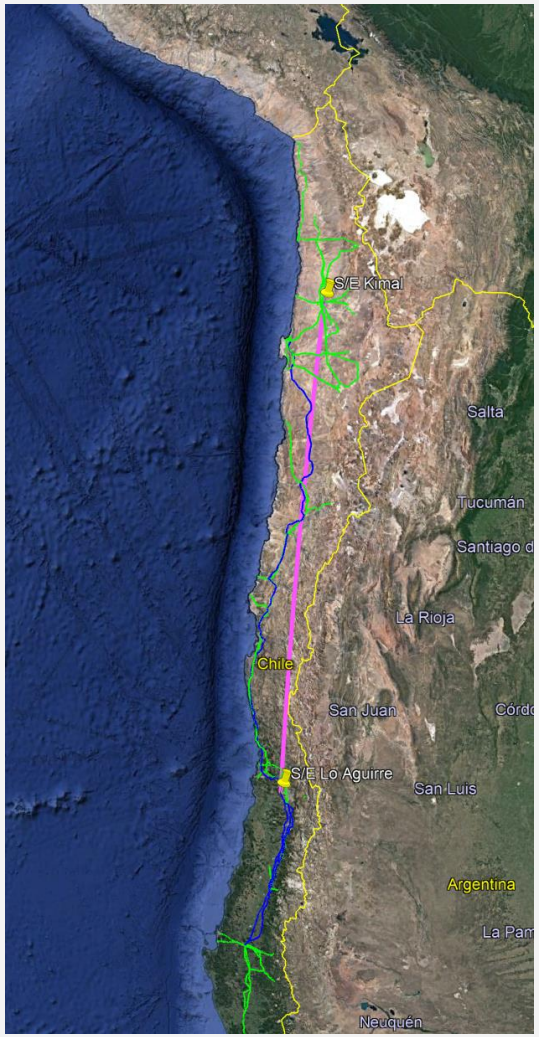
Distributed VAR compensators

PROJECTS: SIPS

Remarks

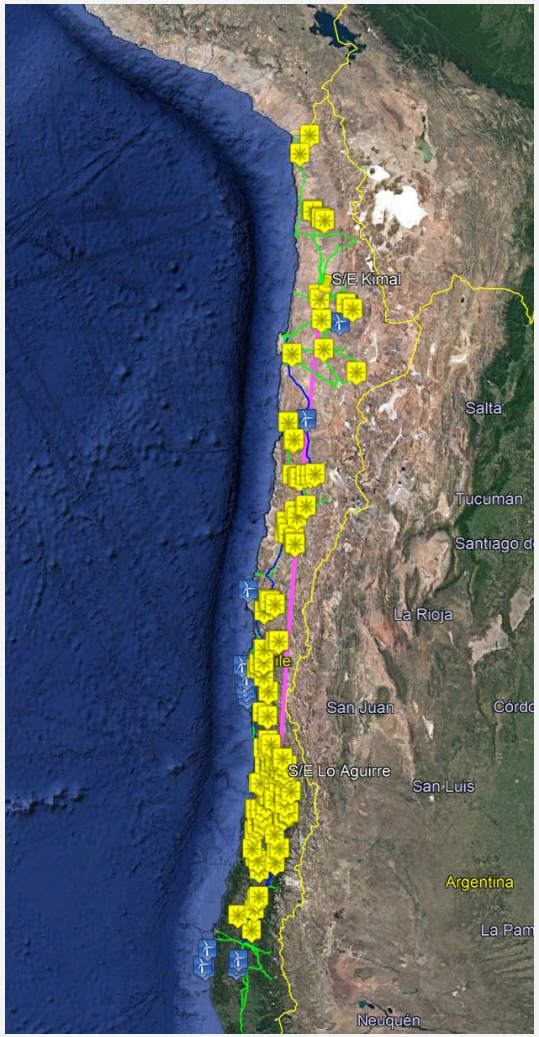
- Hardware in the loop testing.
- Assessment of the dynamic and steady state performance of a high level algorithm (wide area).
- Future algorithms will be tested in the RTDS platform to increase its reliability.
- Upcoming algorithms will include simultaneously optimization of transmission lines ampacity as well as wide area voltage or reactive power control.
- The flexibility of the RTDS will allow testing of different communication protocols or equipment.

PROJECTS: CHILEAN HVDC MODEL



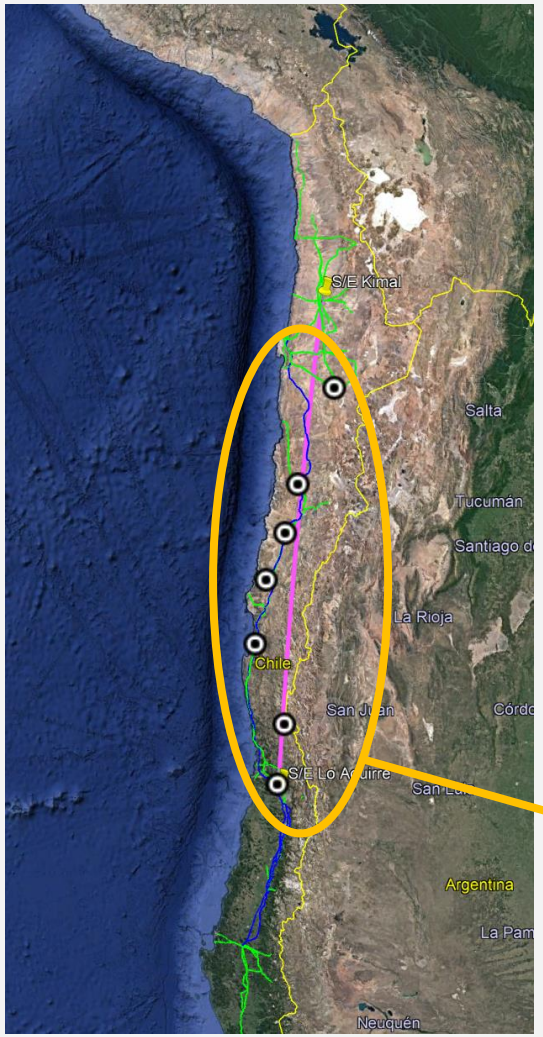
- Bipole HVDC ± 600 kV
- ~ 1500 km
- Two terminals
- Converter stations of 2000 MW
- Scheduled for 2027

PROJECTS: CHILEAN HVDC MODEL



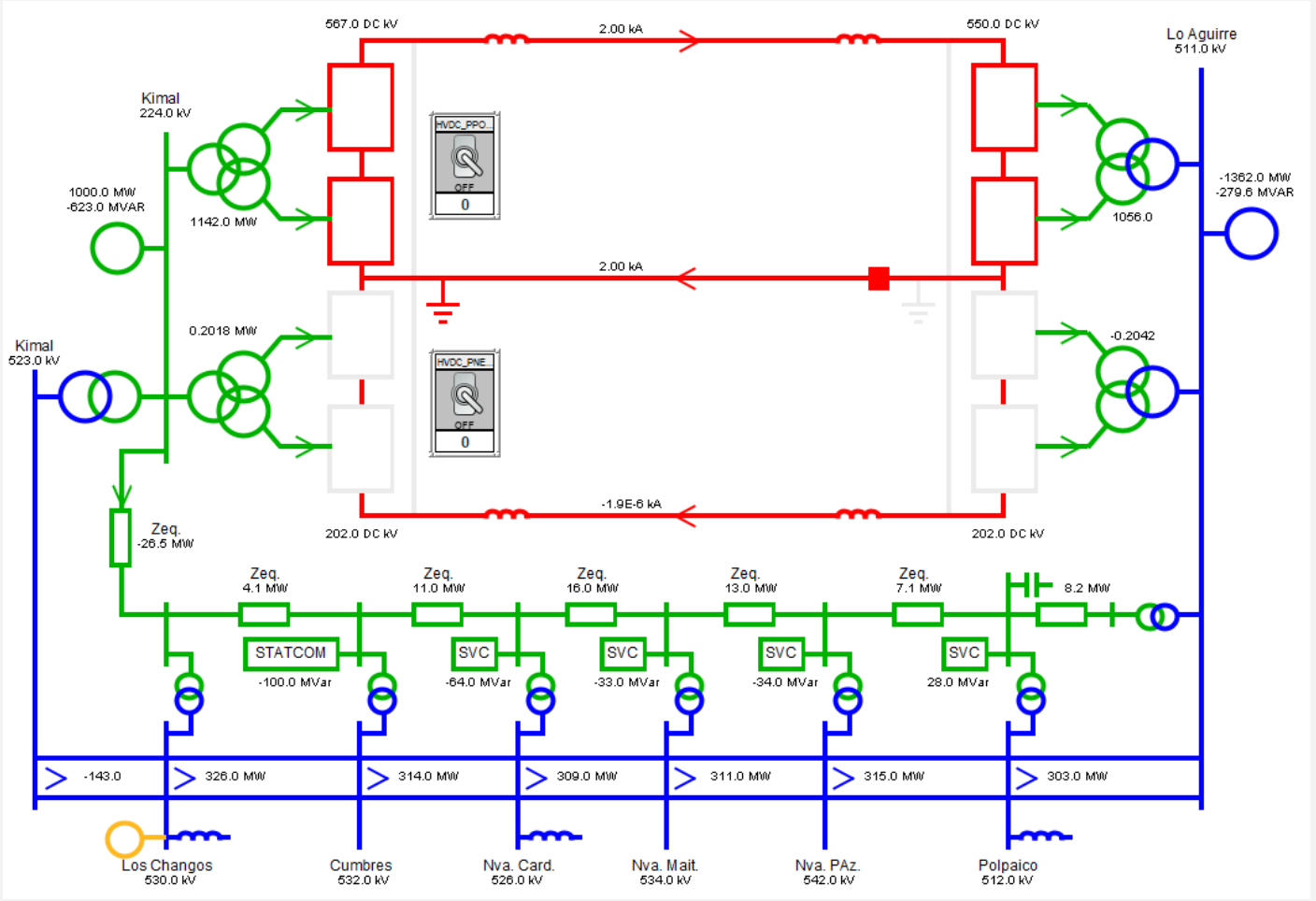
- Bipole HVDC ± 600 kV
- ~ 1500 km
- Two terminals
- Converter stations of 2000 MW
- Scheduled for 2027

PROJECTS: CHILEAN HVDC MODEL

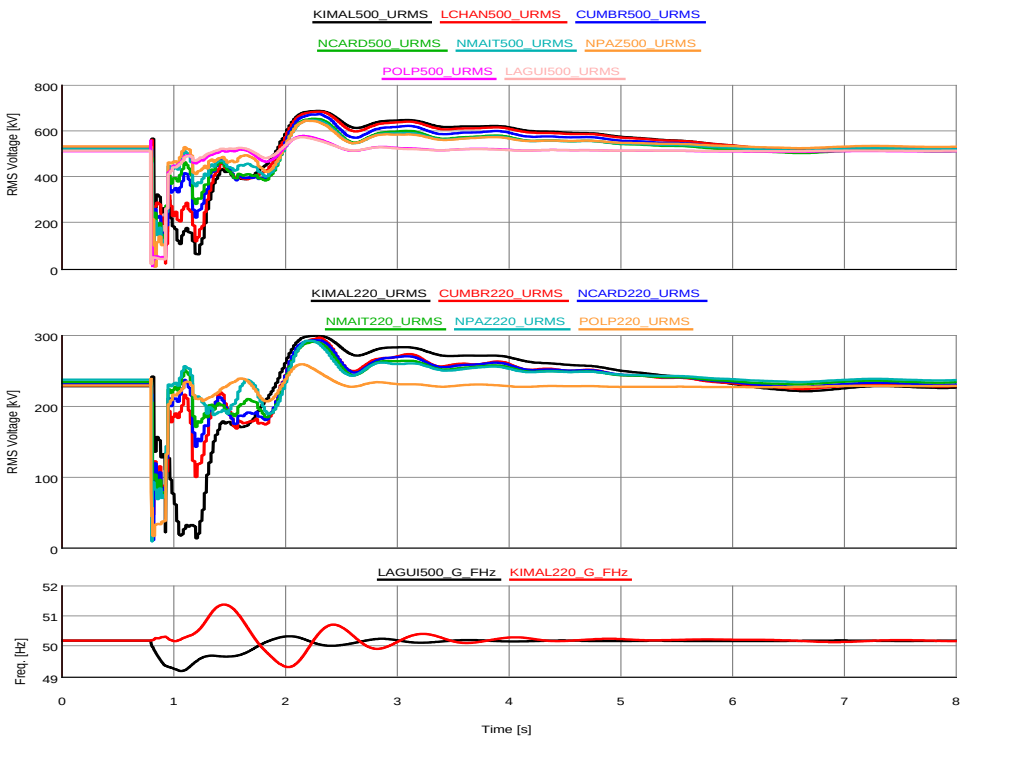


- Bipole HVDC ± 600 kV
- ~ 1500 km
- Two terminals
- Converter stations of 2000 MW
- Scheduled for 2027
- Distributed VAR Compensation (SVC and STATCOM)

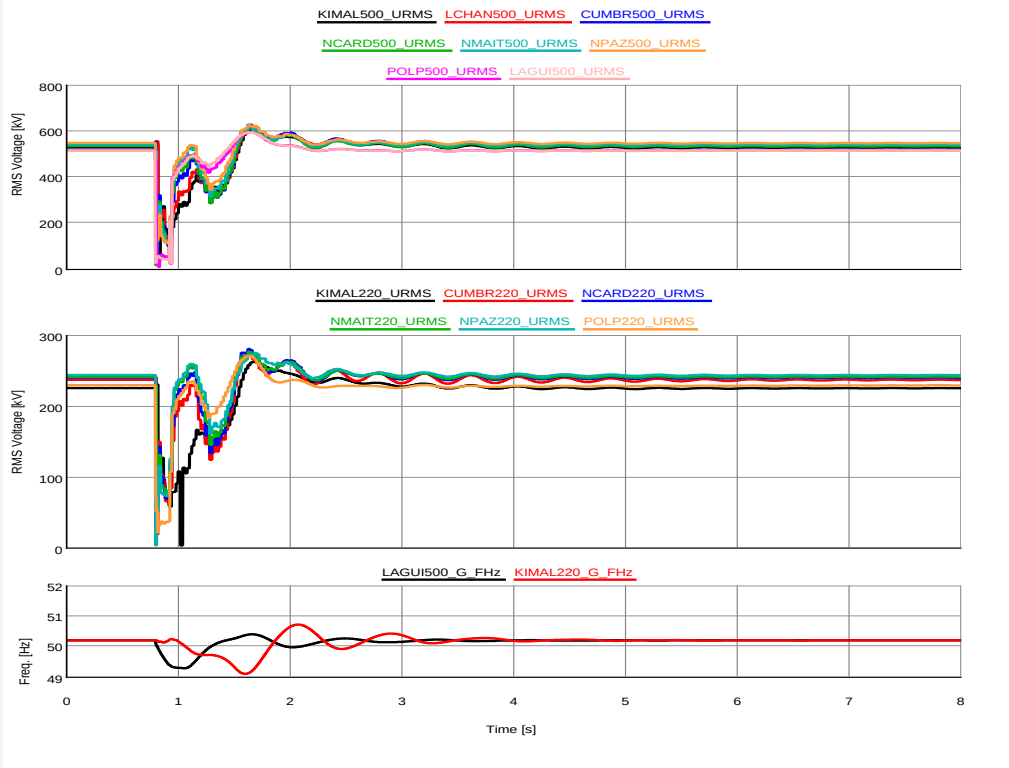
PROJECTS: CHILEAN HVDC MODEL



PROJECTS: CHILEAN HVDC MODEL

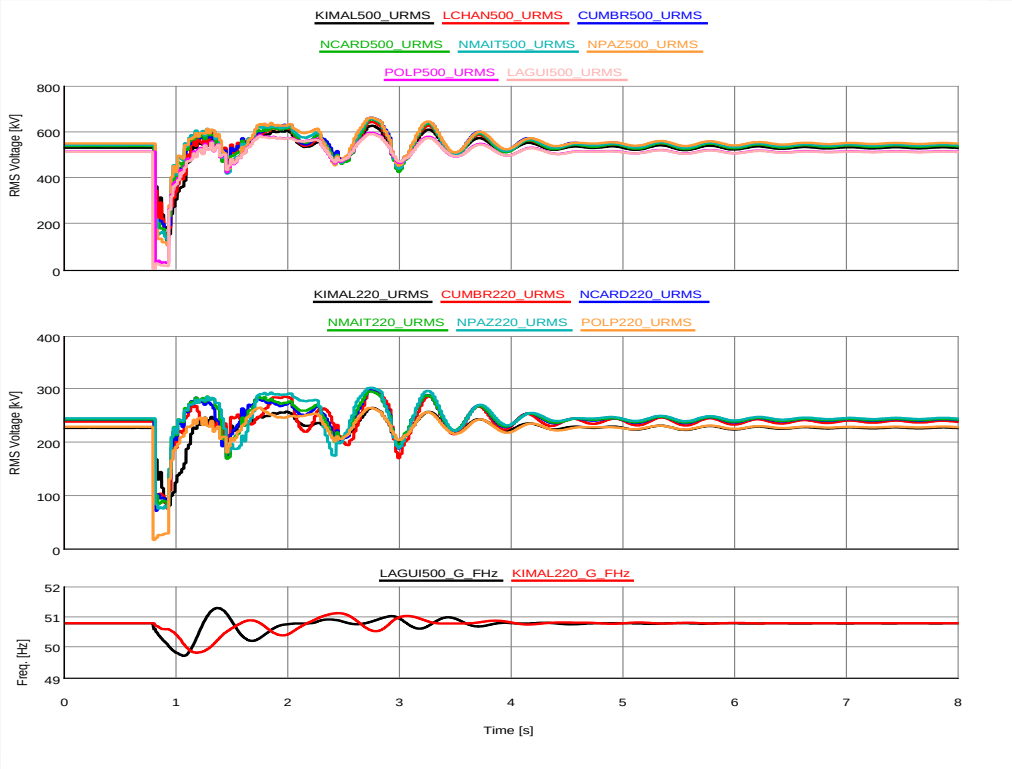


3ph short circuit at Lo Aguirre 500 kV
HVDC out of service



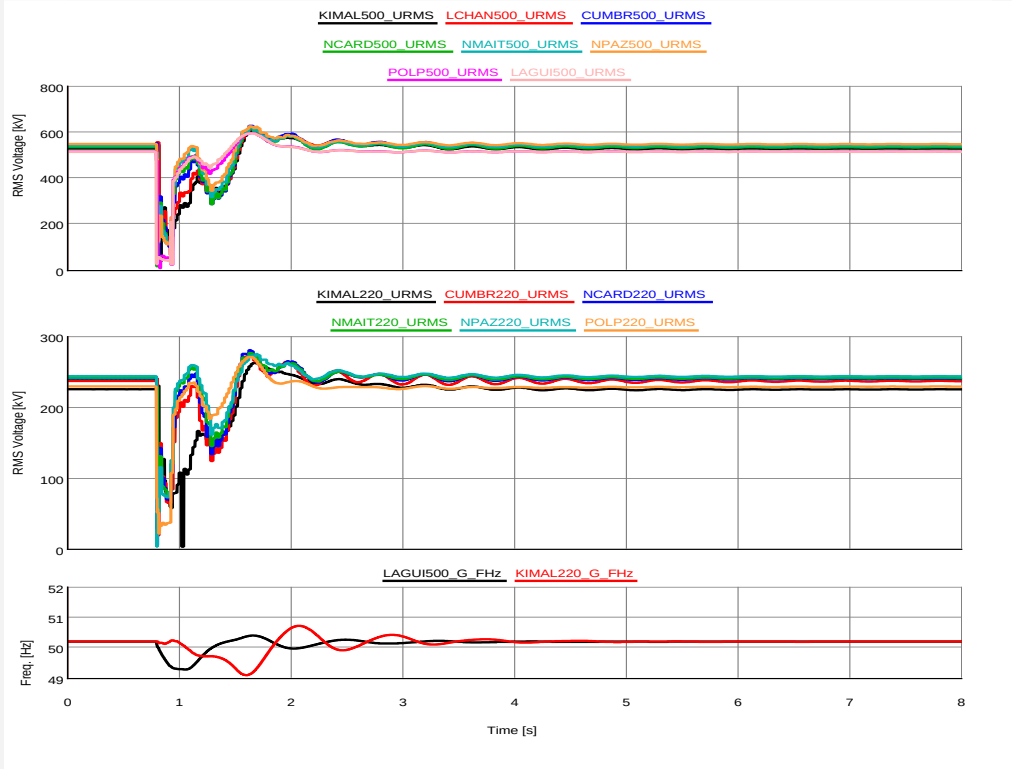
3ph short circuit at Lo Aguirre 500 kV
HVDC in service

PROJECTS: CHILEAN HVDC MODEL



HVDC link in service

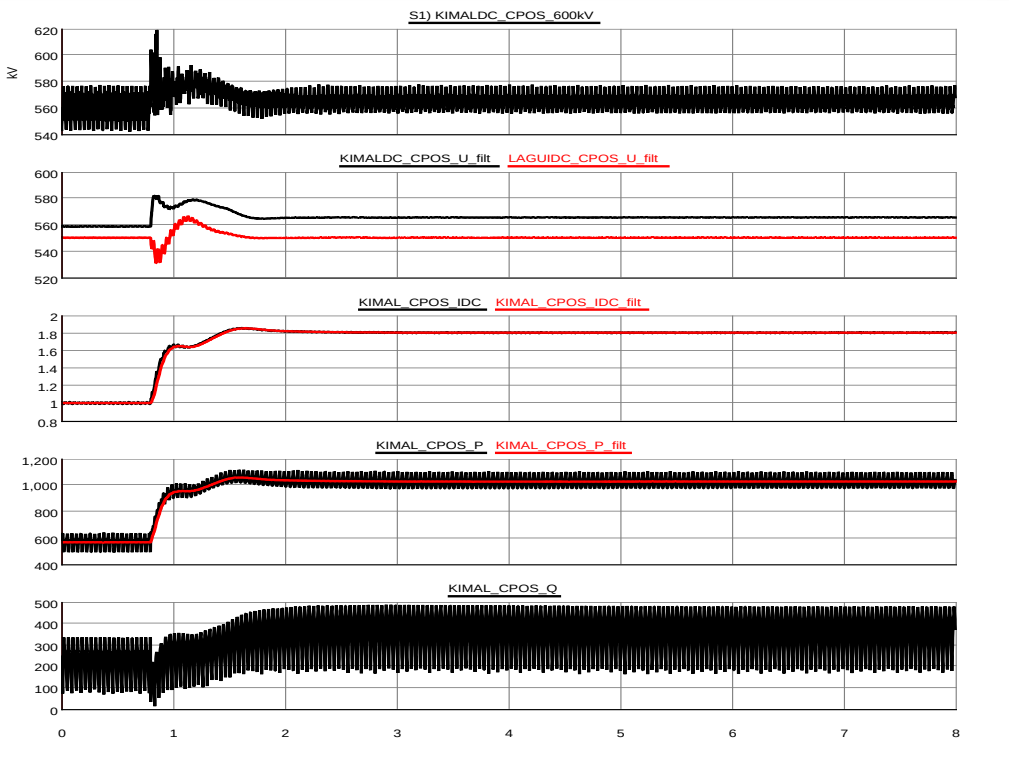
SCR = 4 (at rectifier station)

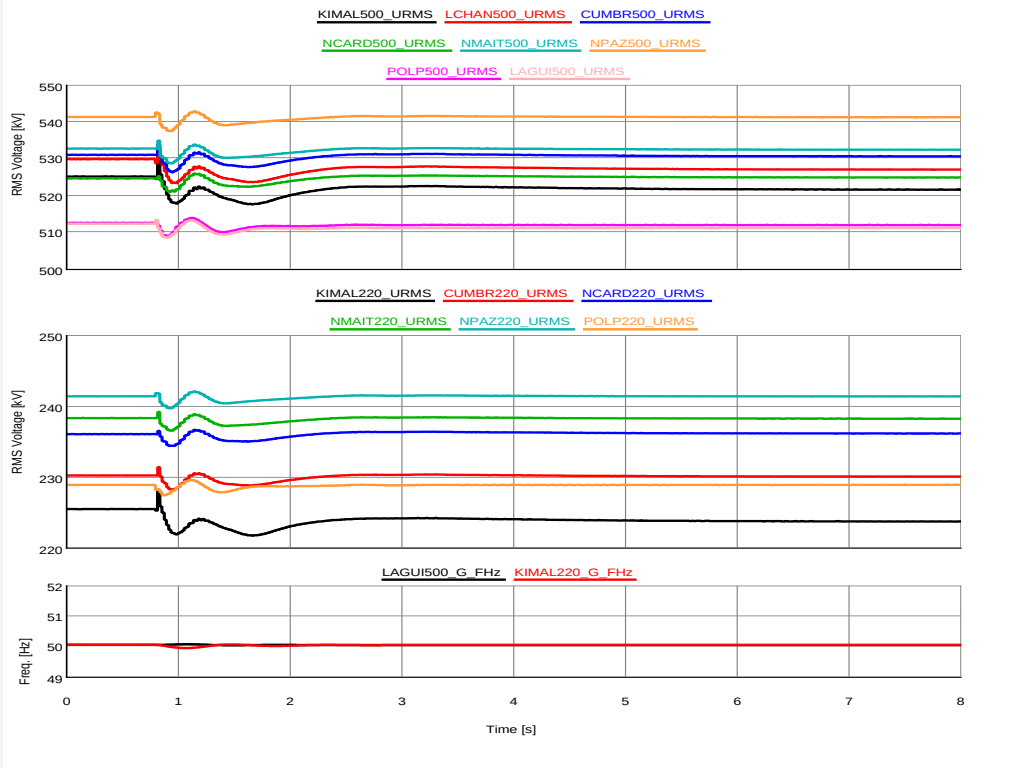


HVDC link in service

SCR = 12.5 (at inverter station)

PROJECTS: CHILEAN HVDC MODEL



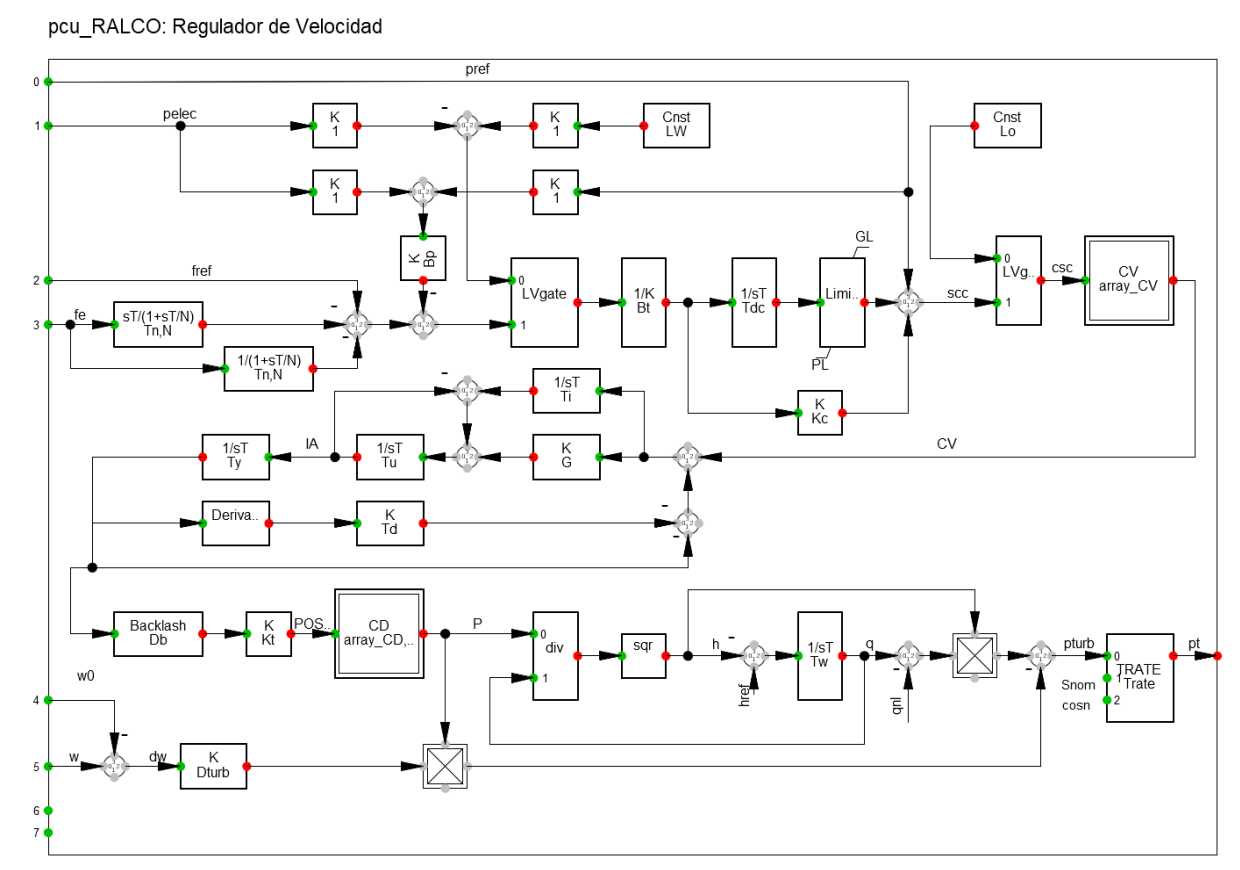


PROJECTS: PARAMETER IDENTIFICATION (STANDARD MODELS)

About 300 models in the Chilean official RMS database

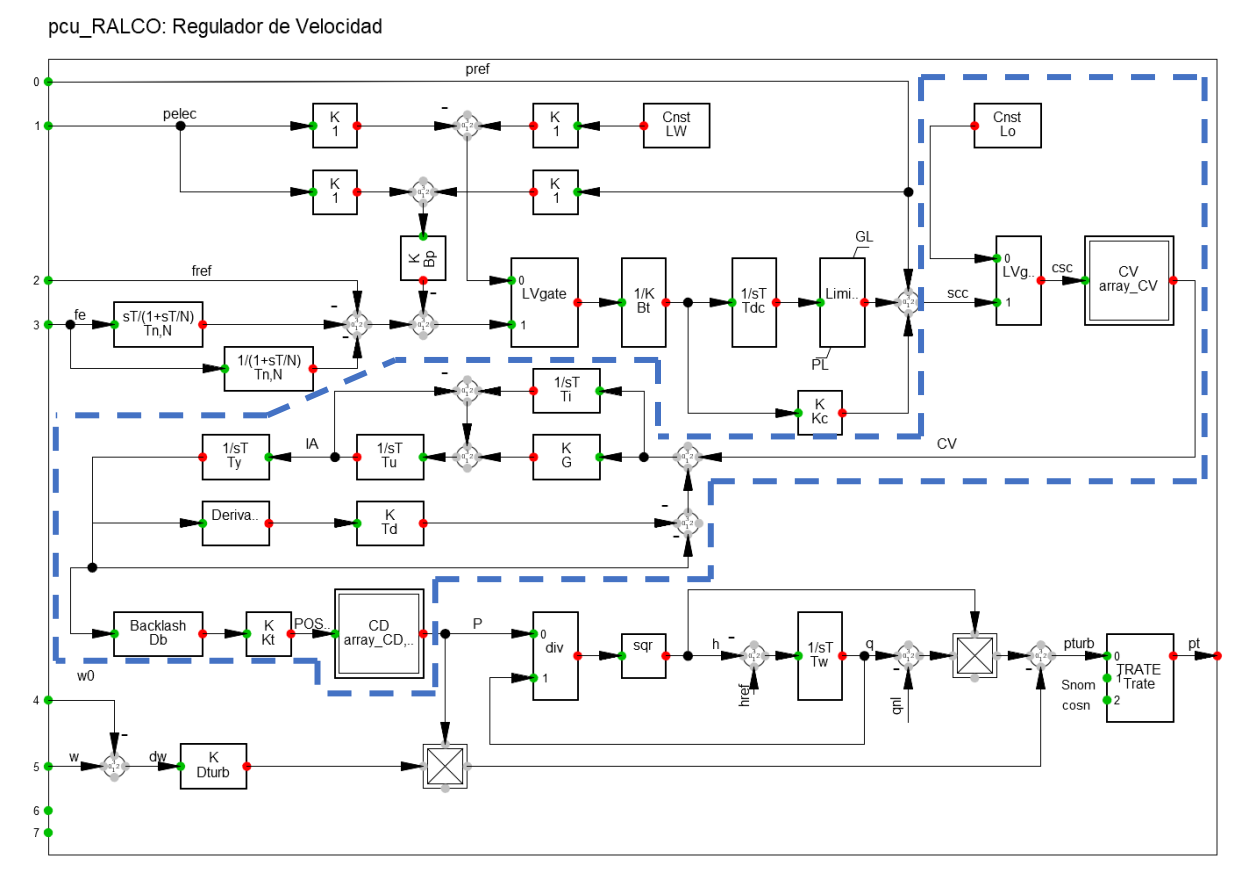
- Synchronous machines (govs, avr, pss, uel and oel)
  - Hydraulic
  - Steam turbines
  - Combined cycle
- Based in power electronics:
  - Wind generators
  - Photovoltaic
  - Solar thermal
  - STATCOMs and SVCs

PROJECTS: PARAMETER IDENTIFICATION (STANDARD MODELS)



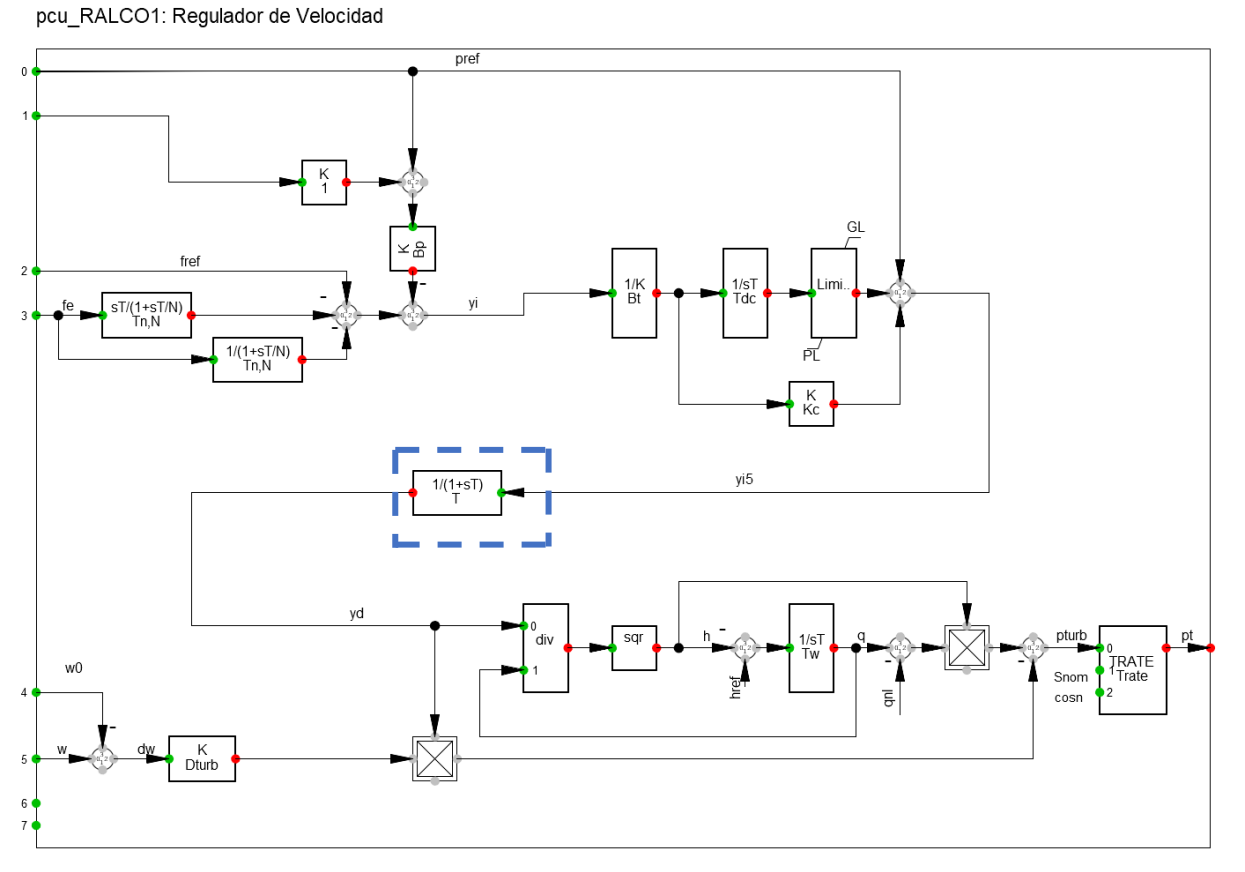
- Modeled in 2005
- PowerFactory (DIgSILENT)

PROJECTS: PARAMETER IDENTIFICATION (STANDARD MODELS)



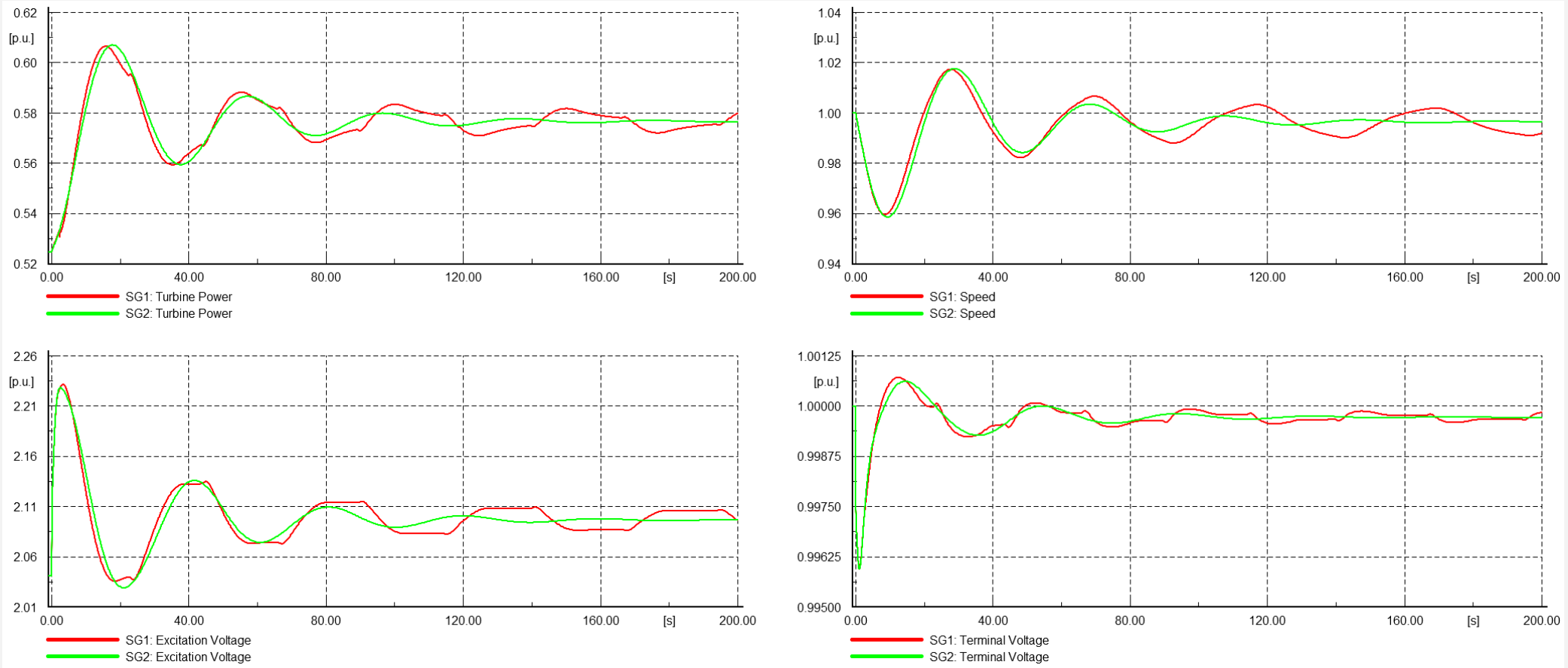
- Modeled in 2005
- PowerFactory (DIgSILENT)
- Out of TSAT standard models
- Due to valve position modeling

PROJECTS: PARAMETER IDENTIFICATION (STANDARD MODELS)

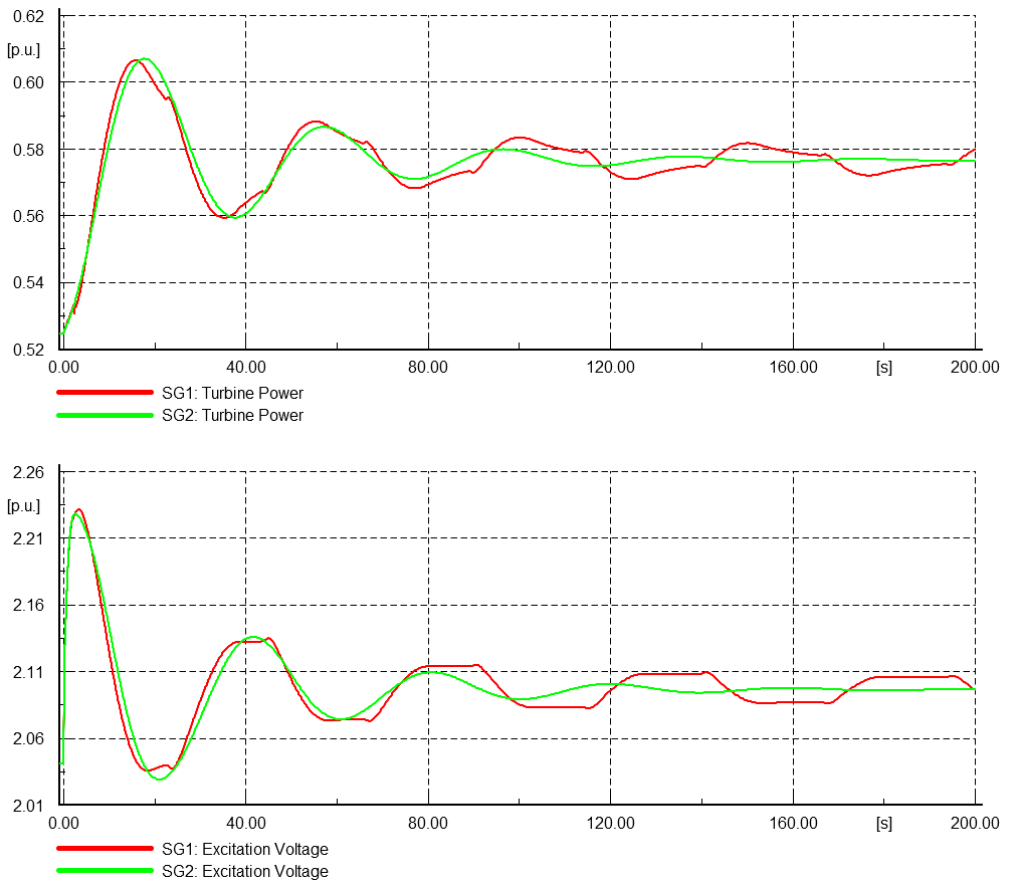


- Modeled in 2005
- PowerFactory (DIgSILENT)
- Out of TSAT standard models
- Due to valve position modeling
- Search for the equivalent model (parameter identification)

PROJECTS: PARAMETER IDENTIFICATION (STANDARD MODELS)

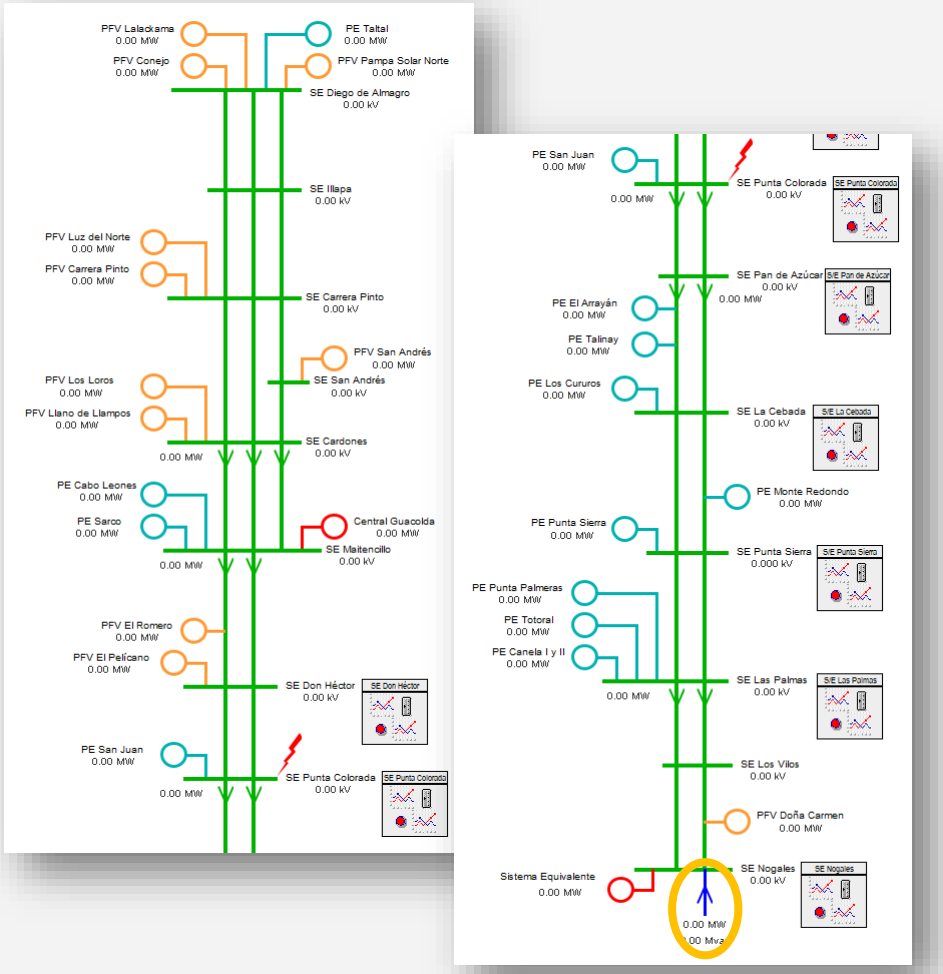


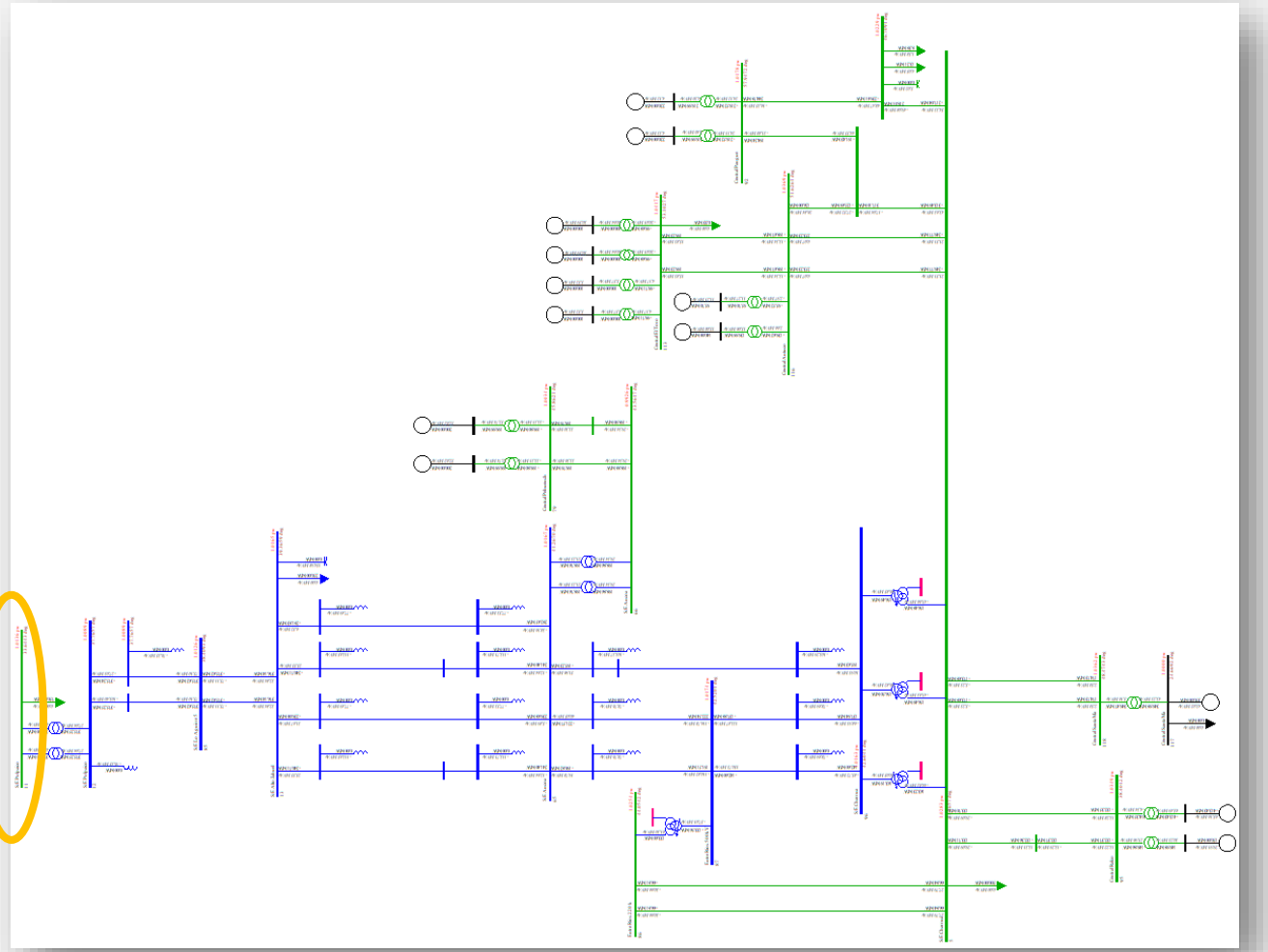
PROJECTS: PARAMETER IDENTIFICATION (STANDARD MODELS)



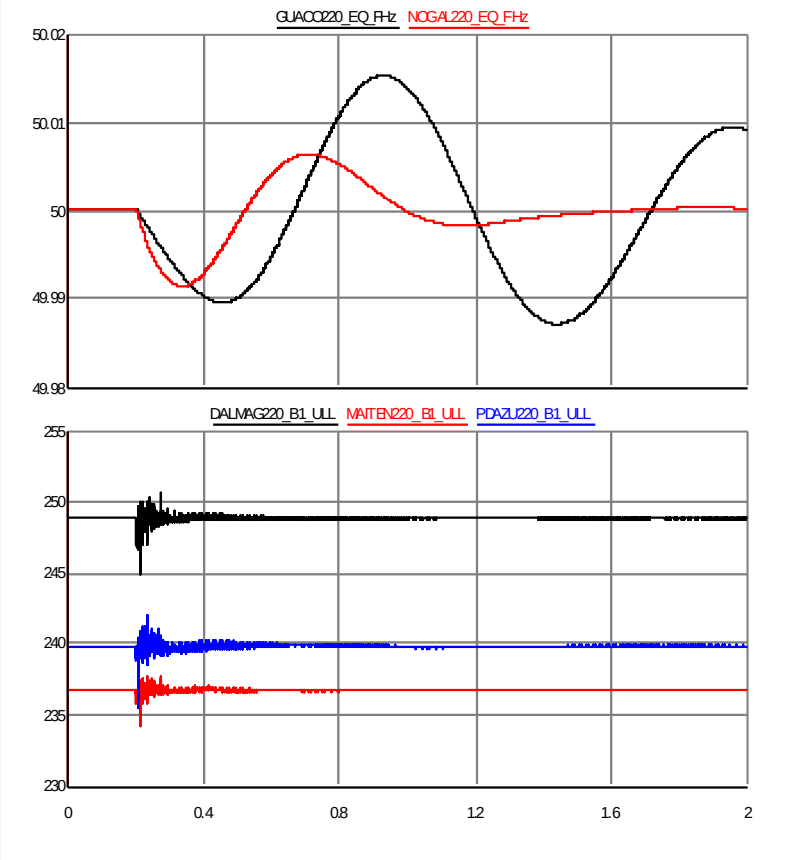
- Particle Swarm Optimization (PSO)
- Equivalent dynamic models could be obtained massively
- It will allow consultants to access the power system database in a standard form

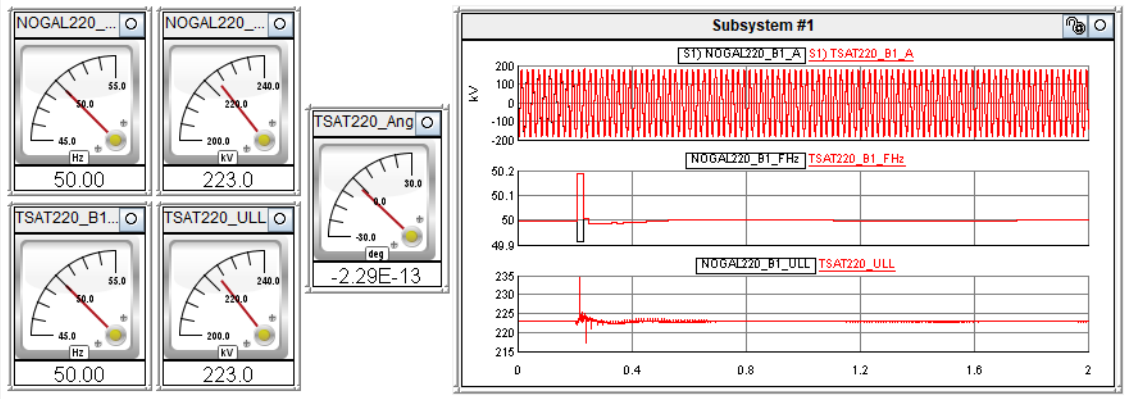
PROJECTS: HYBRID SIMULATIONS

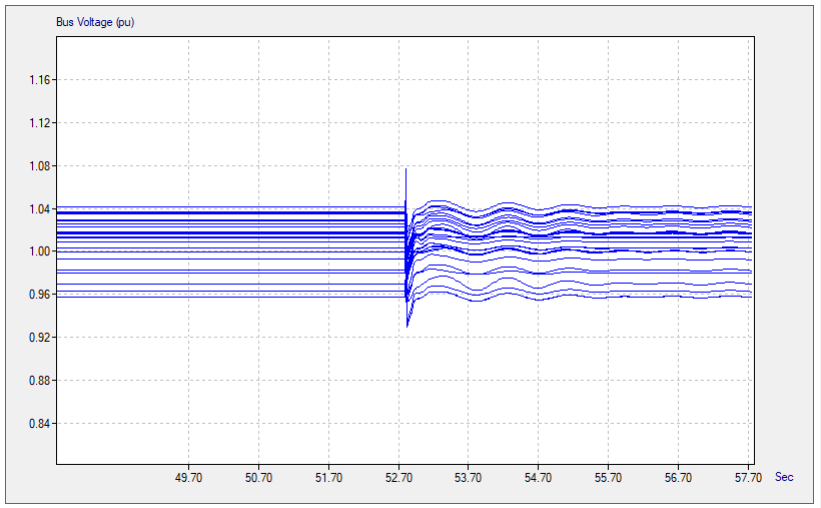




PROJECTS: HYBRID SIMULATIONS

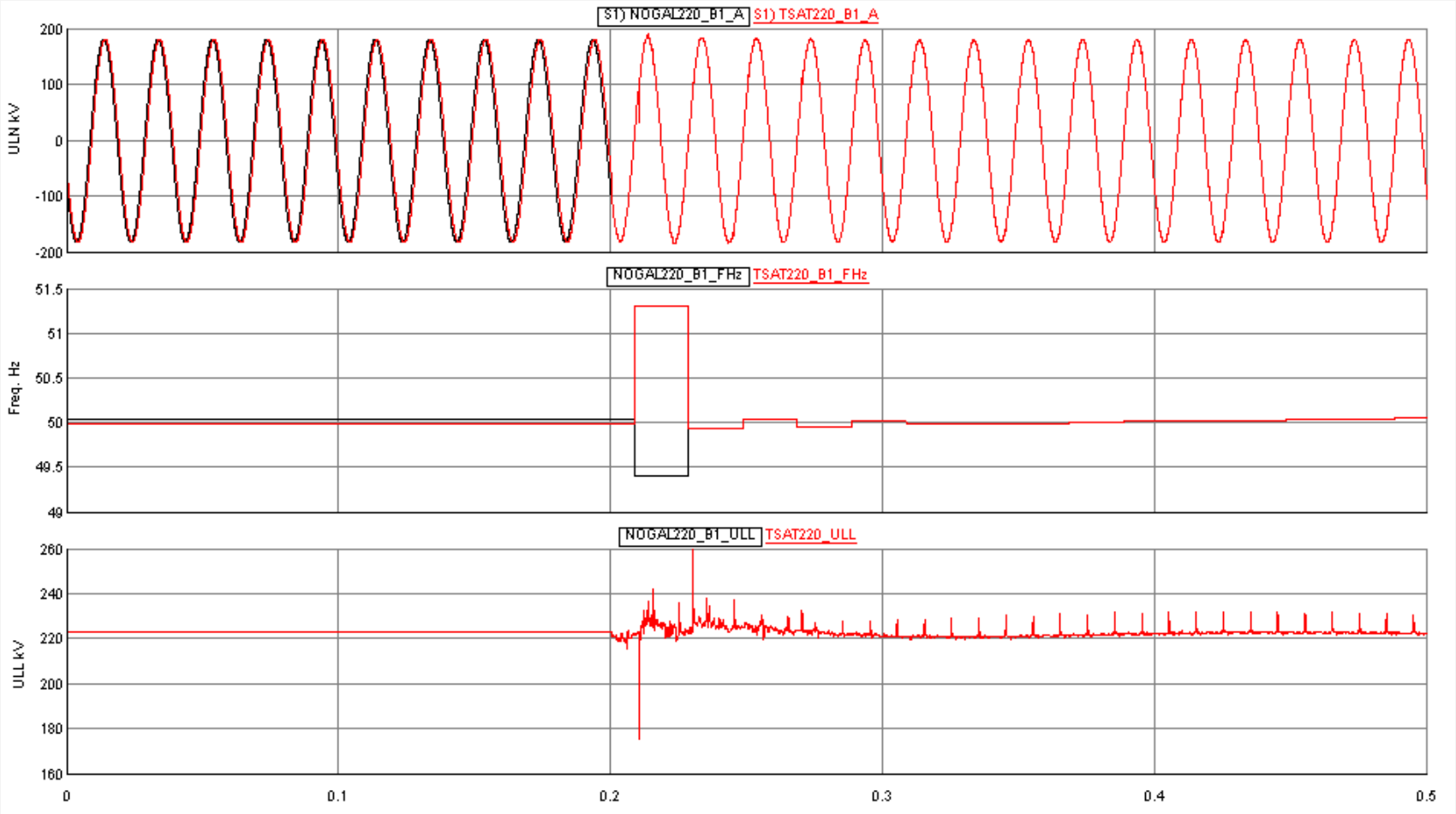




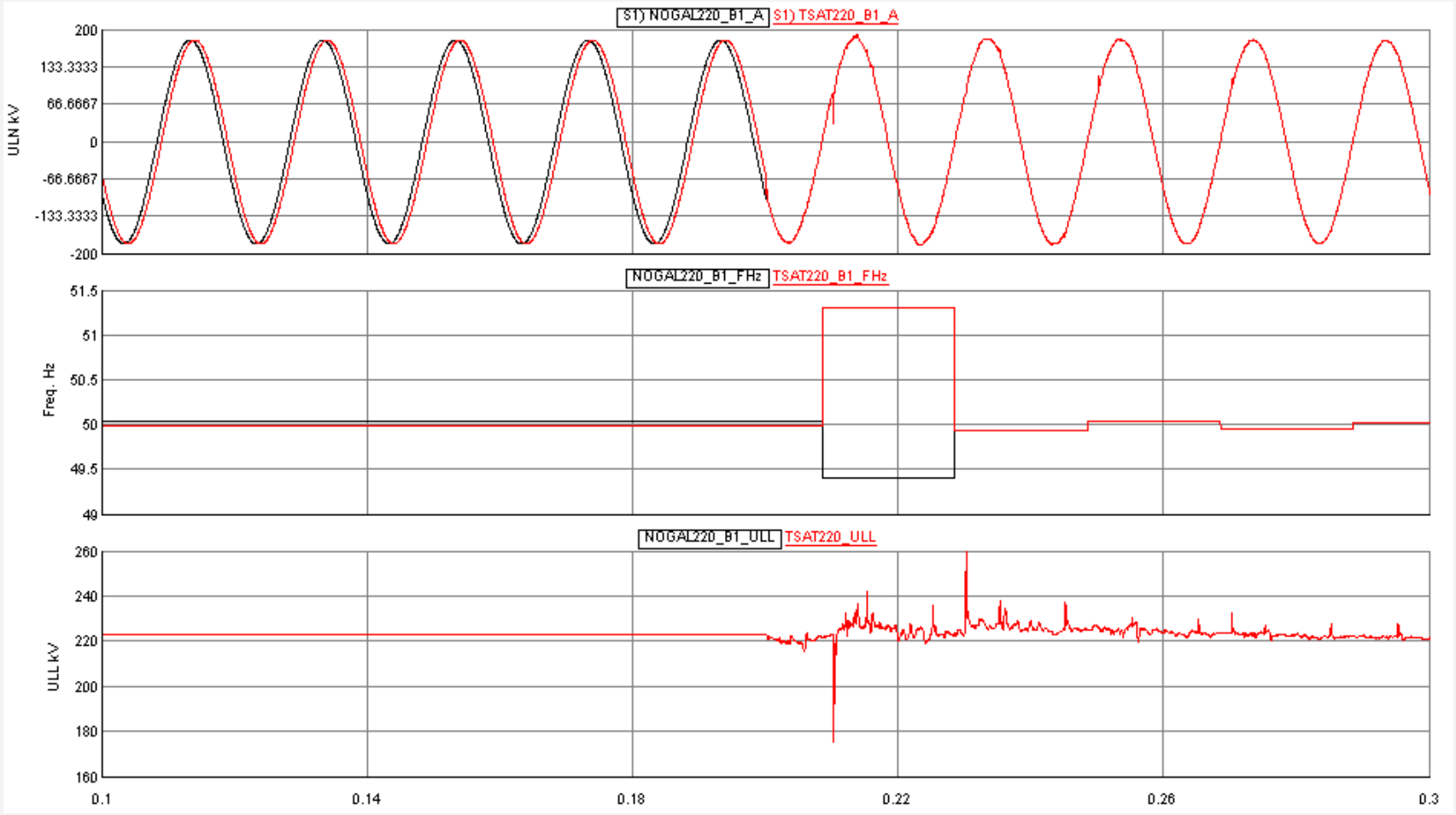


2 deg difference before connection

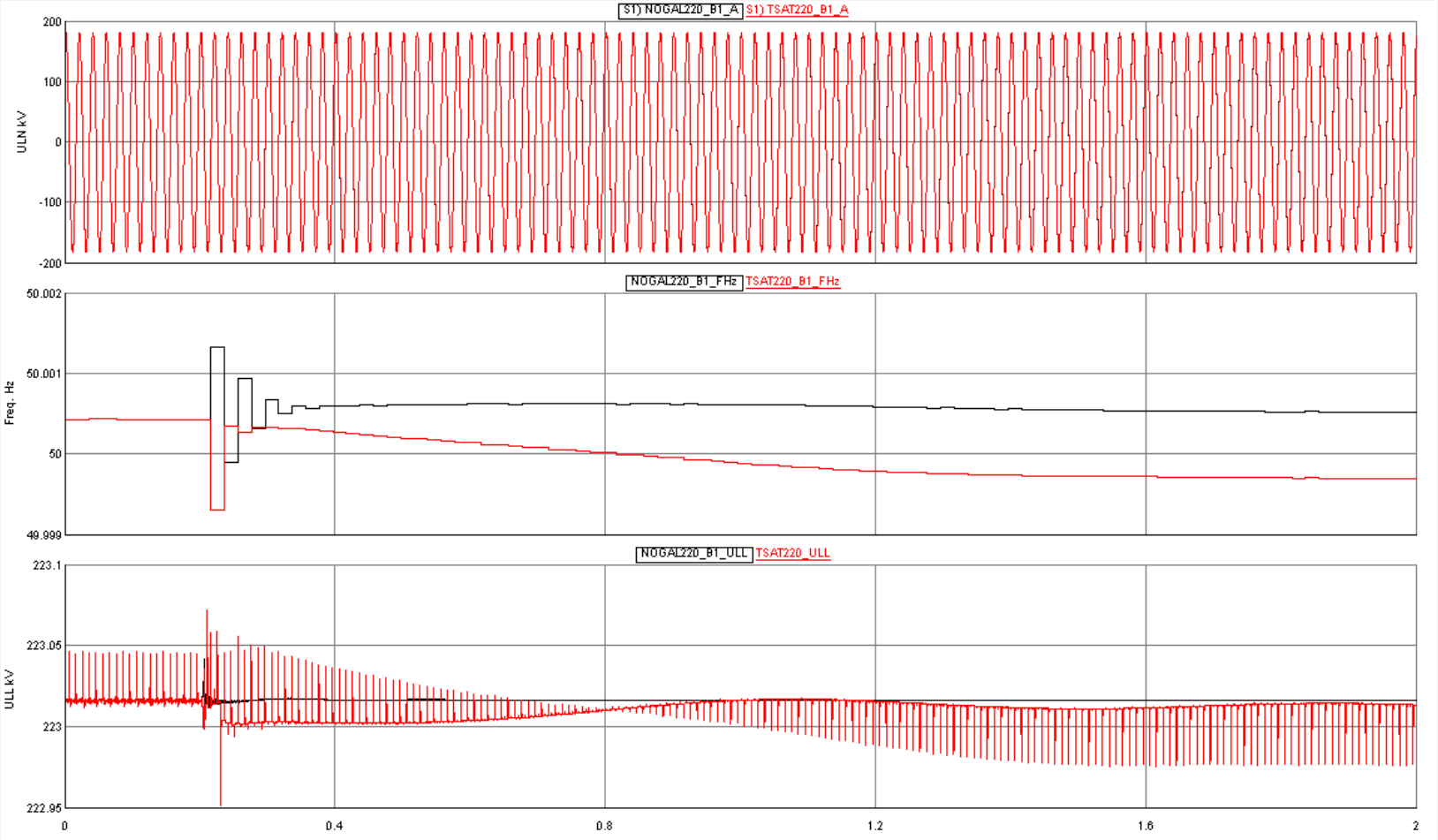
PROJECTS: HYBRID SIMULATIONS



PROJECTS: HYBRID SIMULATIONS

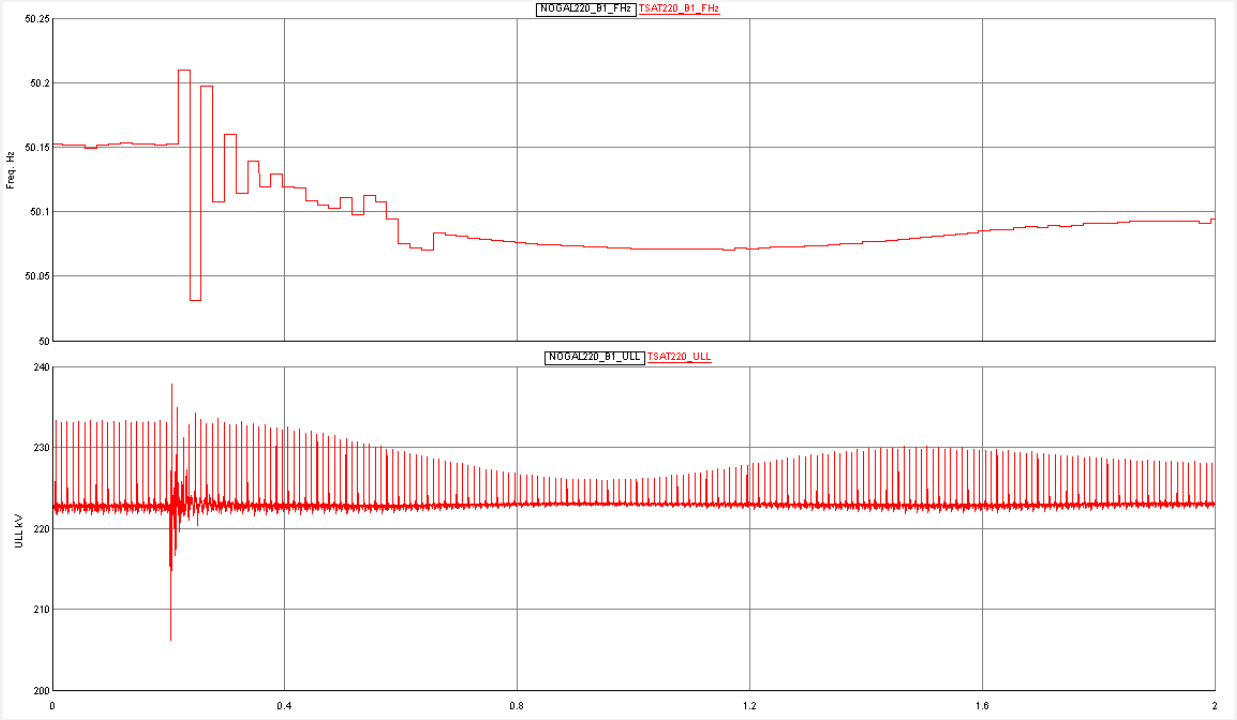


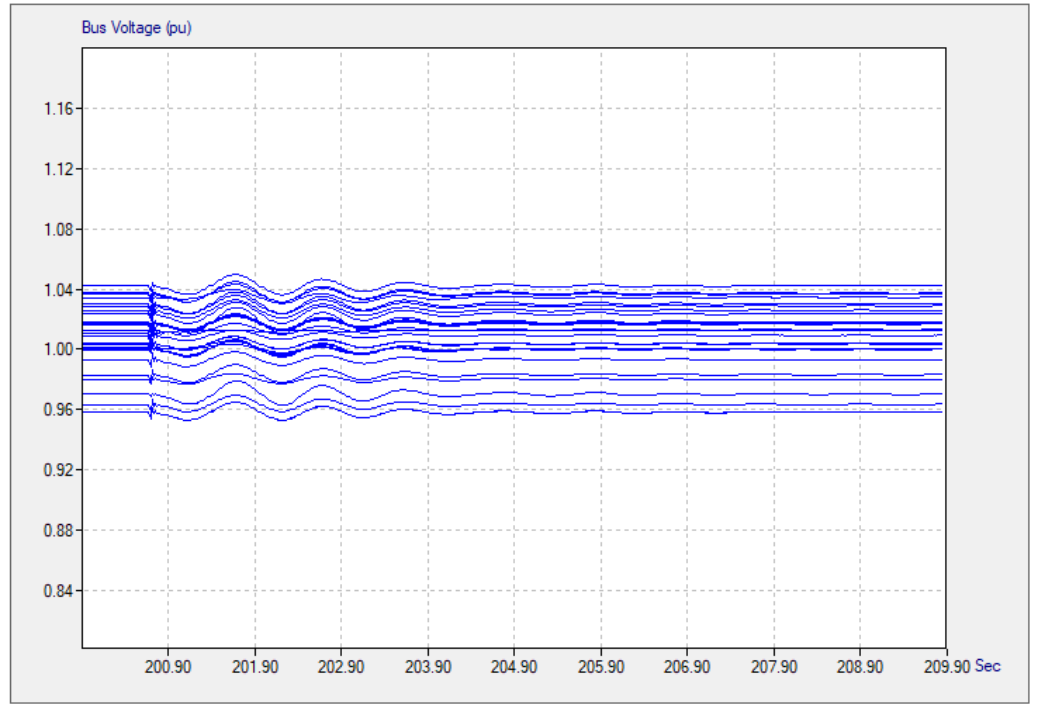
PROJECTS: HYBRID SIMULATIONS



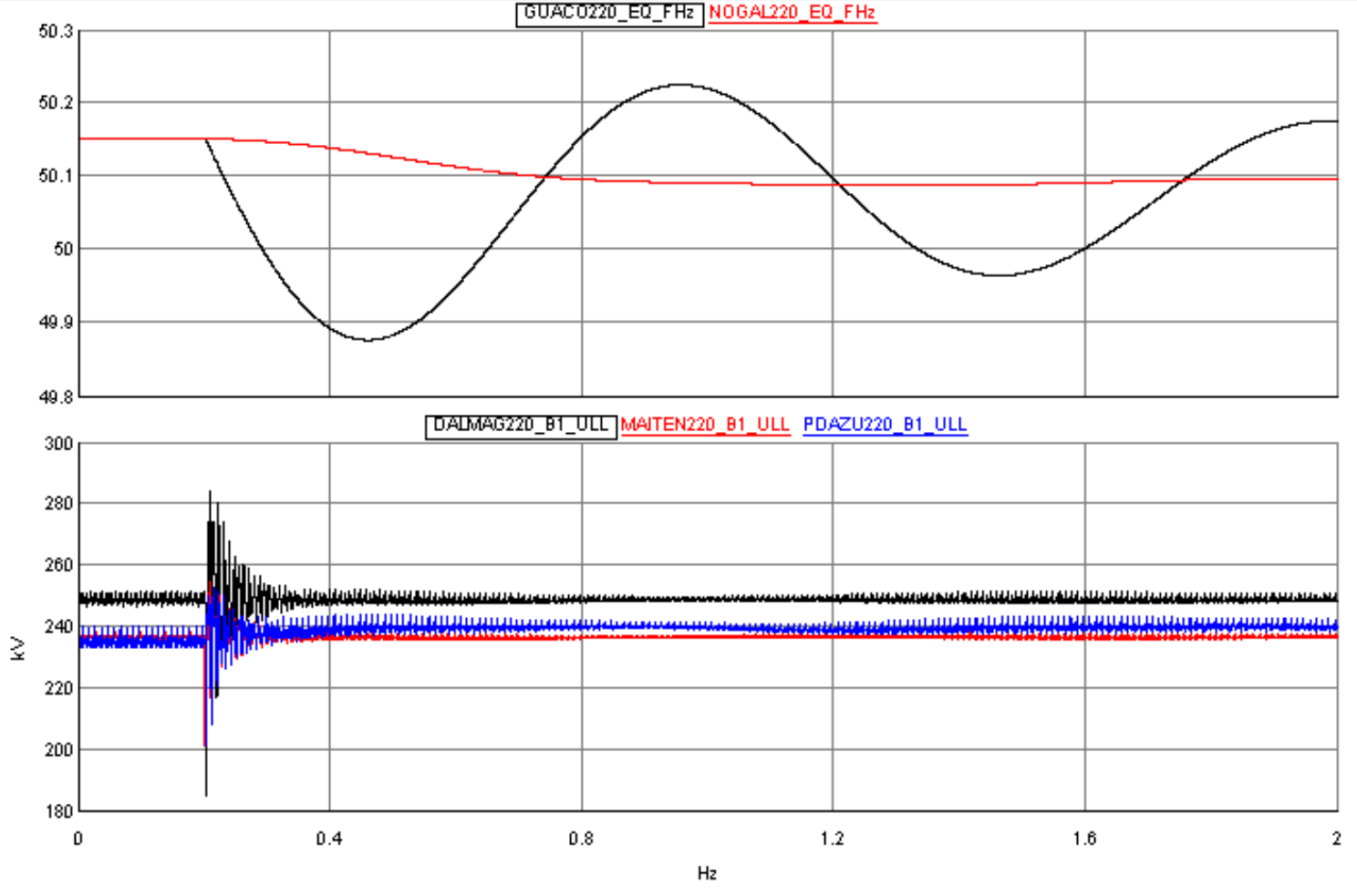
PROJECTS: HYBRID SIMULATIONS

Event: power plant outage (180 MW)





PROJECTS: HYBRID SIMULATIONS



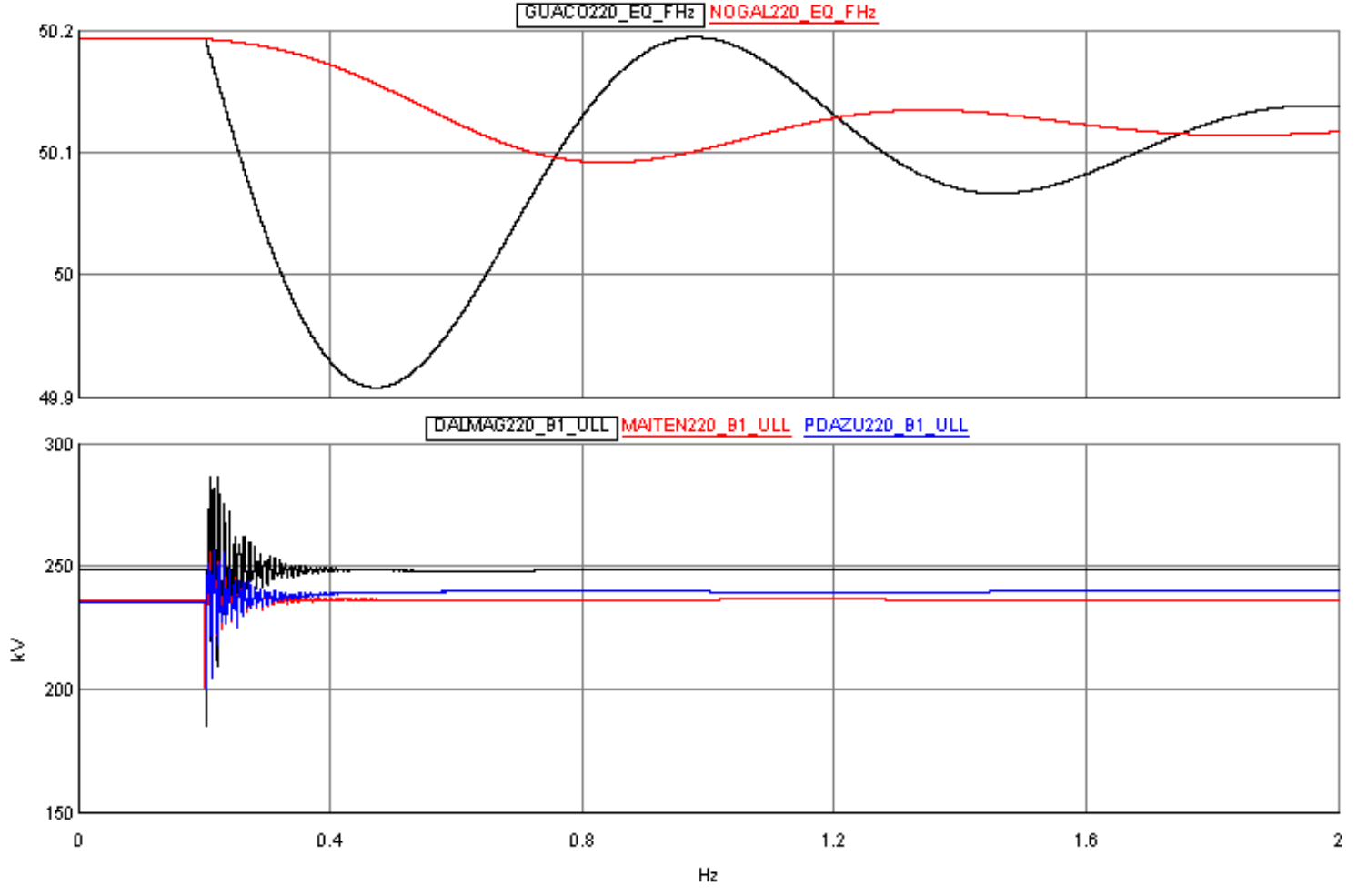
Event:

power plant outage (180 MW)

EMT and RMS models interconnected

$\Delta f \approx -0.05$ Hz

PROJECTS: HYBRID SIMULATIONS



Event:

power plant outage (180 MW)

EMT and RMS models

not connected

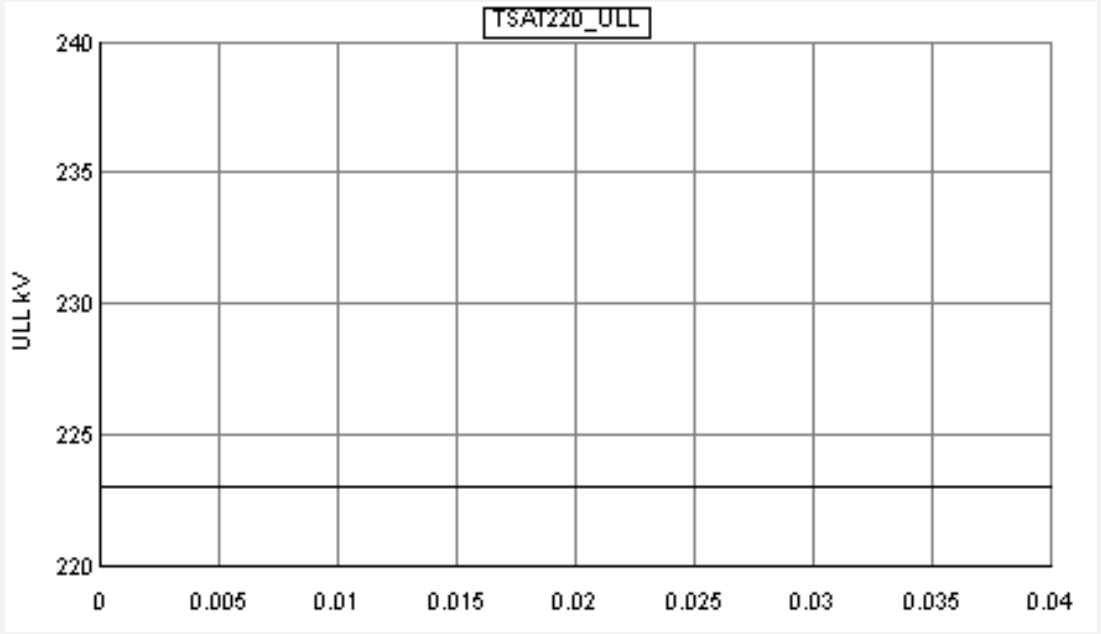
$\Delta f \approx -0.08$ Hz

PROJECTS: HYBRID SIMULATIONS

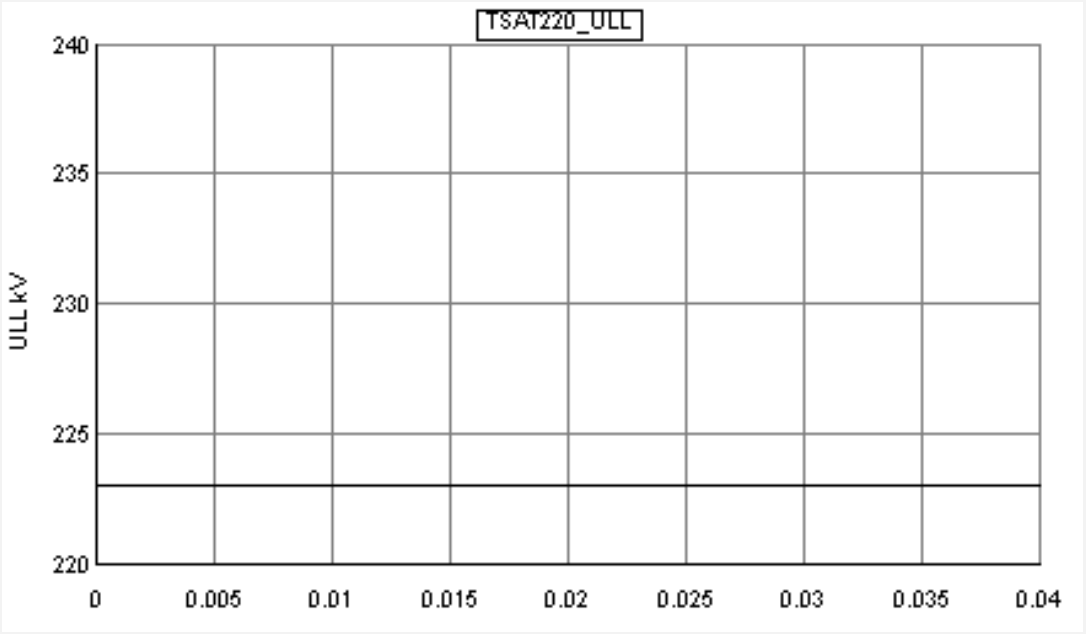
EMT and RMS models interconnected

Transferred power ~ 0 MW

RMS integration step = 0.25 cycles



RMS integration step = 1 cycle

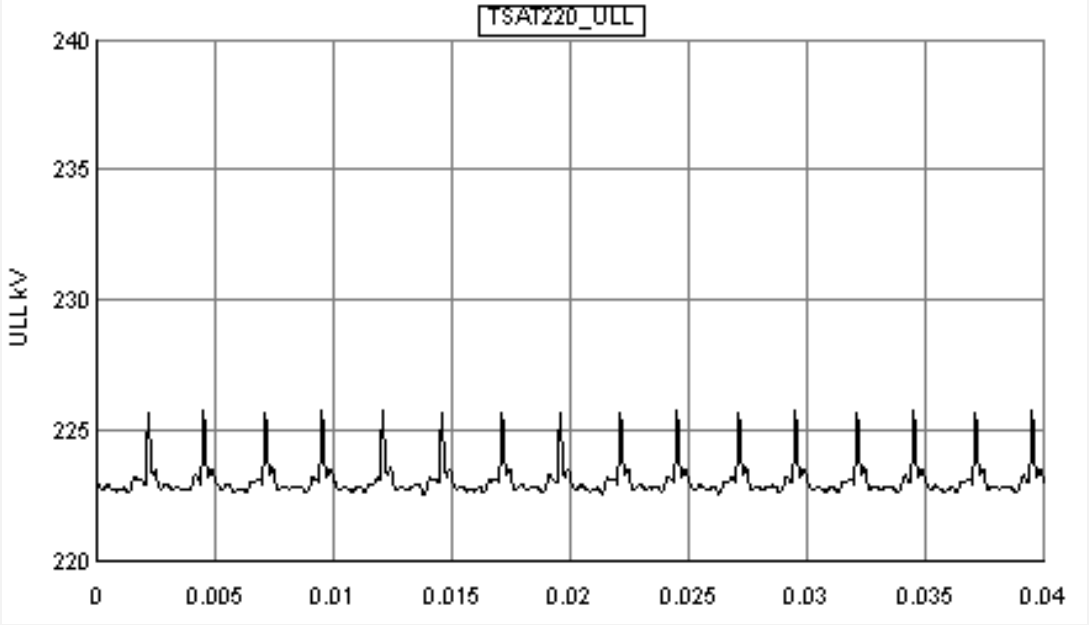


PROJECTS: HYBRID SIMULATIONS

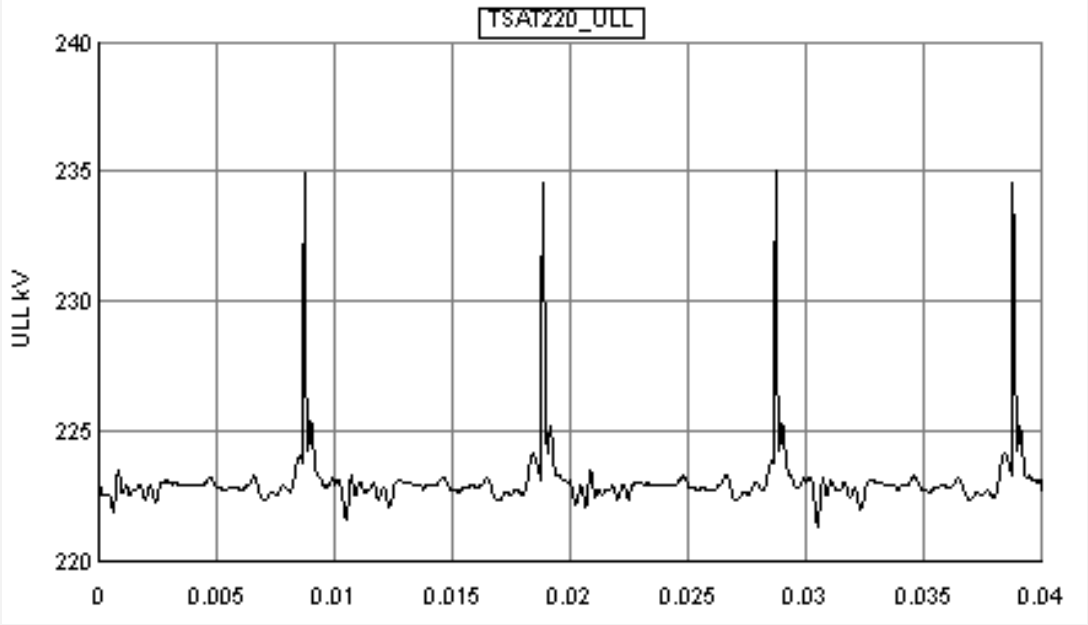
EMT and RMS models interconnected

Transferred power ~ 100 MW (towards RMS model)

RMS integration step = 0.25 cycles



RMS integration step = 1 cycle



CEN WORKS ON REAL TIME SIMULATION

SIMÓN VELOSO

COORDINADOR ELÉCTRICO NACIONAL (CEN, CHILEAN'S ISO)

USER SPOTLIGHT SERIES BY RTDS Technologies