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One case showing the importance of keeping replicas up-to-date is reported, involving Furnas Itaipu HVDC System. The project comprises two bipoles of 3150 MW at ± 600 kV, in commercial operation since 1984 (BP 1) and 1987 (BP 2). The control and protection (C & P) systems replicas were interfaced with a real-time simulator (Figure 1). Initially installed in Sweden, it has been used for the design and tests of the C & P system, like factory systems tests, dynamic performance studies, protection coordination studies and pre-commissioning tests. In 1982 the replicas were moved to Brazil to continue the studies.

Figure 1a) Control System panels at Rectifier Station   Figure 1b) Real-time simulator and control system replicas.
Figure 1 – Control and protection system and replicas.

After some time in commercial operation, the current control amplifier (CCA), in the final part of the pole current control system, started to experience intermittent stall alarms, leading to the “freezing” of converter firing angles orders, hence losing regulation capacity, i.e., feedback ability. Although a CPU reset could solve the issue, it was nonetheless a maintenance action, with a chance of a converter outage. A throughout investigation concluded that an electronic component’s temporary failure due to poor thermal stress supportability provoked by ageing was the cause. Figure 2 presents a simplified block diagram of the Pole Current Control, identifying the CCA part.

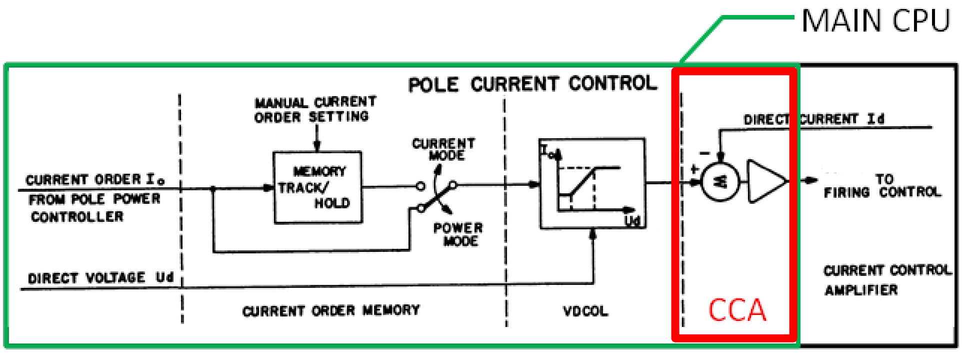

Figure 2 – Pole Current Control simplified block diagram.

As time went by, the failure frequency increased to unacceptable levels. So, in 2011 Furnas decided to mitigate this problem. Since the control system is composed of legacy technology, an exact component replacement was deemed impossible. Therefore, a supplementary hot-standby controller was designed and installed at the C & P replicas connected to Furnas Real-Time Simulator.

The controller replicates all functions with an additional stall supervision routine. To perform in a smooth bumpless fashion, it monitors the main CPU stall alarm and, once flagged, it calculates the difference between the programmed alpha order and the frozen main CPU alpha order (Figure 3).

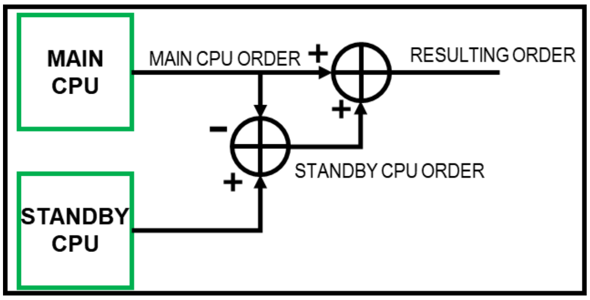

Figure 3 – New Current Control Amplifier simplified block diagram (with the supplementary controller)

It is important to notice that it was only possible to conduct the proposed hardware and software changes and test the performance of the supplementary system with a high degree of confidence, hence de-risking site implementation, because control system replicas were serviceable.

Serviceable replicas mean that:

- Similar tuning of both on-site and replica controls; and
- All modifications were implemented on both on-site and replica controls.

As the supplementary control proved to work as desirable, it was then implemented on site in 2012 and has been continuously in use in all poles since then.

In conclusion:

- The improvement in the control system is a success, as no additional problem regarding this matter has been observed;
- Serviceable control systems replicas were a key point to allow safe and reliable testing before implementing the control improvements on-site; and
- Besides, serviceable (up-to-date) replicas are also useful for several tasks, like disturbance investigation and analysis, offline EMT and RMS models validation, training and others.

In summary, this case shows the importance of keeping Control and Protection (C & P) replicas in serviceable conditions.