A GENERIC 800 KV HVDC BIPOLE MODEL FOR TRANSMISSION PLANNING IN BRAZIL

The Brazilian interconnect power system currently operates with six HVDC bulk long-distance transmission bipoles, as illustrated in Figure 1.

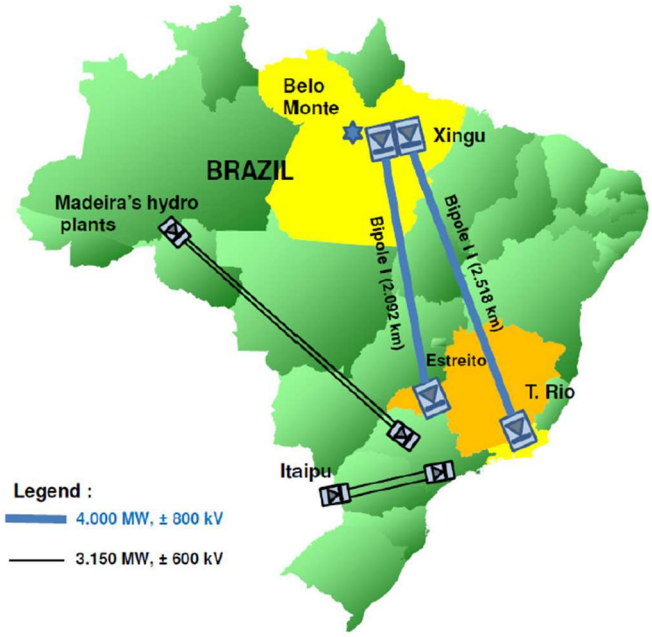

Figure 1 - Long distance HVDC transmission links operating in the Brazilian network

The HVDC pioneer project associated to Itaipu hydropower generation, resulted with two 600 kV bipoles, in operation since 1985. After 25 years, came the two 600 kV Madeira's bipoles, one of the alternatives recommended in the national transmission planning expansion program, part of a large expansion of the country power network. At that time of Madeira's HVDC system studies, planners had the perception that the development of a generic, but realistic HVDC transmission EMT type model was imperative. The benchmarking or public model available were to simple and manufacture's model very difficult to access.

The challenge to study and develop the first 800 kV HVDC transmission project in Brazil, associated to Belo Monte hydro power, leveraged the efforts toward the development of a generic EMT type model, capable to represent the most relevant parts of a HVDC LCC transmission bipolar system, suitable for the planning studies stage of the project.

The concession process in Brazil for new HVDC projects reinforced this perception. The new transmission assets have its concession disputed in bids, and transmission planners must conceive a reference solution, to be provided, alternatively, by a number of manufactures, such as to incentive competition, considering up dated, but tested technologies, already in operation. The winner concessionary contract a manufacture of his choice and has some freedom to modify the reference solution, since the proposed new solution is in accordance with the requirements of the bid technical specification.

This concession process resulted in a diversity of HVDC converter manufactures presented in the Brazilian power system. The last four bipole's concession in dispute, four distinct manufactures were selected, each one within their own conceptions.

Generic HVDC Link Modelling – Belo Monte's bipoles I and II

The previous experience obtained during the Madeira's HVDC system basic project design [1] gave some indication for the development of the 800 kV model, in particular to consider only a set of basic controls and elements necessary for the type of simulations involved. The run-time of detailed EMT type HVDC models, used at that time to demonstrate adequate converter performance, frequently was reported to be very long.

A generic EMT type model was developed and applied during the Belo Monte's first and second bipoles studies with good results [2].

The primary objective of the 800 kV HVDC model was to provide a resource for the electromagnetic transients studies. Additionally, the model was based on control topology found in actual HVDC projects and served also as an exercise in promoting understanding of HVDC control concepts.

The model was based on a generic "transvector" firing control, which receives an alpha order from the pole controls and generates firing pulses to 12 converter valves. The only important user defined settings required for the "transvector" control were proportional and integral gain settings. Simple, higher level controls (pole current control, VDCOL, bipole power controls, etc.) are completely user defined and followed a topology very approximately based on the Itaipu HVDC project. Rather few settings were required to obtain satisfactory performance and the user was free to experiment.

Figure 2 illustrates the "top view" of the Estreito (Minas) and Terminal Rio terminals of the two bipoles in the software. The HVDC lines and the electrode lines were modelled using frequency dependant model. The AC filter banks were generic double tuned banks adjusted to provide the desired Mvar rating and tuned frequencies. The DC filter type was a generic triple tuned filter.

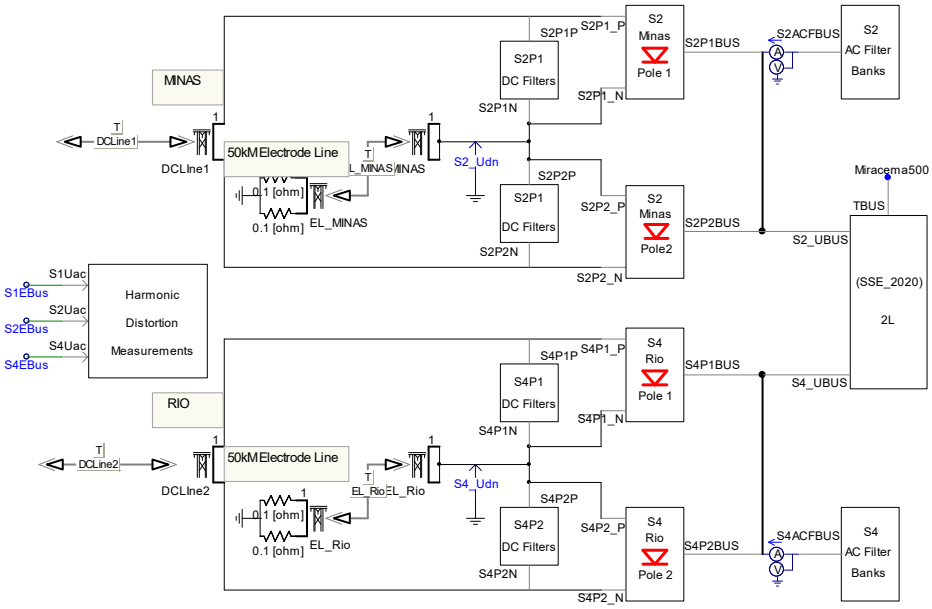

Figure 2 - Estreito (Bipole I) and Terminal Rio (Bipole II) ends of the ± 800 kV HVDC system represented ("top view")

Digital model performance

A relevant issue in the modelling of a large network using digital simulation is related to its computer processing performance, especially nowadays, as everyone expects to work with personal computer with fast processing. Considering such requirements, the modelling concept used for the analysis herein described had an acceptable performance. Using a conventional engineering personal computer with 64 bit operating system, and 8 GB RAM, the run-times resulted in reasonable values, as indicated in Table I, for each type of simulation processed. A reasonable number of AC electrical network elements modelled in the software resulted in nearly 80 three-phase buses.

Table I – Typical simulation run-times

Type of simulation	Snapshot (pre-initialized state) simulation		Actual simulation (from a snapshot simulation)	
	Simulation time (s)	Run-time (minute)	Simulation time (s)	Run-time (minute)
Electromagnetic transients	1	4.4	1	4.5
Dynamic performance	4	18.2	1	5.5
Multi-infeed evaluation	1	13.2	1	13.5

Although a large network was represented in the software, the modelling concept used for the analysis had an acceptable performance, achieving adequate run-times.

Currently, a new 800 kV bipole is under planning development in Brazil, and the generic model has been applied with success.

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