1.0 Introduction

Traditional power system simulators were assembled from purely analog miniature components for modeling transmission lines, transformers and loads. Hydro-Québec and more specifically IREQ are very well known for their contribution in building and operating one of the largest analog real-time simulator in the world. In the late 80’s, computer processing power transformed the analog simulator to an hybrid (analog/digital) one in which fully digital synchronous machine models running on DSP's were interfaced to the rest through D/A conversions. In 1996, IREQ developed Hypersim, a fully digital power system simulator which compare to the hybrid version offers advantages such as compactness, flexibility and scalability. As of today, Hypersim runs on two different platforms: an in-house design based on 533 MHz Alpha processors and a general purpose high-performance parallel machine made by Silicon Graphics.

The Hydro-Québec network, one of the largest in North-America consists mainly of over 35000 MW remote hydraulic generation transmitted over 1000 km by eleven 735 kV transmission lines to two major load centers, Montreal and Quebec cities. Steady-state and transient stabilities of such a vast system are insured by the use of dynamic shunt compensation (synchronous and static compensators) and MOV protected series compensation. The actual transmission system simulated on Hypersim, corresponds to a realistic summer load-flow with simplifications in terms of regrouping some generation stations and sub-transmission lines and loads. This network contains:

- 6 hydraulic generators with full controls (exciter, speed regulator, turbine and stabilizer);
- 4 synchronous compensators with full excitation system;
- 5 static compensators (1 TCR and 4 TSC branches) with detailed internal controls;
- 20 saturable 2 or 3 windings transformers;
- 40 series-compensated transmission lines;
- 3 dynamic loads (transient stability type with adjustable load coefficients);
- 5 MOV for series capacitor over voltage protection;
- 1 gap and by-pass breaker with controls for MOV energy absorption protection.

Out of the 30 nodes assembled (Fig. 1), 28 nodes were used by the automatic task mapper to distribute different computing tasks of the simulated network with a time-step of 56 μs. It is also worthy to mention that some of the nodes were also equipped with I/O boards (16 D/A and 16 A/D) for the purpose of both analog and digital acquisitions.

3.0 Typical simulation results

Many different perturbation scenarios and statistical faults were applied on the system over a period of a week for various purposes such as testing the acquisition and I/O systems, long term numerical stability (over 72 hours) etc., and satisfactory results were obtained. Figures 2a and 2b shows a typical digital acquisition of nearby machine and SVC signals during a 3 ph-g. 6 cycles fault at LG2 735 kV busbar. The machine dynamics and SVC behavior are well
within the expected range of variations. A full validation of the transient behavior is currently under way with EMTP and will be published in a later paper. Figure 3 focuses on the aspect of the comparison between digital and analog acquisitions of the TCR valve voltage of the SVC. Again the results show very good agreement in term of frequency bandwidth and time delay (less than 1.5 time-step or 85 µs).

4.0 Conclusion
High performance fully digital real-time simulation of a large EHV transmission system has been demonstrated on a Hypersim 30 processors simulator. Tests and simulation runs showed that the Hypersim technology is mature enough to be used cost-effectively in large scaled real-time simulations taking into account full machine dynamics and a more detailed power system representation. As a result, large fully digital real-time simulators now allow for very realistic control and protective system studies and testing.

About the Authors
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