De-icer Installation at Lévis Substation on Hydro Québec's High Voltage System

Presenters

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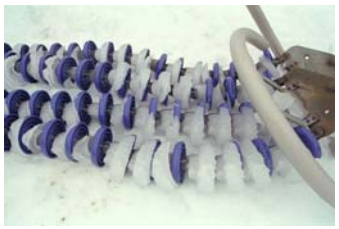
T&D

Background

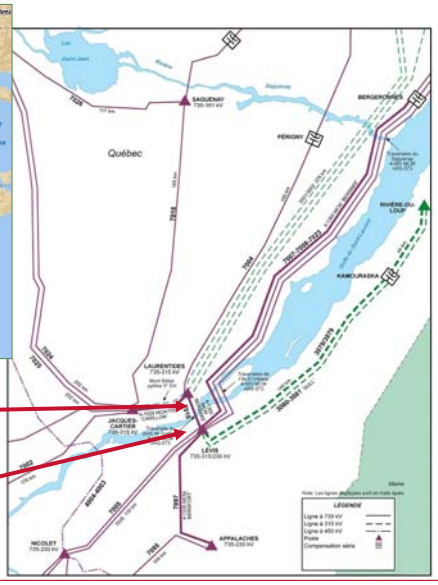
Why a de-icer?



- In December 1998, the Québec region of Canada was hit by one of the worst ice-storms in recorded history

- The ice storm generated ice build-up as much as 75mm
- An accumulation of ice toppled hydro towers and downed hundreds of kilometres of high-voltage transmission lines.

De-icer: Location



Québec city

De-icer at
Lévis Substation

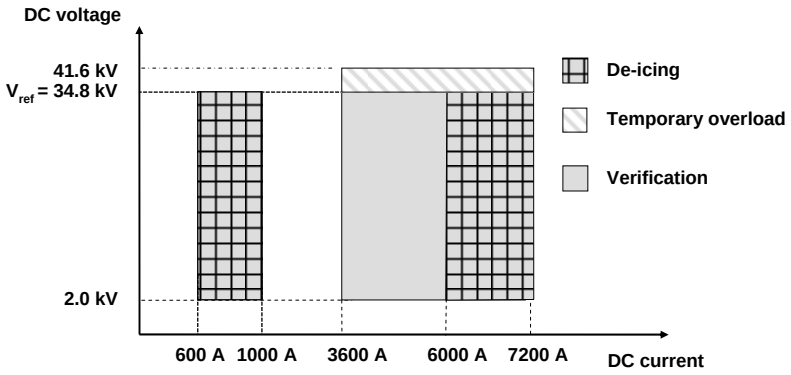
Lines for de-icing

Line	Destination	Length	Voltage
7010	Laurentides	27km	735 kV
7010 +7020	Jacques Cartier	62km	735 kV
7097	Appalaches	78km	735 kV
7007	Bergeronnes	242km	735 kV
3078 / 3079	Rivière du Loup	183km	315 kV

De-icer Mode: Main design ratings

- **Main Ratings:**
  - **Standard de-icer mode - "Nameplate rating" :**
    - **250MW, 7200A / ±17.4kV @ +10°C**
  - **Verification mode :**
    - **200MW, 5760A / ±17.4kV @ +30°C**
  - **1 hour overload :**
    - **300MW, 7200A / ±20.8kV @ +10°C**
  - **Low ambient overload :**
    - **275MW, 7920A / ±17.4kV @ - 5°C**

De-icer Mode: Main design ratings



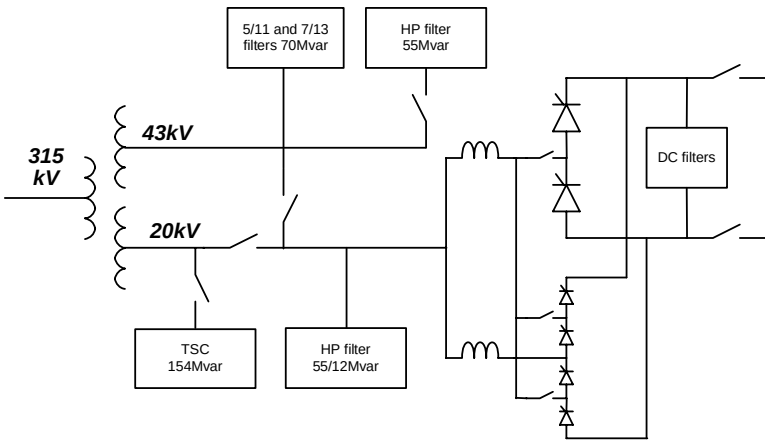
- Because of the different characteristics of the sections, the operating range of current and voltage is large

SVC Mode: Main design ratings

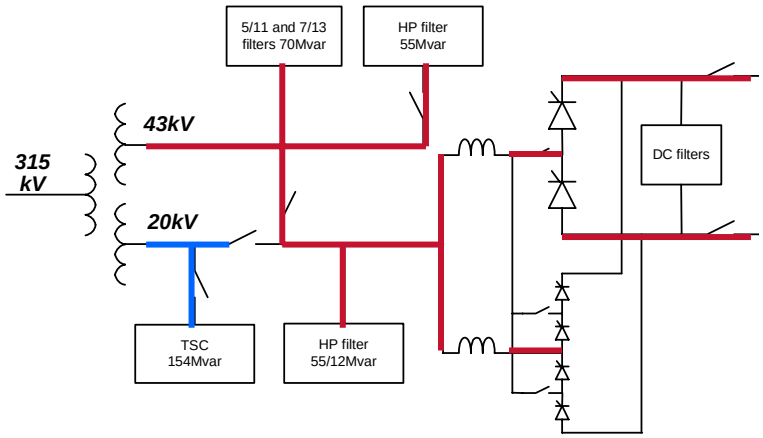
- Main ratings
  - Dynamic range
    - +225 Mvar / -115 Mvar at nominal voltage
  - Target voltage
    - 315 kV ± 5%
  - Slope
  - 3% on 225 Mvar

Solution

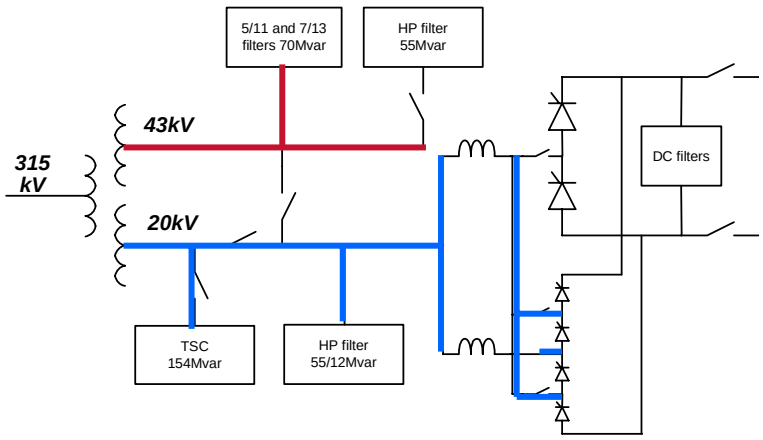
One line diagram



One line diagram: De-icer mode



One line diagram: SVC mode



Studies

- **Main scheme parameters**
  - **Design for both modes**
    - **Use of AC coupling reactors for both modes**
    - **Different temperature ranges for different modes**
      - **Affects the transformer and capacitors**
    - **Different reactive power requirements for different modes**

Studies

- **Filter performance and rating**
  - **AC filter design for all modes**
    - **Different harmonic generation from converters for different modes**
    - **Different temperature ranges for different modes**
    - **13 different line connection arrangements in de-icer mode**
  - **DC filter design for de-icer and verification modes**
    - **13 different line connection arrangements in de-icer mode**
    - **60Hz induction from parallel AC lines in de-icer mode**

Studies

- **Transient studies**
  - **Transient component ratings**
  - **Surge arrester ratings**
  - **Circuit breaker TRV**
  - **Accidental imposition of 735kV or 315kV onto DC bus**

Studies

- Insulation co-ordination
  - Determination of clearances and creepages
  - Enhanced insulation specified for insulators subject to ice

Studies

- Dynamic performance studies
  - Step response in SVC mode
  - Static characteristic
    - Characteristic defined at 315kV, but voltage measured at 735kV
  - Overvoltage and undervoltage response
  - Control loop stability in de-icer mode
  - TSC switching in de-icer mode

Control Performance Verification

Testing of Control System

- **Development of Master Control - DCU (De-icer Control Unit)**
- **Validation of DNP3 Communication**
- **Type test on Real Control (System V)**
- **Static and Dynamic Performance Test on Development Control Cubicle & Simulator**
- **Additional tests on a Control Replica at IREQ**

Type test on Real Control

Real Control (SVC/De-icer and VBE) subjected to a complete type tests program:

Immunity to Electrical Interference (EMC)

Primary Objectives

- No deviation of operating point beyond accuracy limits
- State of all digital I/O shall remain unchanged
- No lane changeover
- No report of a fault event by control system devices

Environmental Tests

Primary Objectives

- No drifting of control operating point or total controls failure permissible due to thermal stress or humidity effects

Static and Dynamic Performance test

Performed on a Development Control Cubicle connected to Manufacturer's RTDS

- TCR/De-icer and TSC firing pulses;
- Same application code;
- 2 lanes
- Additional H/W and software to simulate the plant inputs as required;
- Simulation of profibus outstation for switchgear monitoring.

Static and Dynamic Performance test

Development Control Cubicle and RTDS

Static Tests

- Sequence Control with DCU
- De-Icer Control
  - Control loops
  - De-icer Characteristic (Voltage, Power and Line resistance)
  - Lane Changeover
- SVC Control
  - VI Curve in Voltage Control and Reactive Power Control
  - Open-loop Control
  - Lane Changeover
  - Special control function (Gain Supervisor, Current limiter etc.)
- Harmonic Performance
- Valve Data Back
- Control System Internal faults
- AC Protection
- DC Protection

Static and Dynamic Performance test

Development Control Cubicle and RTDS

Dynamic Performance Tests

- SVC Mode: Small and large Disturbance step response
- De-Icer Mode: Step Response at High and Low Current
- Faults in De-icer mode
- 1-phase Bi-phase and 3 phase faults in SVC mode
- Response to frequency variation in SVC mode
- Stability Margin

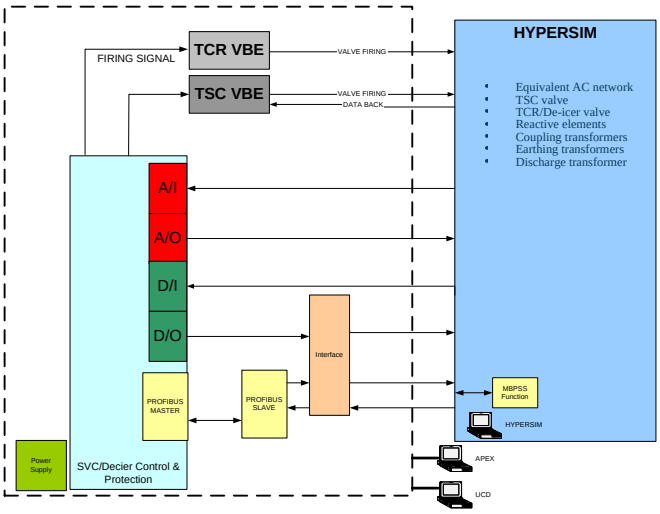
Additional Testing *on a Control Replica (RSPC1)*

Replica connected to HYPERSIM (IREQ simulator)

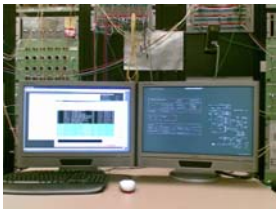
Primary Objectives

- **Provide additional testing facility** (In parallel to Factory Test)
  - **MBPSS(Multi-Band Power System Stabilizer)**
  - **Geomagnetic influence**
  - **Contingencies (additional validation)**
- **Final validation of UCD**
- **Validation of Acceptance Test program**
- **Training (Operator and Field technician)**

Additional Testing *on a Control Replica (RSPC1)*



Simulator Setup

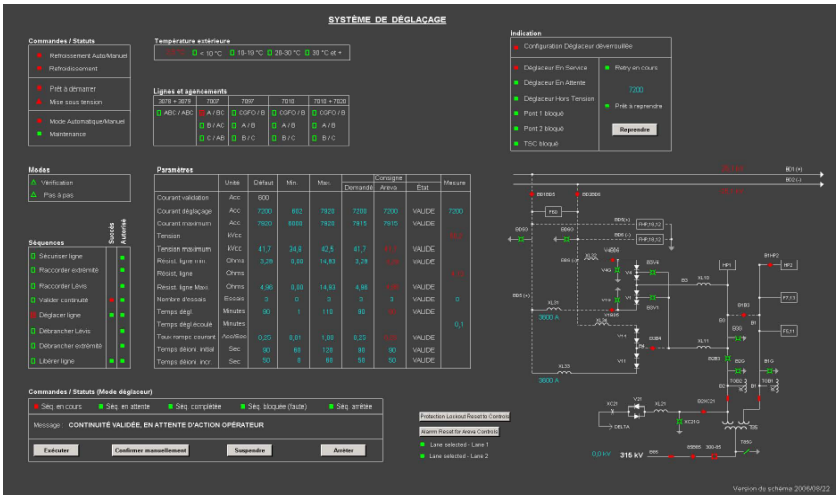


UCD

HYPERSIM

RSPC1

De-icer mode

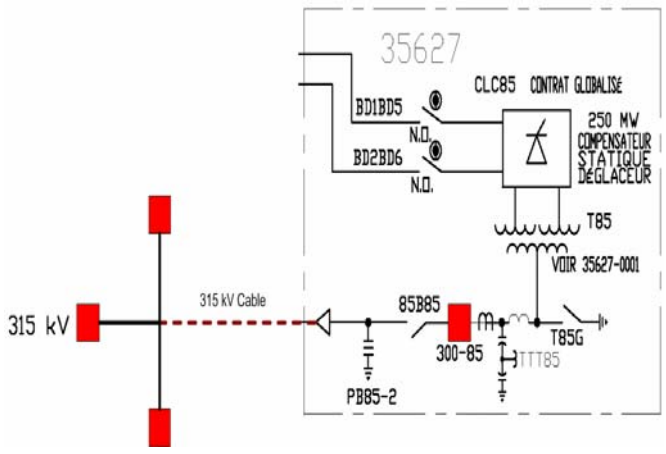


Preparation for the commissioning

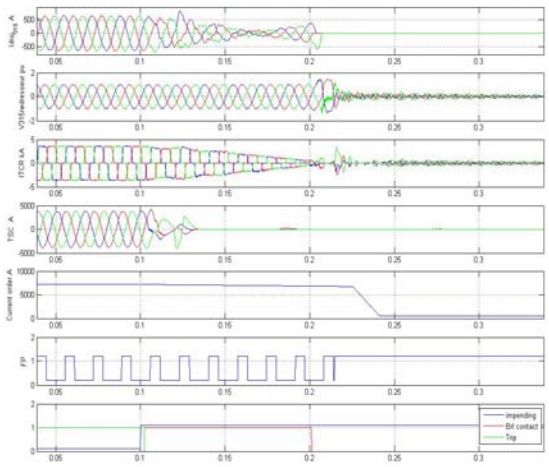
Deicer mode - particular tests singled out

1. **Open Circuit Test Mode; intended for first time energization**
2. **Converter Deblocking in current control**
3. **Review trip sequence – Overvoltage caused by remote isolation of the converter**
4. **Dc voltage measurement failure**
5. **Ac Voltage Error (Fuse failure)**

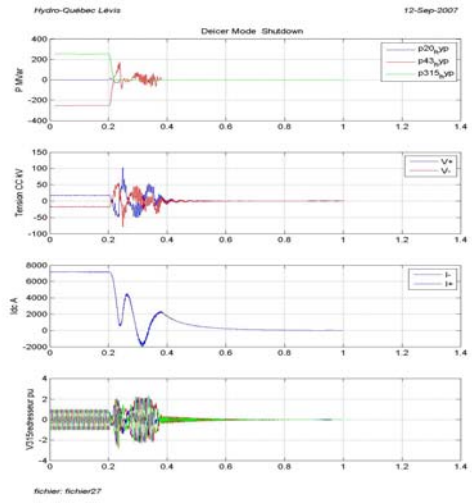
Remote Isolation of the Converter



Normal Shutdown Sequence
by local breaker opening



Deicer mode – Remote Shutdown



No control action

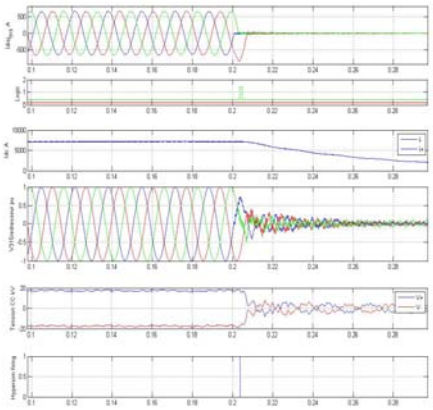
Severe Overvoltage

when connected to longest (247km) line

Deicer mode – Remote Shutdown

Preliminary investigation

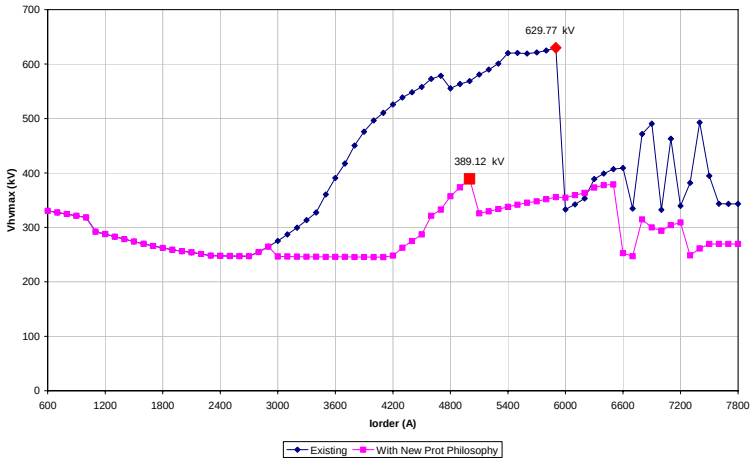
Local detection preferred



Current detection & Control action

No Overvoltage

Limitation of Overvoltage New Protection Philosophy



De-icer installation

De-icer installation

DC converter valves

De-icer installation

AC coupling reactors

De-icer installation

HV connections and transformer

De-icer installation

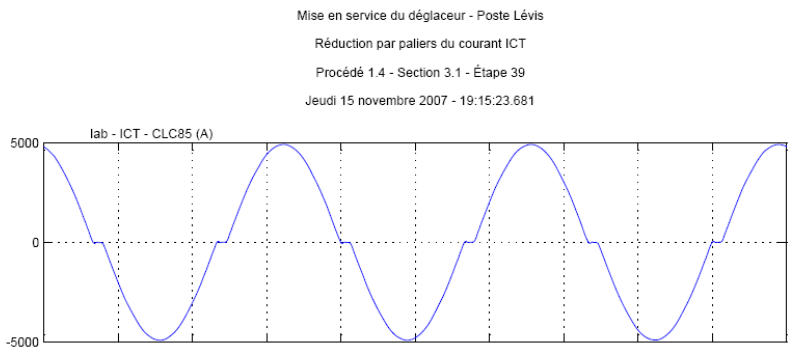
Harmonic filters

De-icer installation

DC filters and DC bus

Commissioning

TCR current



- **Thank you for your attention**