Interaction between AVR Reactive Power Control and High Power AC-DC Converter Control as possible cause of instability

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Abstract—**Two oscillatory episodes took place in the Argentinean power system at 22:20 and 22:50, June 7th, 2008. The first one started when a 40 MVAr capacitors bank was disconnected and the second one started when a 500 kV line was disconnected.**

Both oscillatory episodes produced great variation of active and reactive power in several 330 kV and 500 kV power system nodes.

At first sight, these oscillations seemed inter-area electromechanical oscillations, but carried out studies suggest that this oscillatory behavior could be a consequence of interaction between Reactive Power Control of generators and the ac-dc Converter Control of high power loads.

***Index Terms*-- AC-DC Converter Control - Automatic Voltage Control - Modeling - Power System Dynamic Stability - Power System Stabilizer - Reactive Power Control - Simulation.**

I. INTRODUCTION

ARGENTINA'S power system is composed by two parts: SIP (Sistema Interconectado Patagónico) and SADI (Sistema Argentino de Interconexión) as it is displayed in Fig. 1. The SIP is a small power system located in the south of Argentina with a peak load of 1200 MW, and the SADI is the biggest Argentinean power system with a peak load of nearly 20 GW.

Both systems are interconnected by a 360 km long 500 kV line between Choele Choel and Puerto Madryn substations. A 500/330 kV, 450 MVA autotransformer is connected at Puerto Madryn 330 kV substation.

Before and after SADI-SIP interconnection in 2006 several electromechanical oscillation episodes had taken place, some of them were reported [1]-[8].

The oscillatory episodes developed at 22:20 and at 22:50, June 7th, 2008, were observed in the SADI-SIP 500 kV interconnection line and in the two lines of 330 kV between Fuleufú and Puerto Madryn substations, see Fig. 1.

In a first approach, these oscillations were supposed to be inter-area electromechanical oscillations because the frequency of the power oscillations was near to 0.5 Hz. This was observed in the 500 kV SADI-SIP interconnection line.

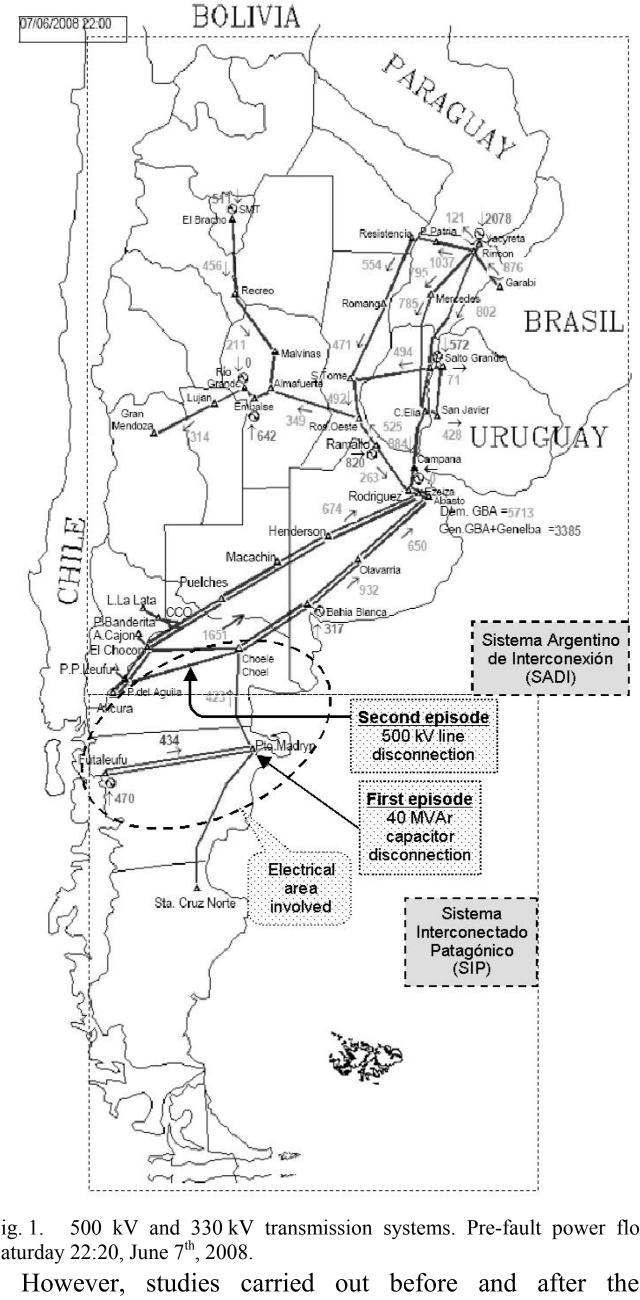

Fig. 1. 500 kV and 330 kV transmission systems. Pre-fault power flow: Saturday 22:20, June 7th, 2008.

However, studies carried out before and after these episodes demonstrated that the inter-area oscillation mode between SADI-SIP systems is well-damped.

To reproduce the oscillatory behavior of June 9, 2008, it was necessary to improve models of:

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- Automatic Voltage Regulator (AVR) to include Reactive Power Control into the generators Excitation Control Systems.
- Load of a facility that produces electrolytic aluminum. This load is composed by high power ac-dc converters.

II. Power System

The electrical power systems involved in the events were the SIP-North and its interconnection with the SADI-South as it is displayed in Fig. 2. At that moment SIP was transmitting 428 MW to SADI.

In the west side of SIP-North is located Futaleufú hydropower plant (4x118 MW), tied to Futaleufú 330 kV substation.

Before SADI-SIP interconnection, this power plant had a strong participation on inter-area electromechanical oscillations [5]-[8].

After the SADI-SIP interconnection, it was necessary to improve the models of Futaleufú controls in order to introduce post-fault stabilizing mechanisms [1]-[4].

Futaleufú substation feeds a local load (approx. 7 MW) and is tied with Puerto Madryn substation by 550 km long 2x330 kV lines.

The SIP has another 500 kV line between Puerto Madryn and Santa Cruz Norte substations, which was out of service during the events.

The 330 kV system is connected to the 132 kV system by two 60 MVA autotransformers**.**

The 132 kV system is 1300 km large, with distributed load and generation, in radial configuration. Most of the load in this system consists of oil fields.

On the 330 kV Puerto Madryn node, there is an aluminum industry which is fed by a total of three transformers: T1, T2 and T3.

T1 (330/34.5 kV) is a two winding transformer and has a rated power of 305 MVA. T2 and T3 are three-winding transformers (330/132/34.5 kV) and each has a rated power of 300/300/140 MVA.

The aluminum industry has four potlines named A, B, C and D. Each potline is fed by a 48-pulse converter. Each converter is composed by four 12-pulse converters connected to a common dc bus.

Each 12-pulse converter is connected to an autotransformer with on-load tap changing.

During the incidents of June 7, 2008, the potlines A and B had two types of converter technology. Each potline had two thyristor converters and two diode with self-saturating reactor converters.

Potlines C and D only have diode converter technology.

Diode converters of potlines A, B, and C are fed from 33 kV bus, while the diode converters of potline D and thyristor converters are fed from 132 kV bus. During the oscillatory events, potline A was demanding a total 175 MW (2*37.5+2*50 MW), potline B 172 MW (2*36+2*50 MW), potline C 132 MW (4*33 MW) and potline D 138 MW (4*34.5 MW). There was also an extra load of 50 MW that consists mainly on auxiliary services. As a result, the total power demanded by loads inside the factory was 667 MW.

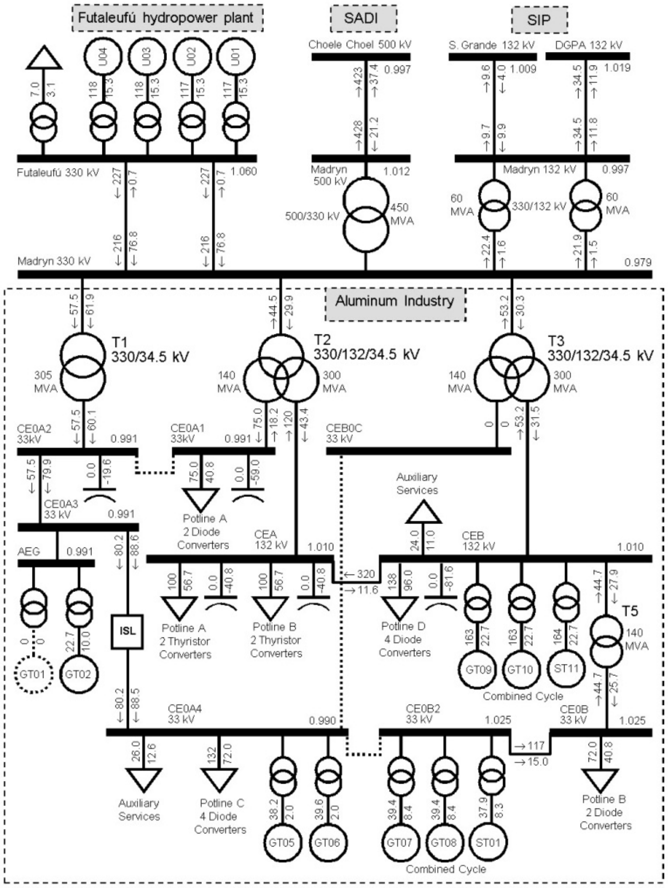

Fig. 2. SIP-North pre-fault power flow (Saturday 22:20, June 7th, 2008).

This aluminum industry owns a power plant composed by 2 gas turbines (GT01 and GT02) rated 24 MW each, 4 gas turbines (GT05 to GT08) rated 40 MW each. GT07 and GT08 operate in combined cycle with steam turbine (ST01) rated 40 MW. There is another combined cycle composed by 2 gas turbines (GT09 and GT10) and 1 steam turbine (ST11) rated 167 MW each.

During the oscillatory events, all turbines were in service (except GT01) delivering a total power of 707 MW. As a result, the net balance implies that the factory was delivering 40 MW to the system. A power flow of the pre events scenario is shown on Fig. 2.

III. Oscillatory Episodes

Fig. 3 and Fig. 4 show records of the active power transmitted from Futaleufú substation to Puerto Madryn substation (2x330 kV lines), during the oscillatory episodes happened respectively at 22:20 and at 22:50, June 7th, 2008.

Fig. 5 shows the active power transmitted from Puerto Madryn substation to Choele Choel substation (500 kV line, interconnection SADI-SIP) between 22:00 and 23:00, June 7th, 2008.

From Fig. 3 and Fig. 4 it can be seen that power oscillation has a frequency near to 0.5 Hz. Also, it can be observed the increasing amplitude of the oscillation, displaying the unstable behavior of the power system.

After the first 175 seconds of the record showed in Fig. 3, a reduction of the oscillation amplitude growth rate is observed.

It seems that the growing of power oscillation amplitude will stop and reach a constant final value. Therefore, the power system will not become unstable. This kind of behavior can be observed in non stable control systems having dead bands and/or limiters.

The first oscillatory episode was initiated by a 40 MVAr capacitor bank disconnection from the CEA 132 kV bus of the factory (see Fig. 1 and Fig. 2).

The second oscillatory episode was initiated by the disconnection of the 500 kV line between Piedra del Águila and Choele Choel substations (see Fig. 1).

The simulations of these events were made with the available dynamic models.

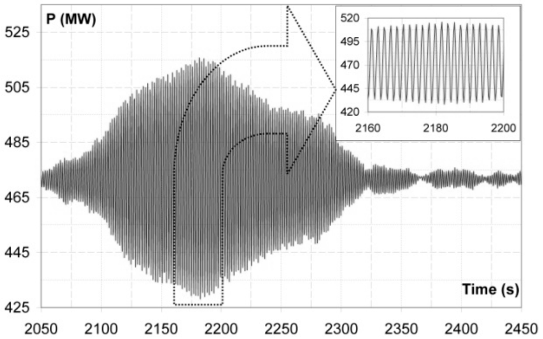

Fig. 3. Saturday 22:20, June 7th, 2008. Record of active power from Futaleufú substation to Puerto Madryn substation. Zoom in upper right corner.

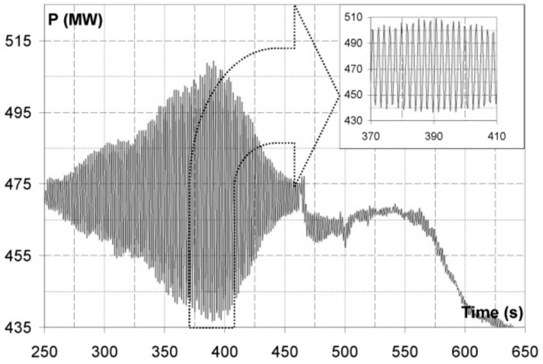

Fig. 4. Saturday 22:50, June 7th, 2008. Record of active power from Futaleufú substation to Puerto Madryn substation. Zoom in upper right corner.

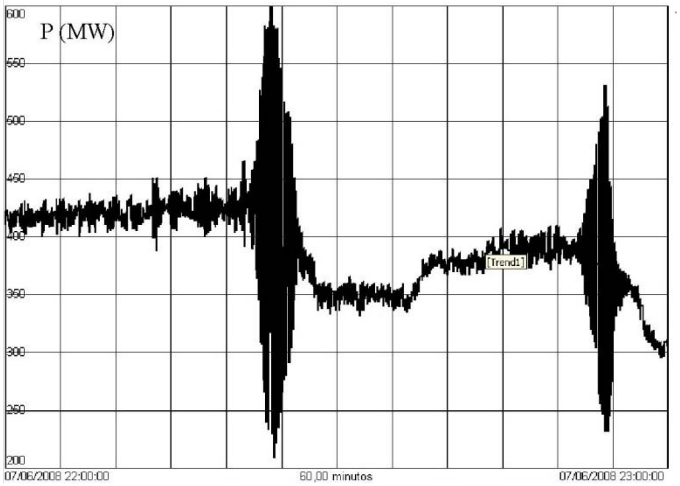

Fig. 5. Saturday 22:00 to 23:00, June 7th, 2008. Record of active power from Puerto Madryn substation to Choele Choel substation.

The results demonstrated that the inter-area oscillation mode between SADI and SIP systems is well-damped.

IV. MODELS

In order to reproduce the occurred events, the models involved in the scenario were checked and improved.

A. Power Plants

In the past, several tests were carried out at Futaleufú power plant to improve the models of *Excitation Control System and its Over and Under Excitation Limiters; PSS; Governor; Gate Control; Turbine; and Water Supply System* [1]-[4].

Also, during commissioning of GT05 to GT10, ST01 and ST11 several tests were conducted in order to improve the models of *Excitation Control System and its Over and Under Excitation Limiters; PSS; Governors and Turbines.*

The GT09, GT10 and ST11 excitation systems consist of static inverting type where the controlled rectifier bridge is fed by an auxiliary transformer connected to the terminal or stator voltage of the generator (rated 15 kV). This excitation system was represented with model type ST1A from IEEE [10].

Fig. 6 shows records from a small signal test made over the GT10 excitation system. This test was carried out by applying a small step to the setpoint of terminal voltage at full speed no load condition [11].

Fig. 6 also shows test reproductions with Semipol model, furnished by manufacturer, and with EST1A model.

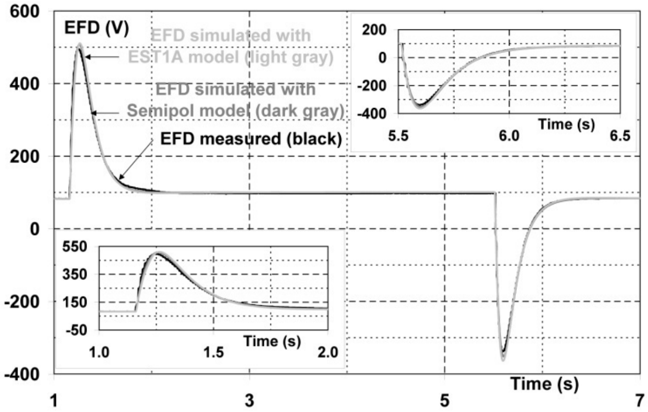

Fig. 6a. GT10 excitation small signal test. Excitation field voltage (EFD).

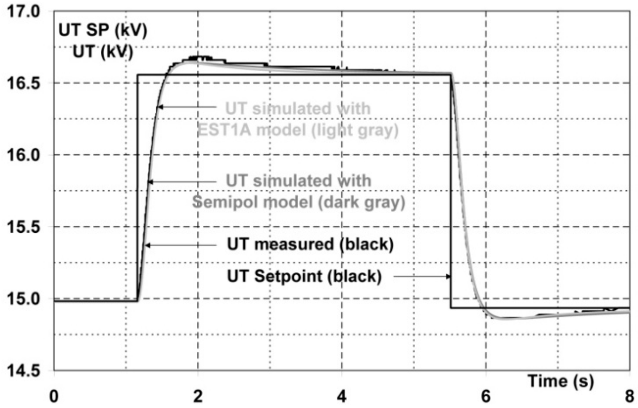

Fig. 6b. GT10 excitation small signal test. Terminal voltage setpoint (UT SP) and terminal voltage (UT).

Fig 6a displays excitation field voltage (EFD) and Fig. 6b displays terminal voltage (UT) and its setpoint (UT SP). The results show a good concordance between signals from test record and from simulations carried out with manufacturer model and with EST1A model.

During the review of the Excitation Control System of the generators of new combined cycle: GT09, GT10 and ST11 it was noticed that the Reactive Power Control was not included.

The simplified model of Automatic Voltage Control (AVR) showed in Fig. 7 was used in GT09 and GT10 to include the Reactive Power Control on the reproduction of the oscillations episodes.

When it is active, the Reactive Power Control of this model generates the terminal voltage setpoint (UT SP). The AVR settings used for GT09 and GT10 are shown in TABLE I.

B. Potlines

Several tests were performed prior to the events to obtain a load model of diode converters [9] from potlines A, B and C. Fig. 8 displays the dc current and ac active power (recorded and simulated with the developed model) from the diode converter.

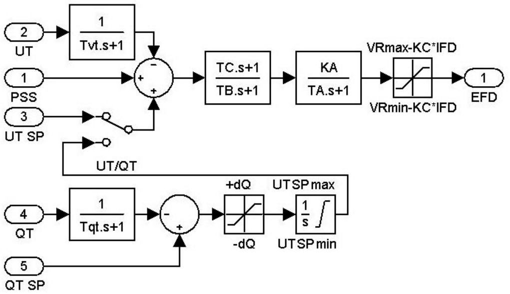

Fig. 7. AVR model with reactive power control used for GT09 and GT10.

TABLE I. AVR settings used for GT09 and GT10.

Tqt	dQ	QT max/min	Tvt	TC	TB	KA	TA	VR max/min
[ms]	[pu]	[pu]	[ms]	[s]	[s]	[pu/pu]	[ms]	[pu]
20	1	+0.1/-0.1	20	3	100	3264	3.3	+6.4/-4.8

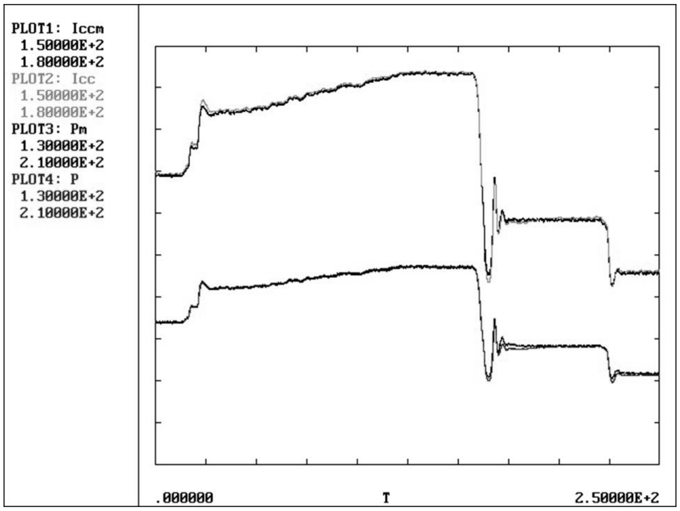

Fig. 8. Potlines C feeding with 4 ac-dc converters with diode and self-saturating reactor. Converters dc current (Iccm and Icc, upper traces) and ac active powers (Pm and P, lower traces). Measured signals (Iccm and Pm, black traces) and simulated signals (Icc and P, gray traces).

Potline D has a different diode converter. The model for these converters was provided by the manufacturer. The same manufacturer provided the model for the new ac-dc thyristor converters for potlines A and B.

The thyristor firing angle is limited to avoid the overload of the diode converters when the 2 types, diode and thyristor, are working in parallel.

This overload can occur because both types of converters are in parallel at dc bus. The thyristor converter can reduce the dc voltage to zero faster than the diode converters. In the same time the thyristor converter reaches 0 Vdc, the diode converter can only reduce its dc voltage output a little quantity (between 0-50 Vdc, depending of the saturable reactor voltage drop).

Fig. 9 shows the load model developed for potlines that are feeding by both types of ac-dc converters. This model is composed by 4 main blocks: Diode Converters, Thyristor Converters, Converters Parallel and potlines. “NTC” indicates the number of thyristor converters (0 to 4). Then, “4-NTC” indicates the number of diode converters. The model has the following inputs: the feeding voltages for diode converters (U33kV) and the feeding voltage for thyristor converters (U132kV). Also, the model has the following outputs: active power (PD) and reactive power (QD) taken from 33 kV bus by diode converters; and active power (PT) and reactive power (QT) taken from 132 kV bus by thyristor converters.

The model has the following main internal signals:

- potline dc current (Idc)
- potline dc current setpoint (Idc SP)
- potline dc voltage (Udc)
- dc current of all diode converters (IdcD)
- dc current of one diode converter (IdcDC)
- dc current setpoint of one diode converter (IdcDC SP)
- dc voltage (UdcD) of diode converters
- active power of one diode converter (PDC)
- reactive power of one diode converter (QDC)
- saturable reactor control current of one diode converter (Ic)
- setpoint of saturable reactor control current of one diode converter (Ic SP)
- saturable reactor voltage drop of one diode converter (dUac)
- ac feeding voltage of one diode converter (UacD)

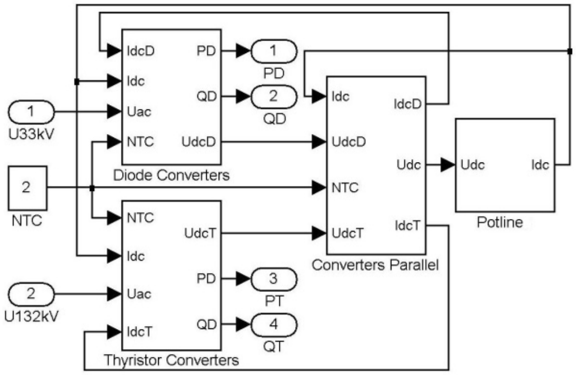

Fig. 9. Potline model used when diode and thyristor converters are working in parallel.

- dc current of all thyristor converters (IdcT)
- dc current of one thyristor converter (IdcTC)
- dc current setpoint of one thyristor converter (IdcTC SP)
- dc voltage (UdcT) of thyristor converters
- active power of one thyristor converter (PTC)
- reactive power of one thyristor converter (QTC)
- thyristor firing angle of one thyristor converter (Alfa)
- ac feeding voltage of one thyristor converter (UacT)

Diode Converters (DC)

Fig.10 shows the “Diode Converters” of Fig. 9. This block has two main controls: Potlines dc current control (“Idc control” block) and converter current control (“Converter Control” block). Both controls are limited P+I type.

Fig. 11 shows the “Idc Control”. It consists of a limited P+I control that provides current setpoint of the “Converter Control” (Fig.12). Only one “Idc Control”, diode or thyristor converter, may be active controlling the potlines series current. The other type must have fixed current setpoint for the “Converter Control” block.

The “Converter control” determines the control current setpoint of the saturable reactor (Ic SP). This current setpoint has a minimum and maximum limit that fixes the span of the voltage drop across saturable reactor.

The diode rectifier input voltage is modified by controlling ac voltage drop (dUac) at the saturable reactor. The “Saturable Reactor Control” scheme is shown in Fig.13. The dU(Ic) block represents the saturation behavior of the reactor. This characteristic determines the operation limits of the dUac.

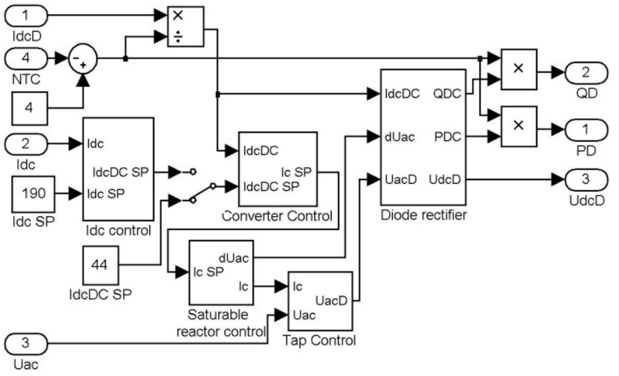

Fig. 10. “Diode Converters” block of Fig. 9.

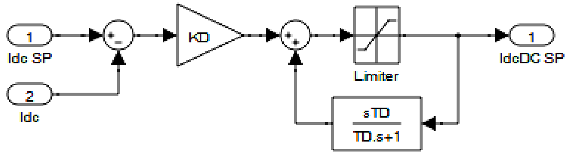

Fig. 11. “Diode Converters”, “Idc Control” block of Fig. 10.

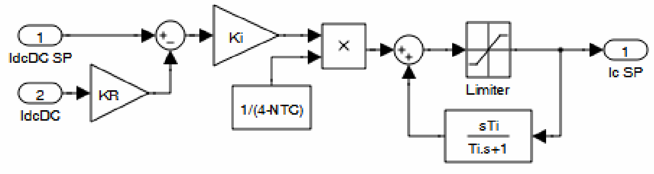

Fig. 12. “Diode Converters”, “Converter Control” block of Fig. 10.

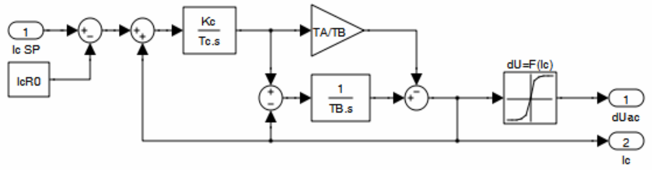

Fig. 13. “Diode Converters”, Saturable Reactor Control block of Fig. 10.

When the control current (Ic) of saturable reactor holds at its upper/lower limit for a given time, a logic algorithm takes control of UacD changing the feeding transformer tap (“Tap control” block). By changing the tap, the saturable reactor is no longer at its upper/lower voltage drop limits and the dUac can operate again between the saturation limits.

Thyristor Converters (TC)

Fig. 14 shows the “Thyristor Converters” of Fig. 9. This block has also two main controls: Potline dc current control (“Idc control” block) and converter current control (“Converter Control” block). Both controls are limited P+I type.

Fig. 15 shows the “Idc Control”. It consists of a limited P+I control that provides current setpoint of the “Converter Control” (Fig.16). The scheme is similar to the shown in Fig. 11, but in this one a feedforward loop is included for a faster response. As it was stated, only one converter type may be controlling the potlines series current.

In this case the “Converter control” provides the firing angle for the thyristors (Alfa). When both types of converters (diode and thyristor) are working in parallel, Alfa is limited to a maximum of 40 degrees. This limit prevents the overload of the diode converters.

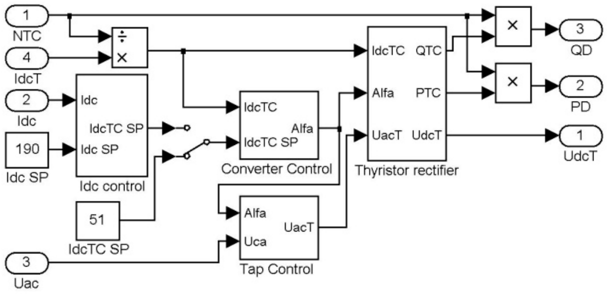

Fig. 14. “Thyristor Converters” block of Fig. 9.

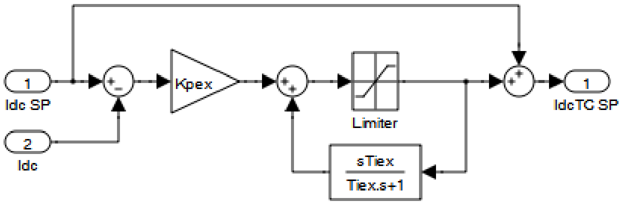

Fig. 15. “Thyristor Converters”, Idc Control block of Fig. 11.

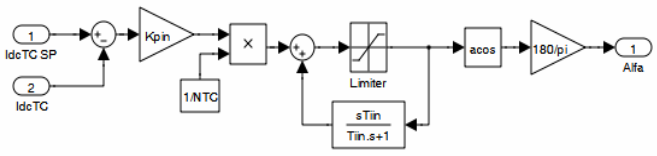

Fig. 16. “Thyristor Converters”, Converter Control block of Fig. 11.

The "Tap Control" block consists of a logic that changes the feeding transformer tap when the firing angle is out of a band (18±4°). By maintaining the angle in this band the reactive power consumption is kept to a low value (near to the rated value provided by the manufacturer).

Potlines dc current is controlled by only one type of converters. The other converters type must be set with a fixed setpoint value. E.g. if thyristor converters controls the Potline dc current, the diode converters will have a fixed setpoint.

Diode Converters take control over the Potline dc current when there are at least 3 converters of this type. Otherwise, the Thyristor Converters take control over the Potline dc current.

Converters Parrallel

The "Converters Parallel" block of Fig. 9 calculates the dc voltage (Udc) applied to the potline and the dc currents supplied by all diode converters (IdcD) and by all thyristor converters (IdcT).

This block solves the corresponding circuit equation using the potline dc current (Idc), the dc voltages of diode converters (UdcD) and thyristor converters (UdcT), and the dc commutation impedances of diode converters and thyristor converters.

Potlines

The "Potline" block of Fig. 9 calculates the potline dc current (Idc) by solving the corresponding circuit equations.

Each pot and its circuit connections are represented by an emf (1.95 V), a resistance (15.5 μΩ) and a L/R ratio (0.5 s). Each potline has a different quantity of pots (A and B: 200; C: 144; and D: 128).

V. SIMULATION

The events were simulated again including the models modifications aforementioned. The Excitation Control Systems (AVR) of GT09 and GT10 had the Reactive Power Control disabled. The results did not show an oscillatory behavior.

Since the oscillatory behavior observed in the events corresponds to non stable control systems, the Reactive Power Control of the Excitation Control Systems (AVR) of GT09 and GT10 were enabled.

To simulate the first event a 40 MVAr capacitor bank is disconnected from the CEA 132 kV (see Fig. 2) at t = 1s. Active power through 330 kV lines starts to oscillate reaching constant amplitude, which is restricted by the voltage setpoint. This is limited by the Reactive Power control (UT SP max, UT SP min; see Fig. 7). At t = 40s the Reactive Power Control of both GTs are disabled. The oscillation is rapidly damped, see Fig. 17.

In order to obtain a similar behavior observed in the records, the control modes of the GTs are changed at different times. At t = 40s GT09 switches to Voltage Control and GT10 switches at t = 60s. With the first switch, the oscillation amplitude is partially reduced. After the second switch the oscillation is fully damped, see Fig. 18.

Fig. 17 and Fig. 18 display the active power transmitted from Futaleufú to Puerto Madryn substations (2x330 kV lines).

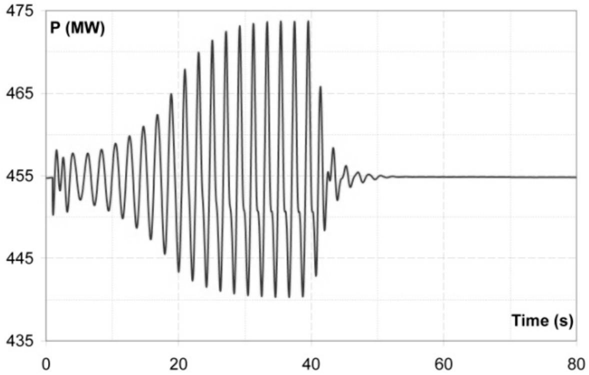

Fig. 17. Simulation of Active power from Futaleufú substation to Puerto Madryn substation.

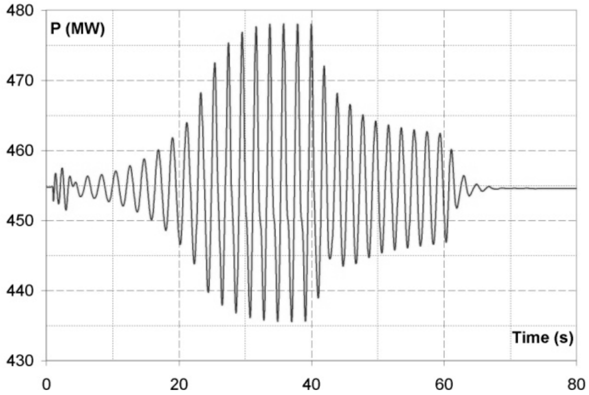

Fig. 18. Simulation of Active power from Futaleufú substation to Puerto Madryn substation.

The second event was not simulated since its behavior is similar to the first simulation (both GTs control switching at the same time).

The simulations showed in Fig. 17 and Fig. 18 display a similar pattern behavior of oscillatory episodes observed in Fig. 4 and Fig. 3 respectively.

Since the potline control pretends to maintain constant the dc current, a change of ac voltage will generate a big reactive power change. This may result in an interaction between the reactive power control (generator AVR) and the converters controls (potlines control). This could explain the shape of the registered oscillation.

VI. CONCLUSIONS

It was intended to explain the oscillatory events in the SADI-SIP interconnection occurred at 22:20 and at 22:50, June 7th, 2008, by means of simulations.

It was verified that these oscillations do not correspond to inter-area oscillations.

For the simulations high power thyristor and diode converter models were used together with AVR and associated Reactive Power Control models.

The results obtained are similar to the records from the events.

From the simulations results it is possible to conclude that the interaction between the generators AVR control loops and the potline converters control system may result in an unstable operation condition.

This phenomenon is currently under study.

This paper remarks the importance of using more accurate models in order to understand the reasons of different types of events.

Until further studies, to avoid these oscillatory episodes, it was suggested that the generators AVR operate with the Reactive Power Control disabled.

VII. ACKNOWLEDGMENT

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VIII. REFERENCES

[1] J. Agüero, J. Mastronardi, R. Molina, M. Beroqui, R. Bianchi, P. Stoeff Belkenoff y L. Balarino, "Operación inestable de la Central Hidroeléctrica Futaleufú producida por transitorios hidráulicos. Descripción y Solución del problema", *XIII Encuentro Regional Iberoamericano, CIGRE,* May 2009, Puerto Iguazú, Argentina, Conference Proceedings, paper C1-29.

[2] J. Agüero, P. Arnera, M. Barbieri, M. Beroqui, R. Bianchi, J. Mastronardi and R. Molina, “Hydraulic Transients in Hydropower Plant. Impact on Power System Dynamic Stability“, *IEEE 2008 PES General Meeting*, Pittsburgh, Estados Unidos, July 2008, Paper PESGM08-000150, Conference Proceedings PES-IEEE GM08.

[3] J. Agüero, B. Barbieri, R. Bianchi Lastra, J. Mastronardi and R. Molina, “Hydropower Plant Models: Water Supply System, Turbine and Governor. Model Validation: On Site Tests and Grid Fault Simulation”, *10th Portuguese-Spanish Congress in Electrical Engineering,* Funchal, Madeira, Portugal, July *2007*, Conference Proceedings, pp. 1.1-1.4.

[4] R. Molina, J. Mastronardi, G. Lo Giudice, P. Belkenoff, M. Beroqui and J. Agüero, “Oscilación en la Central Hidroeléctrica Futaleufú. Diagnóstico y solución del problema”, *XII Encuentro Regional Ibero Americano, CIGRÉ*, May 2007, Foz de Iguazú, Paraná, Brasil, Conference Proceeding, paper C1-105.

[5] J. Agüero, M. Beroqui, M. Barbieri, O. Cosatti and L. Macchione, “Evaluación de la Ampliación de Aluar con el SIP aislado e interconectado al SADI. Parte 1: Aspectos generales y estabilidad dinámica”. *XI Encuentro Regional Iberoamericano, CIGRE,* Ciudad del Este, Paraguay, May 2005, Conference Proceeding, paper C1-94.

[6] J. Agüero, M. Beroqui, R. Bianchi Lastra, O. Cosatti and L. Macchione, “Evaluación de la Ampliación de Aluar con el SIP aislado e interconectado al SADI. Parte 2: Estabilidad transitoria”, *XI Encuentro Regional Iberoamericano, CIGRE,* Ciudad del Este, Paraguay, May 2005, Conference Proceeding, paper C1-106.

[7] J. Agüero and M. Beroqui, "PSS Tuning in Generators located in a Manufacture Plant of Aluminum", *IEEE 2000 PES Summer Meeting,* Seattle, United States, July 2000, Conference Proceedings SM00, Vol. N° 3, pp. 1901-1905.

[8] J. Agüero and M. Beroqui, “Electromechanical Oscillation Damping in one Hydraulic Central”, *IEEE 1999 PES Summer Meeting*. Edmonton, Alberta, Canada, July 1999, Conference Proceedings SM99, Vol. N° 2, pp. 1330-1335.

[9] J. Agüero, M. Beroqui and S. Achilles, “Aluminum Plant. Load Modeling for Stability Studies”, *IEEE 1999 PES Summer Meeting, Edmonton,* Alberta, Canada. July 1999, Conference Proceedings SM99, Vol. N° 2, pp. 1286-1291.

[10] *IEEE Recommended Practice for Excitation System Models for Power System Stability Studies*, IEEE Std. 421.5, 1992.

[11] *IEEE Guide for Identification, Testing, and Evaluation of the Dynamic Performance of Excitation Control Systems*, IEEE Std. 421.2, 1990.

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