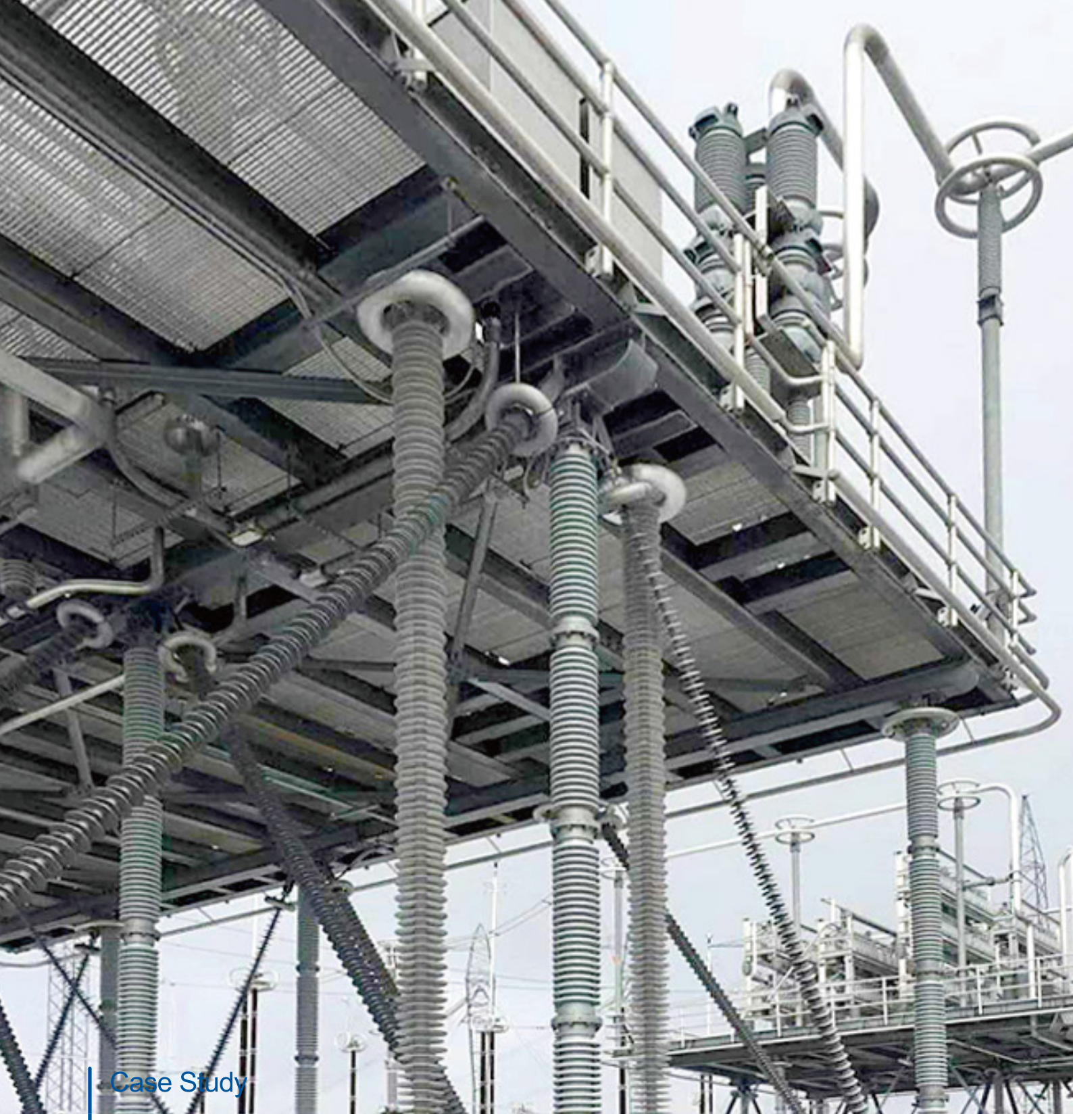


Case Study

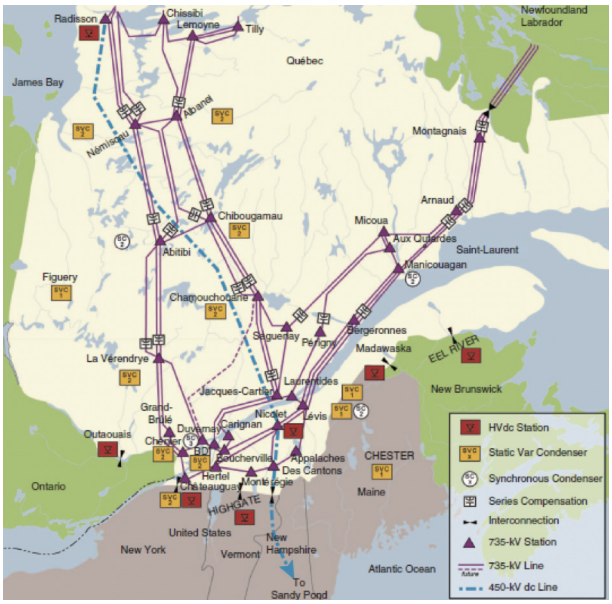
NR Series Compensation Refurbishment

Replacing aging infrastructure at 735kV fixed series compensation substation in Chibougamau Canada in order to maintain transmission system efficiency

NR Electric Co., Ltd.

Project Overview

From 1993 to 1996, about 32 sets of 735kV Series Compensation (SC) systems were installed in the eastern power grid of Canada. Recently, the SC Protection and Control (P&C) system have reached their service life but the primary equipment didn’ t reach the operation life. The spare parts of P&C system are not available from the manufacture. So, to prolong the overall life of 735kV SC system, it is time to upgrade the SC and P&C system.

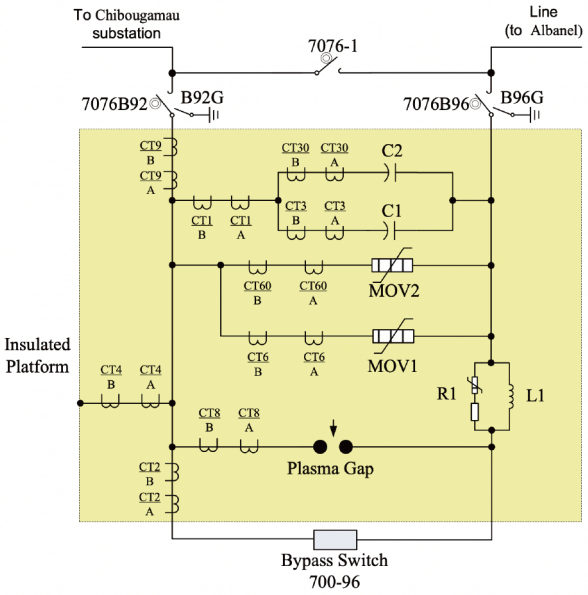


NR Electric replaced the CXC-96, CXC-97 and CXC-98 Fixed Series Compensation (FSC) protection & control system installed in the 735kV Chibougamau to Albanel transmission lines in 2018, which were originally supplied by GE in 1990s.

Item	*CXC-96*	*CXC-97*	*CXC-98*
System Voltage (kVrms)	735	735	735
Power frequency (Hz)		60	
Reactive power (3-phase) (MVar)	325.3	325.3	325.3
Degree of compensation	32%	32%	32%
Rated current (A)	2200	2200	2200
SC Rated voltage (RMS, kV)	49.28	49.28	49.28
Capacitance per phase (μF)	118.42	118.42	118.42
Rated reactance(ohm/phase)	22.4	22.4	22.4
Protective level (p.u.)	2.41	2.41	2.41

Key Challenge

The primary electrical equipment are all reused, including the capacitor banks, MOV, spark gap, damping circuit and the insulated platform, while the existing secondary devices are out of their service life and not able to run normally. The single line diagram (SLD) of the three sets of FSC is as shown below.



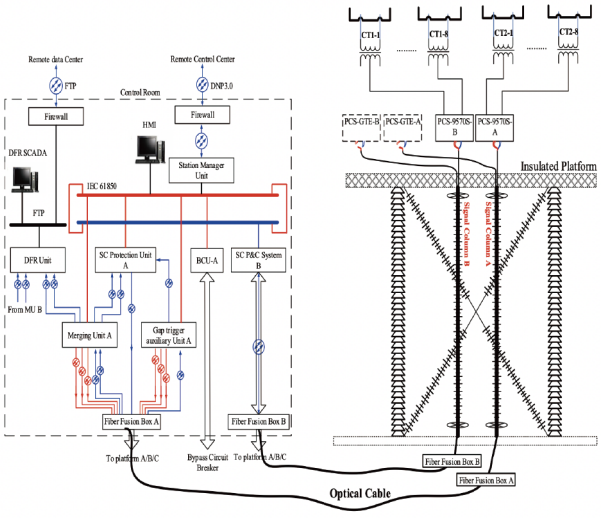
The upgrading scope includes the FSC P&C system, HMI, A/D converter modules, optical signal column and trigger circuit of the plasma gap.

735kV Chibougamau system is an important project for the Quebec to improve the power transmission capacity of hydropower. The modernization of the P&C system is expected to significantly improve the grid reliability and help reduce maintenance needs.

NR provides well-proven key equipment with independent intellectual property rights for this project, such as PAC system, gap trigger system, measuring system and fiber signal column. In strict accordance with the Quebec electricity and technical requirements of series compensation control protection system. NR also carries out optical fiber signal column type experiment as required. Passed all strict factory test, field & commissioning test. NR series compensators project’ s all technical indicators meet the requirements of Hydro-Québec (HQ), and have been highly evaluated.

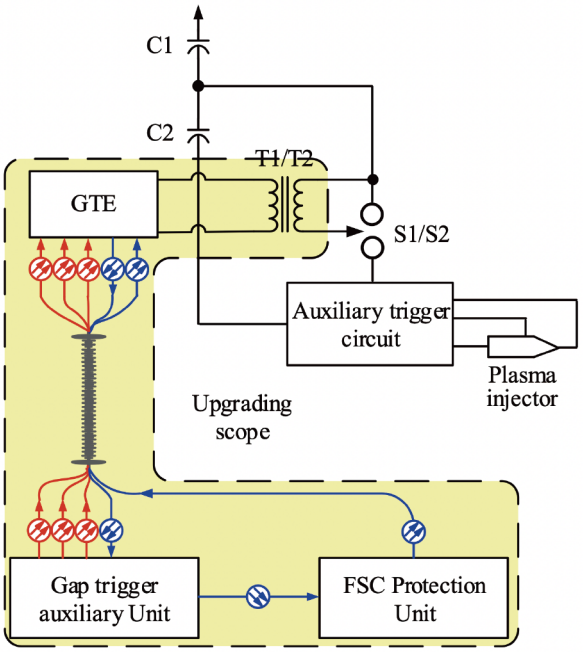
The Solution

The overall configuration of SC PAC system is shown below with hierarchical and distributed structure.



Gap Triggering Electronics (GTE)

As a key equipment of SC system, plasma gap or spark gap plays an important role in protecting the capacitor and MOV. In this project, the upgrading scope of gap triggering circuit is shown below.



The forced trigger plasma gap or spark gap can protect the energy absorbed by MOV from exceeding its limit. When the fault current reaches the MOV threshold, the total time from sending the trigger protection gap signal to breakdown of protection gap is no longer than 1ms. NR GTE not only triggers the spark gap, but also trigger the plasma gap.

Protection & Control

NR' s PAC devices are developed based on the advanced UAPC platform of NR. Main features of the UAPC platform include: modular hardware & software, versatility and flexibility, very strong expandability, high performance, high reliability, high resistance to interference, and support of digital & networked interfaces.

The features of the device are described as follows:

1. The intelligent equipment integrating protection, control, and monitoring provides powerful protection function, flexible configuration, user programmable logic, and configurable binary input and output, which can meet various application requirements.

2. High-performance hardware platform and modularized design, MCU (management control unit) ＋DSP (digital signal processor). MCU manages general fault detector element and DSP manages protection & metering. Their data acquisition system is completely independent in electronic circuit. DC power supply of output relay is controlled by the operation of fault detector element. This prevents mal-operation due to error from ADC or damage of any apparatus.

3. Equipment hardware & software adopt modular design and hardware modules can be flexibly expanded using high-speed internal bus, allowing versatile application, easy expansion, and maintenance.

4. The bypass mode of pickup＋protection operation output is adopted to eliminate mal-operation due to fault in protection unit hardware.

5. All main protection functions are truly realized by any one unit.

6. Modular programs allow flexible protection configuration and easy adjustment of functions.

The NR supplied SC protection & control cabinets on site are as follows.

A/D conversion cabinets on the insulated platform are shown below.

The optical signal columns after replacement are illustrated below.

Comprehensive Protection Function

Main protections for fixed series compensation system of mainstream configuration are:

1. Capacitor unbalance protection;
2. Capacitor overload protection;
3. MOV (Metal Oxide Varistors) overload protection;
4. MOV failure protection;
5. Gap self-trigger protection;
6. Gap long conduction protection;
7. Refuse/delay trigger protection;
8. Flashover to platform protection;
9. SSR protection;
10. Capacitor discharge protection;
11. Line current supervision;
12. Pole disagreement protection;
13. Bypass breaker failure protection;
14. Optical fiber system failure.

Professional System Design

NR possess professional capability in system design, and by adopting the technology such as BPA, EMTDC, RTDS real-time digital simulation system and dynamic model simulation system according to the condition of the custom system and the problem to be solved. NR can make a detailed system analysis, confirm the system design specification, control strategy and acquire the product running effect before its practical running.

Strict Technical Standards and Severe Service Conditions

The SC protection & control cabinets, A/D conversion system, gap triggering system, passed the environmental test, EMC test, vibration test and combustion test according to the Hydro Quebec' s technical standards.

The electronics on the insulated platform, including the A/D conversion modules and gap trigger electronics passed the cold temperature -50 ° C test.

The optical signal column passed the design test, type test and temperature cycle test from -50 °C to +50 °C.

NR's Series Compensation System Features

For long distance bulk transmission corridor, NR provides series compensation solution which helps power utility reinforce transmission infrastructure and increase transmission capacity against more investment on requirement on new lines.

NR Electric has extensive experiences about brand new SC project and upgrading the SC PAC system. Until now, NR has upgraded three SC PAC systems originally supplied by the other manufacturers. Among these cases, seven SC supplied by GE, four SC' s supplied by Siemens, three SC' s supplied by Nokian. Also in December 2014, NR Electric won a contract of upgrading two SC protection & control systems which were originally supplied by Nokian and one of the SC protection & control systems has been completed and put in operation in June of 2015. In May 2016, NR won three 735kV SC protection & control system upgrading projects in Chibougamau substation from Hydro Quebec and the refurbishment three FSC protection & control system had been put in service on May, August and November 2018.

Series compensation is a cutting edge technology that can reduce transfer reactance, increase the transient and voltage stability in transmission systems, most notably in bulk transmission corridors. This technology is part of NR's family of Flexible AC Transmission Systems (FACTS) solutions that increases the capacity & reliability of existing transmission networks and contributes to the development of smart grids.

Solution Benefits

- Professional capability in system design to tailor products for user' s requirement.
- The characteristic of self-trigger and forced trigger of NR' s Spark Gap is stable and reliable.
- Stable triggering system.
- The measuring system using ECT against strong on-site interference.
- NR' s PAC devices are developed based on the advanced UAPC platform of NR.
- Comprehensive protection function.

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