Study Committee C4

Power System Technical Performance

Paper 11117_2022

Argentina's Power System Stability Assessment for Itaipú – Yacyretá Interconnection.

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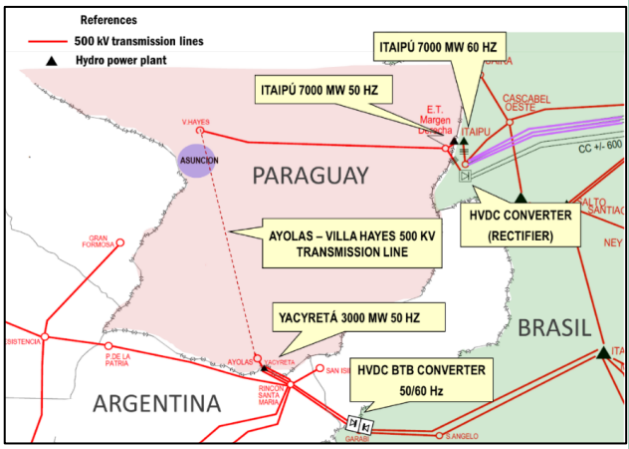
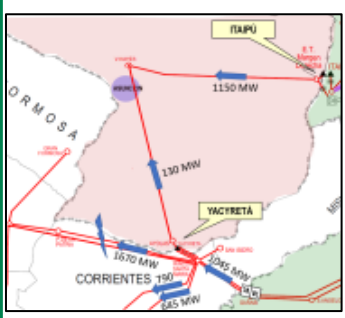
MOTIVATION

- Argentina's power system has been, for many years, connected at 500 kV to a part of the Paraguayan power system through Yacyretá hydro power plant (3000 MW), owned by both countries.
- In 2021, the Republic of Paraguay completed the 500 kV transmission line that connects the Ayolas and Villa Hayes substations, thus interconnecting the Itaipú 50 Hz hydro power plant (7000 MW) with Yacyretá, and consequently the entire Paraguayan power system with the Argentine system.
- This paper presents the main challenges found during the preliminary studies performed to assess, from the point of view of the Argentine Interconnected System's (SADI) security, the stability of this new interconnection.

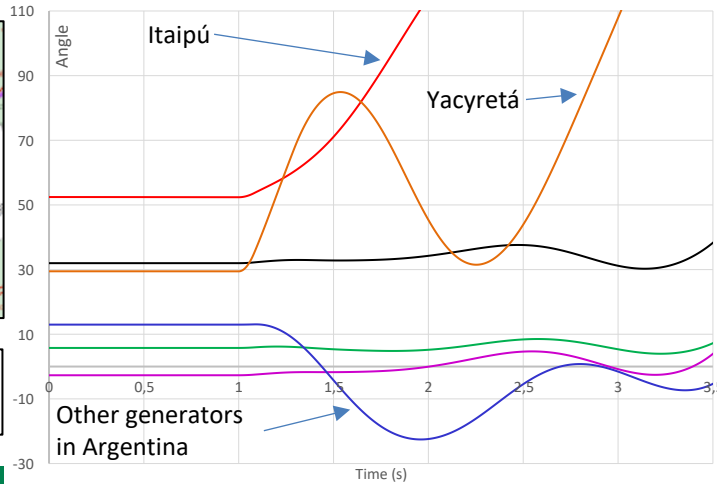


PRELIMINARY STABILITY ASSESSMENT



Only currently in-service Argentina's SPSs (special protection schemes) were considered.

This simulation revealed the need to implement new SPSs or reprogram existing ones, so that the SADI can continue its stable operation after a design contingency, single fault or high-probability-of-occurrence double fault.



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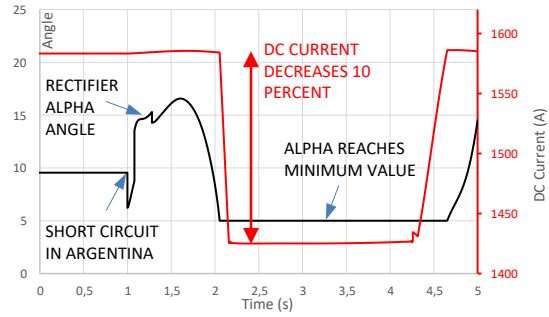
ABOUT HVDC LINKS MODELLING AND STABILITY

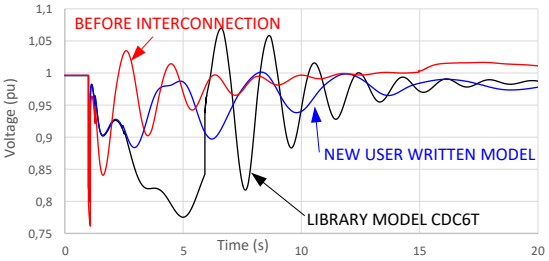
In the first stability simulations it was observed that, under faults in the Argentine electric system, the CDC6T library model of the Paraguay - Brazil HVDC link, made a sudden power decrease. This dynamic behaviour was striking since power on the HVDC link was expected to remain almost constant. This decrease in transmitted power in the direction Paraguay → Brazil involved a sudden 400 MW transfer increase between Yacyretá and the Argentine system in the first post-contingency seconds, deteriorating the dynamic behaviour of the entire system.

Later, CAMMESA received a new HVDC link user-written model in which **all its control loops were represented in detail.** With this new and more detailed model, the sudden decrease in HVDC link power transfer **was not observed.**

The figure compares voltage time evolution in one bus of the Argentine system for three simulations under the same contingency.

This example highlights the importance of HVDC links complete modelling in determining system's transmission capacity, not being advisable the use of simplified models in cases like this one, when transient stability margins are small.

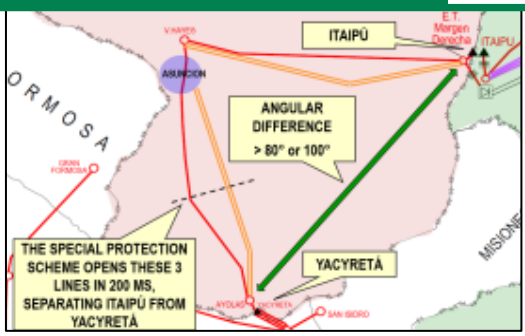




STABILITY ASSESSMENT OF PARAGUAY'S SPS FOR SYSTEM SEPARATION

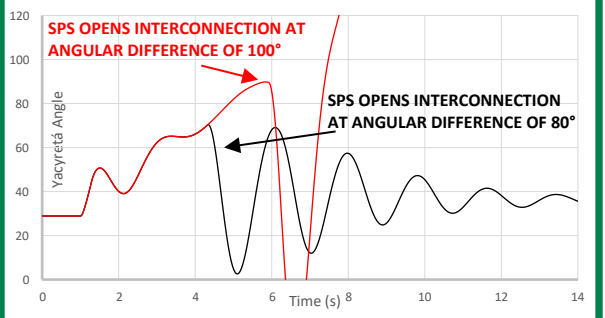
The new **SPS** will open Argentina – Paraguay interconnection in case of severe contingencies, to avoid loss of synchronism and uncontrolled separation.

The SPS has multiple activation triggers, one of them is **by maximum angle between Margen Derecha and Ayolas substations, intended to avoid loss of synchronism between Itaipú and Yacyretá power plants.**

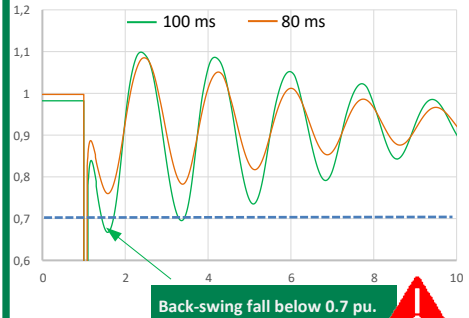


100° setting — **Loss of synchronism between Itaipú and Yacyretá power plants with respect to the rest of the generators in the Argentine system.**

80° setting — **The system maintains stability, and even complies with SADI's dynamic performance criteria.**



Fault clearance time influence.



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UNDERFREQUENCY SYSTEM SEPARATION

A new protection was planned to separate the Argentine and Paraguayan systems when the frequency fell below 49.3 Hz.

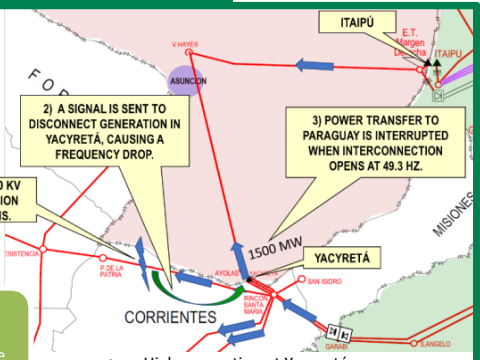
In combination with SADI's currently operating SPS (called DAG NEA), it could reduce SADI's transient stability margins.

Short circuit near Yacyretá followed by disconnection of the 500 kV TL Rincón – Paso de la Patria.

Yacyretá's generators tend to accelerate with respect to the rest of SADI's generators.

To prevent loss of synchronism DAG NEA SPS disconnects in 200 ms generation at Yacyretá.

This results in a frequency decrease that can activate the 49.3 Hz protection, opening the interconnection.



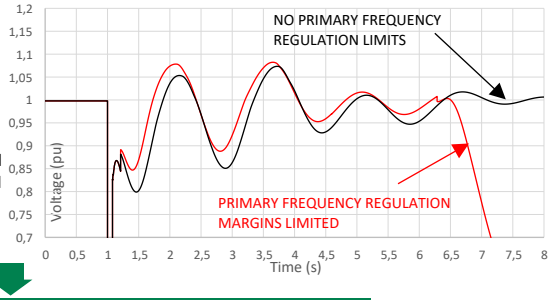
- High generation at Yacyretá.
- High Brasil → SADI power transfer.

When frequency reaches 49.3 Hz the 500 kV transmission system that connects Yacyretá with the rest of the Argentine system will receive an active power step equal to the power interrupted at the interconnection, which can reach values of up to 1500 MW, possibly causing a voltage collapse in the northeast of Argentina's power system and the loss of synchronism of Yacyretá power plant.

Impact of primary frequency regulation reserves on system separation at 49.3 Hz

The figure compares a case in which regulation reserves are correctly modelled, with another case in which units speed/power governors are left free, being able to increase their power up to the limit imposed by the prime mover.

In the first case, the frequency will drop below 49.3 Hz, the protection that separates the Argentine system from the Paraguayan system will be activated **and the voltage collapse and loss of synchronism mentioned above could occur**. In the second case, the units of the Argentine system would make an extraordinary power contribution, **the frequency will not reach 49.3 Hz and the system will evolve without losing stability.**



An adequate representation of generator power contribution during transients is essential.

CONCLUSIONS

- After carrying out transient stability simulations, it was concluded that to maximize power transfers between countries, it is necessary to implement new SPSs.
- It has been proven that interconnection's stability is highly sensitive to SPSs and protections settings, as well as to dynamic behaviour of HVDC's controls and generator's spinning reserve. Therefore, a high degree of accuracy will be required when performing simulations to determine transmission system's operational security limits.
- To maximize power transfers, it is mandatory to maintain a close collaboration between countries involved, allowing a constant improvement and updating of databases for load flow and electromechanical transient studies.
- Given that the interconnection will be operating close to transient stability limits, it will be essential to implement backup protections for possible failure of main special protection schemes.