Description of the new RAS to be installed in the Power System of Uruguay

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***Abstract*--This paper describes the mechanism by which the new Remedial Action Scheme (RAS) to be installed in Uruguay determines corrective actions for major single and multiple contingencies in the 500kV system. The general mechanism is divided into 8 logics that calculate automatically without operator intervention necessary load shedding to balance demand with generation or eliminate overloads. Also determines the disconnection of stations to achieve the load shedding, lines to separate systems or isolate small zones and shunt capacitive compensation for voltage control. The system also calculates the required change in the power exchange in the HVDC link between Uruguay and Brazil.**

***Index Terms*—RAS, Stability, Overloads, Event, Contingency**

I. Introduction

URUGUAY is a small country between Brazil and Argentina. The population is 3.5 million people with a peak demand of 2000 MW approximately. The transmission system is built in 500kV and 150kV. It is strong interconnected with Argentina with a transfer capacity of 2000MW and is also interconnected with Brazil through two HVDC links of 70MW and 500MW. In Figure 1 there is a simplified one line diagram showing 500kV equipment in red and 150kV equipment in blue. Most of the generation is located in the North and in the center of the country while the 70% of the demand is in the south. As a consequence, transmission lines from the north to the center and from the center to the south are critical. There are contingencies associated with the loss of one or more 500kV equipment that produce overloads on some of the equipment that remain in service, voltage instability and frequency instability problems due to imbalances between demand and generation. Most such contingencies require disconnecting load or lines from the system to ensure the stability of the system and the integrity of the equipment. In most cases disconnection must be performed so fast that has to be done automatically, having chosen the stations to be disconnected previously and conveniently. Such solutions are commonly referred to by the acronym RAS, which in English means "Remedial Action Scheme". RAS schemes are generally developed as a custom design because predicting the actions to be taken upon the occurrence of a contingency, depends strongly on the characteristics of the particular Power System. The installation of the Uruguayan RAS was awarded to Schweitzer Engineering Laboratories.

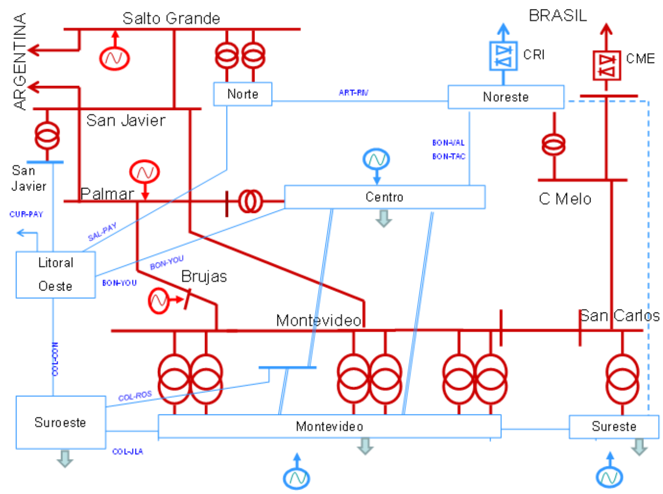

Figure 1

II. RAS description

There are 14 equipment identified which produce severe contingencies when they go out of service alone or even worst, when more than one equipment goes out of service. These 14 equipment consist on twelve 500kV lines, one 500/150kV transformer and the 500MW HVDC link between Uruguay and Brazil. The individual outage of one of this equipment is called Event. In the same way, contingency is defined as the occurrence of an event or combination of events that may require corrective action. In the case of the Uruguayan RAS system (hereafter RAS), 64 contingencies can be set up. So far, 24 contingencies have been defined, 9 are single events, 7 are combination of two events, 7 are combination of 3 events and 1 is a combination of 4 events.

The RAS has a 100ms cycle calculation. In each cycle determines the actions required for the 24 contingencies. However, it checks if a contingency has happened every 2 ms. The time in which actions are executed, since the contingency is detected until the last action is executed, will be less than 200ms. Next, the mechanism by which the RAS determines the actions for each contingency is described, explaining the different logics in detail.

III. Logics

The general mechanism is divided into 8 logics: PSE, DAC-General, DAC-Balance, DAD, LSP, DAR-Qc, DAR-DAC and DAL

A. PSE logic

The SSP logic is responsible for the selection of the system state. A state will be in general a combination of equipment out of service, but may also be added certain variables chosen from the SCADA. The RAS can supervise the state of 64 equipment, these are defined as Critical Equipment (hereafter *CE*). The RAS allow the definition of 1000 different states. The state of the CE in real time is recorded in a vector called *J* (64-element long), in which each element represents a *CE* state where *1* indicates it is out of service and *0* indicates it is in service. The definition of the states is performed through an array named *S* (States Array), of dimensions 1000x64 (1000 states by 64 *CE*). For any state (row in the array), a value of *1* in a column indicates that the corresponding CE is out of service in the state and a *0* indicates it is in service.

The number of all possible states of the *J* vector considering the outage of one (N-1), two (N-2) or three (N-3) *CE* at the same time, is calculated by $C_1^{64} + C_2^{64} + C_3^{64} = 64 + 2016 + 41664$. Therefore, the maximum number of 1000 states can be achieved very easily. Because of this, an additional *JE* array with dimensions of 64x64 (64 contingencies x 64 *CE*) is created to define the relevant *CE* involved in the definition of a state for every contingency. From the system state given by *J* vector, another vector is defined, $J_i = J(1\,row, 64\,cols) * JE\ (row\ i, 64\,cols)$ and the array $Si = S(1000\,rows, 64\,cols) * JE(row\ i, 64\,cols)$ for every contingency *i*. To select the state in *S* array from real power system state described be vector *J*, vector *Ji* has to be found in array *Si*, going throw row 1 to the end of *Si* looking for the first match. The selected state is called s_i. If no match is found, state 1000 is selected automatically.

With this method, there will be 64 different states, one for each contingency, instead of one unique state described by *J* vector. As explained later, most RAS parameters depend on the contingency and the state selected for the contingency. Therefore, one row of *S* matrix can represent completely different states for contingencies with no relevant *CE* in common.

B. DAC-General logic

This logic calculates the amount of load (MW) to be disconnected from the power system for contingencies that produce overloads or voltage stability problems. The spirit of the DAC-General formula is to calculate the exact load shedding to leave a certain equipment loaded at some particular value. The equipment that can be selected in the RAS for this purpose is any of the previously defined as *CE*. The amount of load to be disconnected for contingency *i* in order to alleviate the *CE j* is called $DAC_{0_i}(j)$ and is calculated as follows:

$$DAC_{0i}(j) = \left(\frac{DF_{s_i ij} \cdot \left(\sum_e C_{ei} \cdot \phi_{ei}\right) - \left(NM_{CEj} - C_{CEj} \cdot \phi_{CEj}\right)}{AFL_{s_i ij}} + K_i\right) \quad \textbf{(1)}$$

$DAC_{0i}(j)[MW]$: load shedding necessary to leave equipment *j* loaded at value NM_{CEj} for contingency *i*.

$DF_{s_i ij}$: Distribution factor between equipment defined as events for contingency *i*. Depends on the state of the system for contingency *i*.

$\phi_{ei}[MW]$: Power flow in equipment defined as events for contingency *i*.

C_{ei}: Constant multiplying power flow on equipment defined for event *e*. It is independent of the state.

NM_{CEj}: Post contingency power flow desired in the *CE*, typically thermal rating for 1 hour, voltage drop limitation or stability limit.

ϕ_{CEj}: Power flow in *CE j* before the contingency.

C_{CEj}: Constant multiplying power flow in *CE j*. It is independent of the state.

$AFL_{s_i ij}$: Alleviation factor between the load to be disconnected and *CE j*. Depends on the state of the system for contingency *i*.

K_i: Constant, only depends on the contingency.

The numerator calculates the excess of power flow in the *CE* above its limit (NM) after the contingency. In particular, the first term calculates the increase in active power flow in the *CE* coming from the equipment defined as events for the contingency. The second term subtracts the available power flow margin under NM limit in the *CE* before the contingency. If this term is positive, the power flow in the *CE* is less than NM limit before the contingency and the load shedding is reduced. If it is negative the power flow was greater than NM limit before the contingency and the load shedding is increased.

The alleviation factor in the denominator takes into account the fact that the disconnection of a certain amount of load will reduce the power flow in the *CE* in only a percentage of this amount. For example, if AFL=0.4, when disconnecting 100MW the power flow in the *CE* will be reduced in 40 MW.

Ki is a constant parameter useful to correct or increase the load shedding with a fix value. It only depends on the contingency.

Several equipment can be overloaded because of a contingency. Because of this the RAS allows to define up to 8 *CE* for each contingency. The final load shedding for contingency *i* is calculated as:

$$DAC_{0i} = \max\left(DAC_{0i1}, \ldots DAC_{0ij}, \ldots DAC_{0i8}\right) \quad \textbf{(2)}$$

In addition, for the *CE* more restrictive according eq 2, *j_max*, the logic calculates variable *Ri* as:

$$R_i = \frac{AFC_{s_i ij\_max}}{AFL_{s_i ij\_max}} \quad \textbf{(3)}$$

$AFC_{s_i ij\_max}$: Alleviation factor between HVDC link power transfer and *CE j_max*, and may be different form AFL.

This variable is used by DAD logic, explained later.

C. DAC-Balance logic

DAC-balance logic calculates the load shedding (MW) for contingencies that require to disconnect a large part of Uruguay's power system from Argentina's power system. Such contingencies leave a very weak interconnection between both countries with only 150kV lines. The actions required have to trip the 150kV lines firstly and then help to regulate the frequency in the Uruguayan system. The spirit of the DAC-balance formula is to calculate the exact load shedding to achieve a balance between demand and generation in the Uruguayan system. The load shedding for contingency *i* in order to balance the system is called DAC_{0i} isolated and is calculated as follows:

$$DAC_{0i} = C_e.\left(\sum_e C_{ei}.\phi_{ei} + \sum_{CE} C_{CEi}.\phi_{CEi}\right) + K_i \qquad \textbf{(4)}$$

The first sum includes the power flow through the equipment defined as events for contingency *i*. The second sum includes power flow in the equipment to be disconnected on purpose to completely separate both systems. Both summands have the positive sign convention for power flow going into the island and negative power flow going out of the island. DAC_{0i} can be negative indicating an excess generation. The RAS has no actions to disconnect generators. However, power exchange between Uruguay and Brazil using the HVDC link can be modified for this purpose increasing the exportation or reducing the importation, with previously agreed trading arrangements between both countries. This mechanism is explained in detail in the description of the DAD logic.

Using DAL logic, the RAS can disconnect up to 63 lines as part of the actions. Within this list are several *CE*. The RAS can choose only critical for use in the formula of DAC-Balance equipment. This logic also calculates the factor Ri.

D. DAD logic

The Uruguayan and Brazilian power system are now connected by a HVDC link at Melo station (*Converter* hereafter) with a transfer capacity of 500MW. DAD logic aims to modify the active power exchange in the *Converter* in order to reduce the load shedding calculated by the DAC-General and DAC-General logics. It is important to clarify that the acronym DAD is created from Spanish language and there is no relation with any hierarchical meaning.

The final load shedding for contingency *i* is calculated as:

$$DAC_i = \max(DAC_{0i} - DAD_i.R_i, 0) \qquad \textbf{(5)}$$

$DAD_i = P_{CME\_i_f} - P_{CME_o}$: Active power flow change at CME calculated by DAD logic for contingency *i*.

$P_{CME\_i_f}$: Final active power flow at the *Converter* calculated by DAD logic for contingency *i*. Positive values represent power flowing from Brazil to Uruguay.

P_{cme_o}: Active power flow at *Converter* before contingency *i* happens.

Variable *Ri* can be understood as a change of base because disconnecting load or changing the power flow at the *Converter* may have different influence on *CE*. Therefore subtraction cannot be performed directly. DAC_{oi} is calculated according to AFL and DAD must be calculated according to AFC.

The are two ways to calculate DAD_i.

1) Option 1

In this option, the purpose of DAD logic is to reduce the maximum load shedding DAC_{0i} as much as possible, or make it zero in the ideal case. So, it is necessary to find a value of *DADi* verifying the following equation:

$$DAC_{0i} - DAD_i.R_i = 0 \qquad \textbf{(6)}$$

Defining variable DAC_Δ as the value of DAD_i who satisfies equation (6), then for DAC-General logic:

$$DAC_\Delta = \frac{\max(DAC_{0i}, 0)}{R_i} \qquad \textbf{(7)}$$

And for DAC-Balance logic:

$$DAC_\Delta = \frac{DAC_{0i}}{R_i} \qquad \textbf{(8)}$$

As a particular case, it is defined $DAC_\Delta = 0 \; when \; R_i = 0$.

The theoretical final transfer (P_{CME_i}) at the *Converter* for contingency *i* is then calculated as:

$$P^{teo}_{CME_i} = max\left(min\left(P_{CME_0} + DAC_\Delta, INT_{MAX_{s_i}i}\right), INT_{MIN_{s_i}i}\right) \qquad \textbf{(9)}$$

$INT_{MAX\_s_i\_i} = min\left(P_{iMU\_s_i\_i}, P_{iMT}\right)$: Maximum power flow at the *Converter* from Brazil to Uruguay.

$INT_{MIN\_s_i\_i} = max\left(P_{eMU\_s_i\_i}, P_{eMT}\right)$: Maximum power flow at the *Converter* from Uruguay to Brazil.

$P_{iMU\_s_i\_i}$: Power flow limit at the *Converter* from Brazil to Uruguay depending on the contingency *i* and state s_i. This parameter is loaded in the RAS as a table with dimensions of (1000 states x 64 contingencies). $P_{iMU\_s_i\_i} \geq 0$.

P_{iMT}: Power flow limit at the *Converter* from Brazil to Uruguay depending on commercial or operational agreements between the Dispatch Center of both countries. This parameter is sent to RAS through SCADA. $P_{iMT} \geq 0$.

$P_{eMU\_s\_i}$: Power flow limit at the *Converter* from Uruguay to Brazil depending on the contingency *i* and state s_i. This parameter is loaded in the RAS as a table with dimensions of (1000 states x 64 contingencies). $P_{eMU\_s\_i} \leq 0$.

P_{eMT}: Power flow limit at the *Converter* from Uruguay to Brazil depending on commercial or operational agreements between the Dispatch Center of both countries. This parameter is sent to RAS through SCADA. $P_{iMT} \leq 0$.

Limits $P_{iMU\_s_i\_i}$ and $P_{eMU\_s_i\_i}$ are used to contemplate restrictions of *short-circuit capacity* for the *Converter*, transfer limits in the post contingency network, etc.

Thus, DAD logic has great flexibility and can increase or decrease the transfer and even change the direction of the power flow. In this way, it is the only logic capable of taking actions when generation is greater than demand ($DAC_{0i} < 0$).

2) Option 2

In some particular cases, depending on the contingency, the response speed of the *Converter* to change power may not be enough to replace load shedding. Therefore, Option 2 is designed to maintain the original transfer at the *Converter* and in some cases, trip the *Converter*. The final theoretical transfer $P^{teo}_{CME\_i}$ for contingency i is then calculated as:

$$IF\ (DAC_{\Delta} < 0) AND \left(P_{CME_0} > 0\right)$$
$$P^{teo}_{CME\_i} = 0$$
$$ELSE \qquad \textbf{(10)}$$
$$P^{teo}_{CME\_i} = max\left(min\left(P_{CME_0}, INT_{MAX_{s_i\_i}}\right), INT_{MIN_{s_i\_i}}\right)$$
$$END$$

Thus, if the load shedding is negative (excess of generation) and the *Converter* is importing power (transfer from Brazil to Uruguay) the transfer is set in zero by tripping the *Converter*. If with this action, demand becomes greater than generation, load shedding is necessary. Otherwise, the transfer is changed only to comply with the limits.

E. LSP logic

After calculating the load shedding, "Load Selection Process" logic selects the stations that will be tripped. Load is tripped disconnecting the entire Transmission Station opening the 150kV switches of all load transformers in the station. So far, 28 Transmission Stations have been defined to be tripped by the RAS. Stations are grouped by zones, existing up to 32 possible zones. The advantage of this is that stations can be grouped in one or more zones for each contingency taking into consideration if the station belongs to the area of influence of the contingency or not.

Each zone can be defined with a selection of stations (up to 128) and lines (up to 127), see Figure 2. A station can belong to more than one zone. The lines should be chosen are those that feed the area so that stations can be disconnected individually or all at once tripping the lines selected. The disconnection of the area by lines is used as an alternative way instead of disconnecting stations one by one.

			Zones						
		Row #	1	2	3	4	5	......	32
Threshold (%)		1	80	90	0	75	0	......	0
Substations	MVA	2	1	0	0	0	0	0	0
	MVF	3	1	0	1	0	0	0	0
	SOL	4	0	1	1	0	0	0	0
	PES	5	0	1	1	0	0	0	0
		.	.	.	.	.	.	.	.
		.	.	.	.	.	.	.	.
		.	.	.	.	.	.	.	.
		129	0	0	0	0	0	0	0
Lines	MVA-BIF1	130	1	0	0	0	0	0	0
	MVA-BIF2	131	1	0	1	0	0	0	0
		.	.	.	.	.	.	.	.
		.	.	.	.	.	.	.	.
		.	.	.	.	.	.	.	.
		256	0	0	0	0	0	0	0

Figure 2

Based on studies it can be seen that tripping too many stations from the same zone, leaving the zone with lines/cables only without load, may cause troubles for voltage control due to the reactive power generated by these equipment.

The decision of disconnecting load tripping lines or stations is taken based on a threshold defined in the first row of the table. This threshold value represents the percentage of load to be disconnected on the total load of the zone from which the zone will be tripped by lines and not by stations.

Once the zones have been created, zones can be assigned for each contingency using Table shown in Figure 3. The selection is done by assigning a non-zero number to for the zone that also indicates the priority with which the stations will be chosen in that zone instead of stations from other zones. That is, the load shedding will be done with stations from the zone with priority one, then with stations from the zone with priority two and so on. Within each zone, stations are sorted by load, from the highest to the lowest. The station placed at the beginning of the zone has the greatest load and the station in the last place has the lowest load.

Zones	Contingencies					
	Contingency 1	Contingency 2	Contingency 3	Contingency 4	.....	Contingency 64
1	3	2	5	3	.....	0
2	1	1	2	1	.....	0
3	2	0	3	2	.....	0
4	4	0	0	4	.....	0
5	0	0	4	0	.....	0
6	0	0	1	0	.....	0
.	.	.	.	.	.....	.
.	.	.	.	.	.....	.
.	.	.	.	.	.....	.
32	0	0	0	0	.....	0

Figure 3

The logic selects loads according to the following procedure:

- Stations are sorted by zone first and then within each zone by load, from highest to lowest.
- With the amount of load shedding for contingency i previously determined (DAC_i), stations are selected from the sorted list until the total load selected is greater than DAC_i.
- During the selection, if the percentage of load selected for a particular zone is greater than the threshold of the zone, the zone is tripped by lines, not by stations.
- In order to obtain a more accurate load shedding, the last selected station will be replaced by the smaller station (still unselected) such that the total amount of load selected is greater or equal than DAC_i.

There is the possibility for the Dispatch Operator to disable any station so the RAS will no select this station. The RAS respects this condition provided the equivalent load shedding of all enabled stations is greater or equal to the *DACi*. If this is not true, RAS will not consider the selection of the Operator and will assume that all stations are available.

F. DAR-Qc logic

This logic calculates the capacitor bank disconnection (which is done in parallel with the load shedding) to contribute to the post contingency system voltage control.

For each contingency, the amount of capacitive reactive power disconnection is calculated according to the following formula:

$$Qc_i = \alpha_i . DAC_i + \beta_i + \gamma_i . Q_i \qquad \textbf{(11)}$$

Qc_i: capacitive reactive power to be disconnected for contingency i

$\alpha_i, \beta_i, \gamma_i$: constants, three for each contingency.

$Q_i = \sum_e C_{ei} . \phi r_{ei}$: Reactive power flow in the equipment associated with the events defined for contingency i. Constants C_{ei} are the same as for the calculation of *DACi*.

Once the amount of reactive power to be disconnected is calculated, capacitor banks to be switched off to comply with

Qc_i are selected. The RAS has the ability to trip up to 32 capacitor banks. The order in which the capacitors are selected is determined by a merit list preloaded in the RAS.

G. DAL logic

DAL logic handles the automatic tripping of transmission lines to separate systems or to create islands. The RAS has the ability to trip up to 63 lines. The trip of a line is decided based on the contingency and system state. Each line has an associated dimension table 1000x64 (states x contingencies) in which a 1 in the position (p, q) indicates that the line should be tripped for state p and contingency q. It has an additional table of the same dimensions indicating a delay in milliseconds to send the DAL actions.

H. DAR-DAC logic

After performing the actions of the RAS, it may happen that due to an error in the load shedding (miscalculation, communication failure, switches failure, undesired loss of generation due to the contingency, etc.) some equipment could remain overloaded or with very low voltage. In these cases, the DAR-DAC logic generates additional load shedding assuming that actions were not enough. The RAS allows the user to select two *CE* per contingency, one to check the voltage and the other one to check power flow after the contingency happens.

After the RAS finish executing the actions calculated for contingency *i*, wait a predefined time and check again for any voltage or power flow out of bounds. If the limits are violated, an additional station from the list created for contingency *i* by LSP logic is tripped. The RAS will check the limits again every second and will continue tripping stations. The process continues until no limit is violated or until a maximum amount of additional load is tripped.

I. Logics interaction

Each contingency has an associated formula, DAC-General or DAC-Balance, which calculates the load shedding DAC_{0i} (MW) required for contingency *i*. DAD logic then tries to reduce DAC_{0i} through a change in the power flow in the Converter, DAD_i. The final load shedding considering the changes in the Converter is called DAC_i. The LSP logic is responsible in the end for selecting the stations that must be disconnected to achieve DAC_i. The logic DAR-Qc uses $DACi$ as an input value to calculate the amount of capacitive reactive power to be disconnected by tripping capacitor banks. This is needed to control the system voltage after the contingency happens. DAL logic selects the equipment that must be disconnected to separate systems and create islands. Finally DAR-DAC logic verifies that after the actions have been executed by the RAS there is no equipment overloaded or with under voltage, in which case the RAS will keep tripping stations. Every logic can be disabled individually.

IV. Simulator

It was developed in Python language a program to create automatically all the distribution and alleviation factor tables. Moreover a simulator in Python and Matlab language implements all the logics of the RAS (in Matlab), runs simulations in PSSE (with Python) and graphics (in Matlab) all output variables obtained from PSSE simulations.

V. Simulation Results

As an example of the performance of DAC-Balance formula, Figure 4 shows the system frequency for one of the worst double contingency in the Uruguayan power system, when the two lines between San Javier and Palmar 500kV stations go out of service. The red plot is the frequency without RAS actions and blue plot is the frequency when the RAS is enabled.

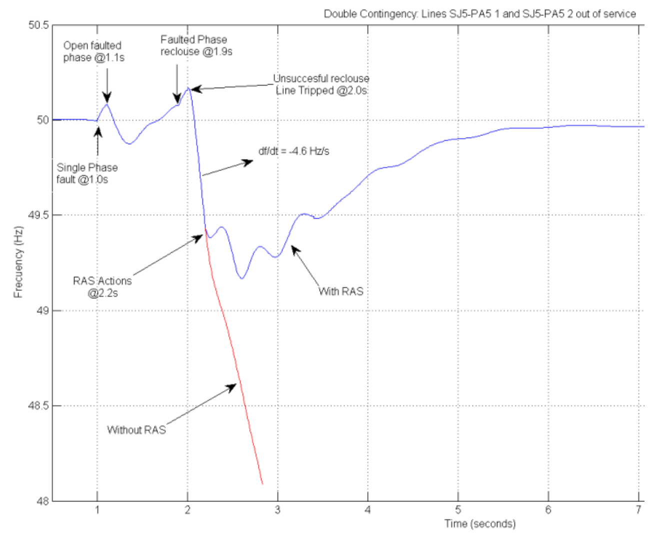

Figure 4

Because of the fast actions of the RAS, the frequency recovers preventing a system frequency collapse.

As an example of the performance of DAC-General formula, Figure 5 shows power flow of two of the most important 500/150kV transformers in the system (TrMA5 and TrMB5) when the line between stations MA5 and MI5 goes out of service. In blue is the power flow of the CE with greatest *DAC0i* (TrMA5) and in green is the power flow of TrMB5.

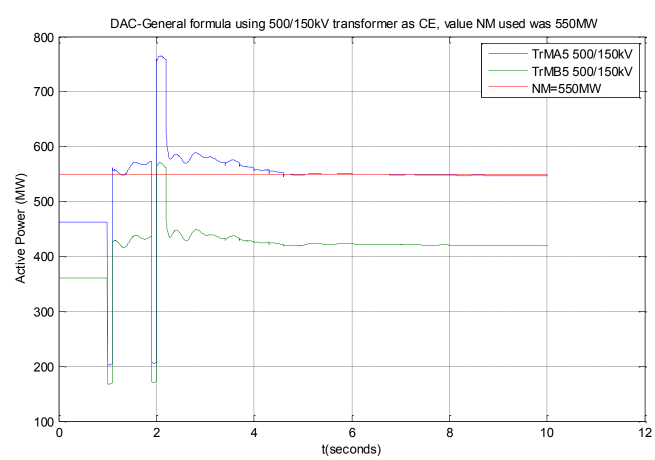

Figure 5

The NM value used is 550MW. The load shedding is executed at 2.2 seconds. Because of the fast actions, the transformer remains in service preventing the cascade output of both transformers.

VI. Conclusions

The new RAS has many advantages for the power system and the System Operators. It requires minimum intervention of the System Operator, it is fast and very flexible. The logics provide a very accurate load shedding. With the two different formulas, a very wide number of contingencies are considered. The Load Selection Process logic allows to define and group stations considering the influence zone of the contingencies. The simulator developed helps in the tuning of the parameters. The RAS is designed to allow future expansion with little interruption to the performance.

SEL engineers are currently working on the project. Open Line Detection Algorithms have been tested in the field with successful results verifying the previous RTDS simulations [1]. Also, some action signals were tested successfully. The end of the project is expected by June 2016.

VII. ACKNOWLEDGMENT

The UTE team would like to distinguish Eng. Fredy Sánchez, whose contributions to the design of the RAS algorithm were essential for the project succeed. He will be always remembered for us.

VIII. References

[1] Julián Malcón, Nicolás Yedrzejewski, Ashok Balasubramanian, Rameez Syed, and Sai Krishna Raghupathula, "Implementing a Country-Wide Modular Remedial Action Scheme in Uruguay," *Western Protective Relay Conference (WPRC), October 2015, available at SEL webpage.*

IX. Biographies

Sebastián Beledo was born in Durazno, Uruguay, on June, 1981. He graduated in Electrical Engineering (2009) from Universidad de la República, Uruguay. Since 2012 he work as Dynamic Studies Expert at the National Dispatch Center , UTE.

David Bonjour was graduated as Electrical Engineer in “Facultad de Ingeniería de la Universidad de la República” in 1997. Since 1994 he works in Dispatch Center of UTE- Uruguay. His special area of interest of work includes studies of transient electromagnetic and electromechanical planning associated with the operation of the electrical system. He is currently head of the Department of Planning and Studies of the System.

Fredy Sánchez Dapiaggi (1966-2014) was born in Montevideo, Uruguay, on December, 1966. He graduated in Electrical Engineering from Universidad de la República, Uruguay. His special area of interest of work includes studies of transient electromagnetic and electromechanical planning, equipment modelling, associated with the operation of the electrical system. He was with UTE from 2006 to 2014 as Dynamic Studies Expert at the National Dispatch Center.

Nicolás Yedrzejewski was born in Montevideo, Uruguay, on December, 1979. He graduated in Electrical Engineering (2006) from Universidad de la República, Uruguay. From 2004 to 2007 worked in CIME Ingeniería related with comprehensive protection against atmospheric discharges projects. He is with the Electrical Engineering Institute at Universidad de la República since 2006 now as an Associate Professor. He is with UTE since 2007 as Dynamic Studies Expert at the National Dispatch Center.