

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

Presenters

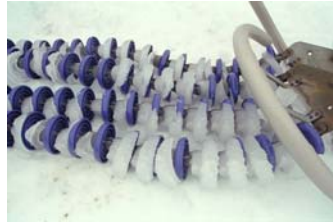
Chris Horwill : AREVA T&D

Hubert Bilodeau : Hydro Québec

IEEE T&D Conference, Chicago 2008

Background

Why a de-icer?

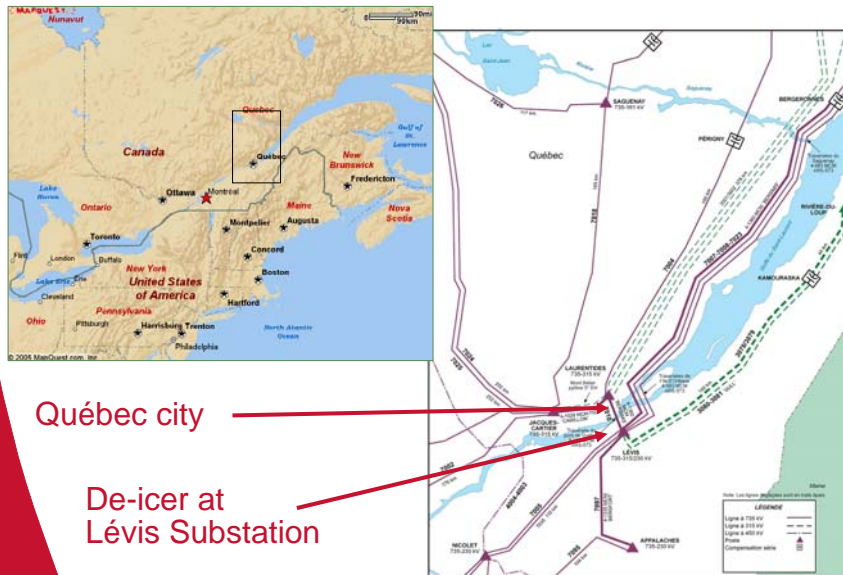


► In December 1998, the Québec region of Canada was hit by one of the worst ice-storms in recorded history

- 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

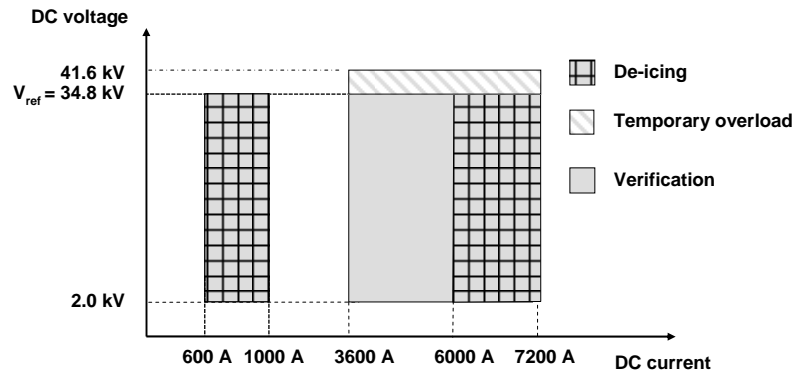


Line	Destination	Length	Voltage
7010	Laurentides	27km	735 kV
7010 +7020	Jacques Cartier	62km	735 kV
7097	Appalaches	78km	735 kV
7007	Bergeronnes	242km	735 kV
3078 / 3079	Rivière du Loup	183km	315 kV

► Main Ratings:

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

De-icer Mode: Main design ratings



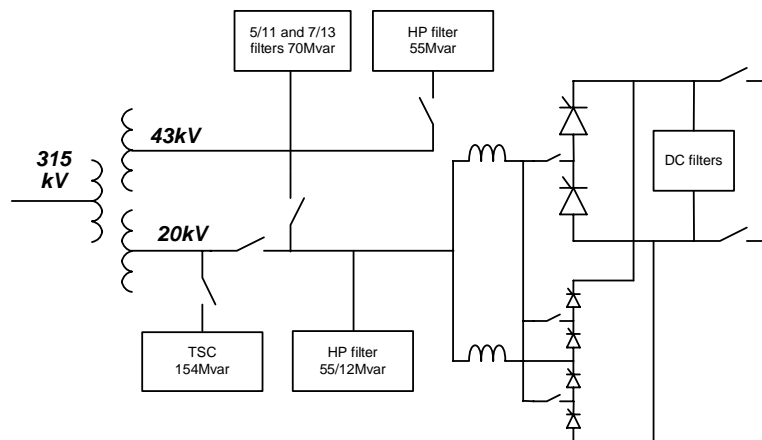
- ▶ Because of the different characteristics of the sections, the operating range of current and voltage is large

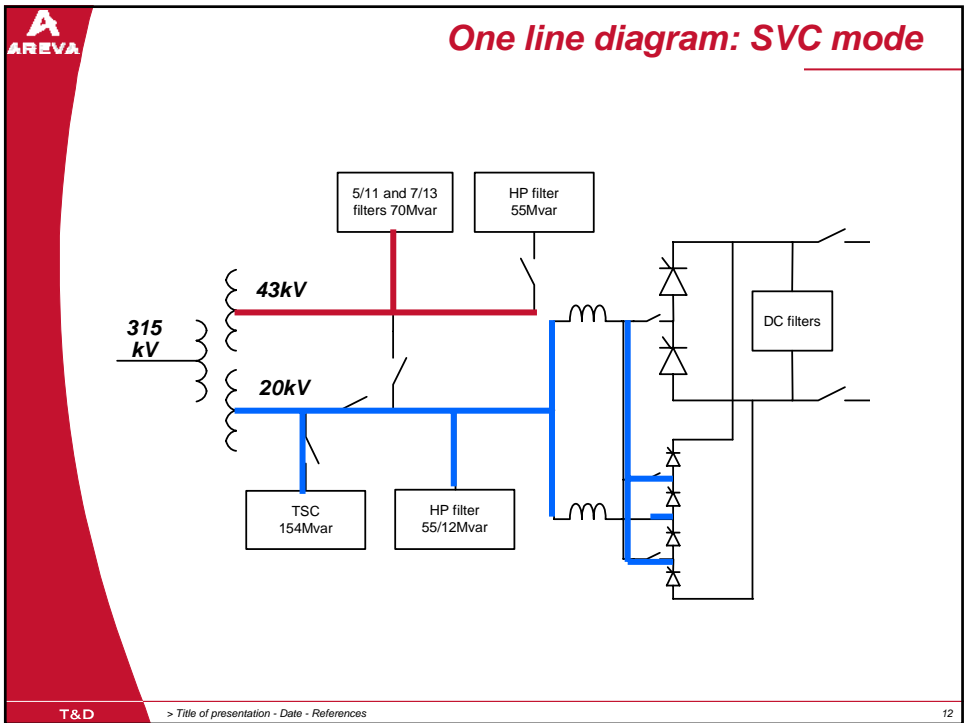
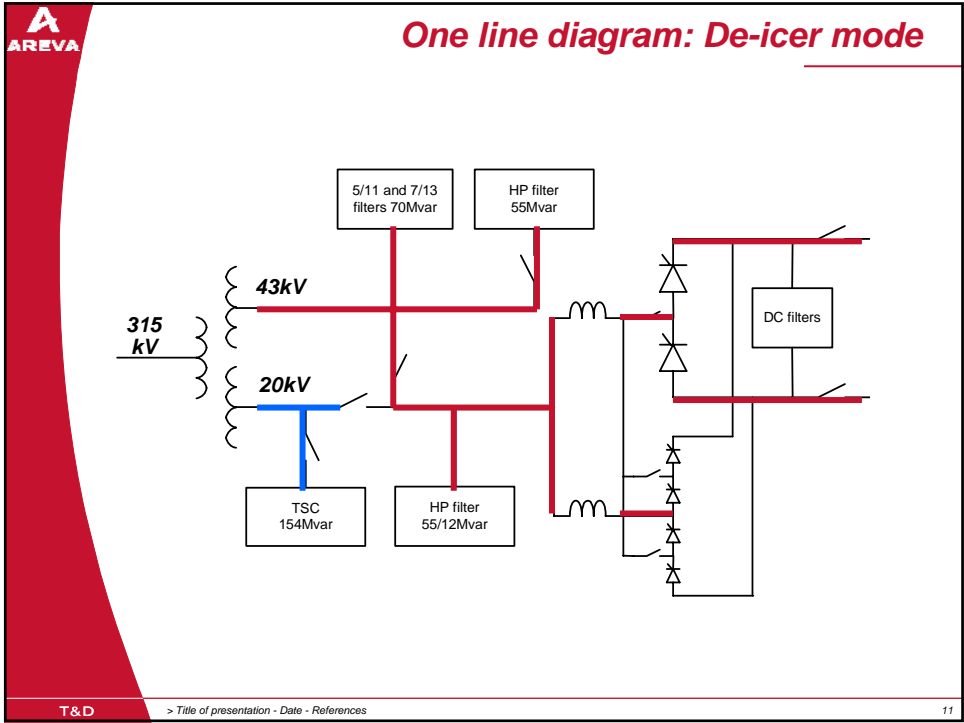
SVC Mode: Main design ratings

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

Solution

One line diagram





Studies

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

▶ **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

▶ **Transient studies**

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

▶ **Insulation co-ordination**

- ◆ **Determination of clearances and creepages**
- ◆ **Enhanced insulation specified for insulators subject to ice**

▶ **Dynamic performance studies**

- ◆ **Step response in SVC mode**
- ◆ **Static characteristic**
 - **Characteristic defined at 315kV, but voltage measured at 735kV**
- ◆ **Overtoltage 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**

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

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.

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

Development Control Cubicle and RTDS

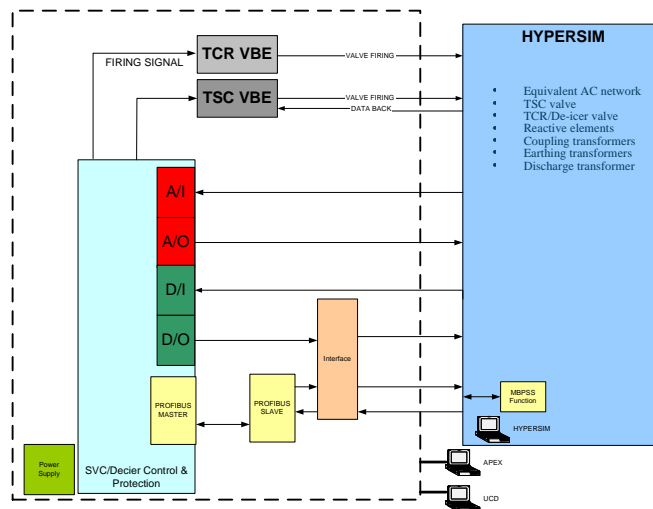
Dynamic Performance Tests

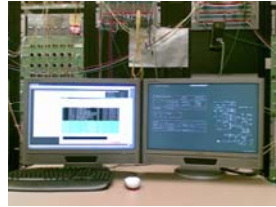
- ◆ SVC Mode: Small and large Disturbance step response
- ◆ De-Icer Mode: Step Response at High and Low Current
- ◆ Faults in De-icer mode
- ◆ 1-phase Bi-phase and 3 phase faults in SVC mode
- ◆ Response to frequency variation in SVC mode
- ◆ Stability Margin

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)**





UCD



HYPERMIM



RSPC1



SYSTÈME DE DÉGLAÇAGE

Commandes / Status

- Retour à l'arrêt
- Maintien en arrêt
- Prêt à partir
- Mise sous tension
- Mode Automatique
- Maintenance

Température extérieure

< 10°C | 10-19°C | 20-30°C | 30°C et +

Indication

- Configuration Déglaceur ouverte
- Déglaceur En Service
- Déglaceur En Arrêt
- Déglaceur Hors Tension
- Part 1 bloqué
- Part 2 bloqué
- TSC bloqué
- Ready en cours
- 7200
- Prêt à reprendre

Reprendre

Liens et agencements

Liens + zone	TOP	TOP	TOP	TOP + TOP
0 A/C	0 B/C	0 C/D	0 D/E	0 E/F
0 F/G	0 G/H	0 H/I	0 I/J	0 J/K

Paramètres

Unité	Defaut	Min	Max	Normal	Actuel	Etat	Message
Courant nominal	ACC	900					
Courant réglage	ACC	7000	800	7000	7000	VALEUR	7300
Courant maximum	ACC	7800	8000	7800	7815	VALEUR	
Tension	Min						315
Tension maximum	Min	41,7	34,8	42,5	47,2	VALEUR	
Resist. ligne Min	Ohms	5,28	5,28	14,93	5,28	VALEUR	5,28
Resist. ligne Max	Ohms	4,86	5,80	14,83	4,86	VALEUR	0
Nombre armoires	Etages	0	0	0	0	VALEUR	0
Temps dégl.	Minutes	90	1	115	90	VALEUR	
Temps dégl. max	Minutes					VALEUR	0,1
Temps de rep. puissance	Secondes	525	5,81	1,80	5,25	VALEUR	
Temps de rep. initial	Sec	90	85	150	80	VALEUR	
Temps de rep. incr	Sec	50	3	65	55	VALEUR	

Commandes / Status (Mode déglaceur)

- Seq. en cours
- Seq. en attente
- Seq. complète
- Seq. bloquée (busy)
- Seq. arrêtée

Message: CONTINUITÉ VALIDÉE. EN ATTENTE D'ACTION OPÉRATEUR

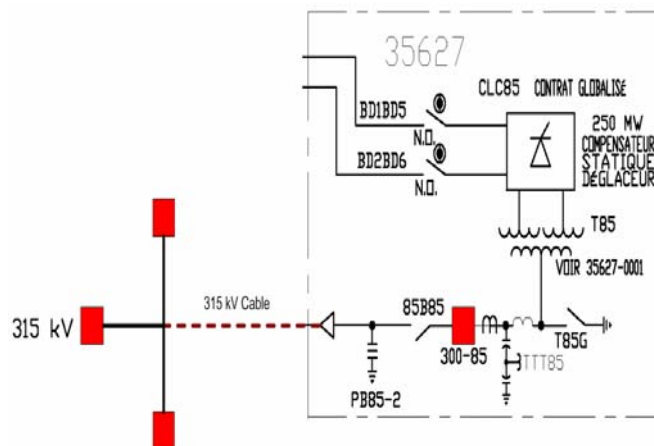
Buttons: Exécuter, Conditionner manuellement, Supprimer, Arrêter

Indications de ligne

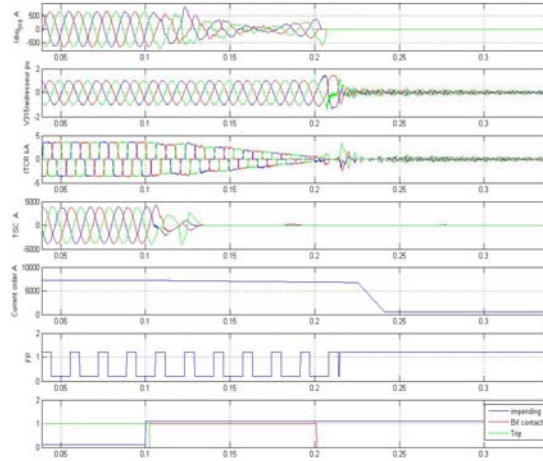
- Line selected - Ligne 1
- Line selected - Ligne 2

Deicer mode - particular tests singled out

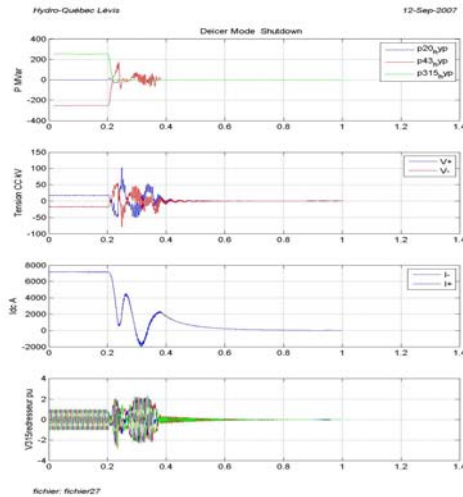
1. Open Circuit Test Mode; intended for first time energization
2. Converter Deblocking in current control
3. Review trip sequence – Overvoltage caused by remote isolation of the converter
4. Dc voltage measurement failure
5. Ac Voltage Error (Fuse failure)



Normal Shutdown Sequence by local breaker opening



Deicer mode – Remote Shutdown

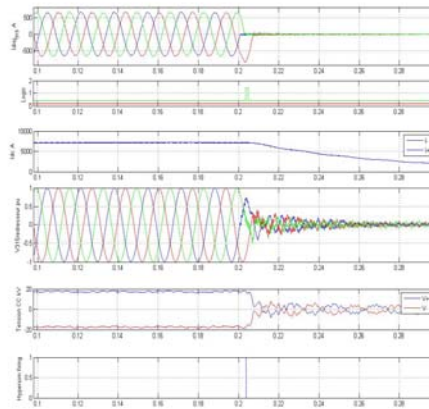


No control action
Severe Overvoltage
when connected to
longest (247km) line

Deicer mode – Remote Shutdown

Preliminary investigation

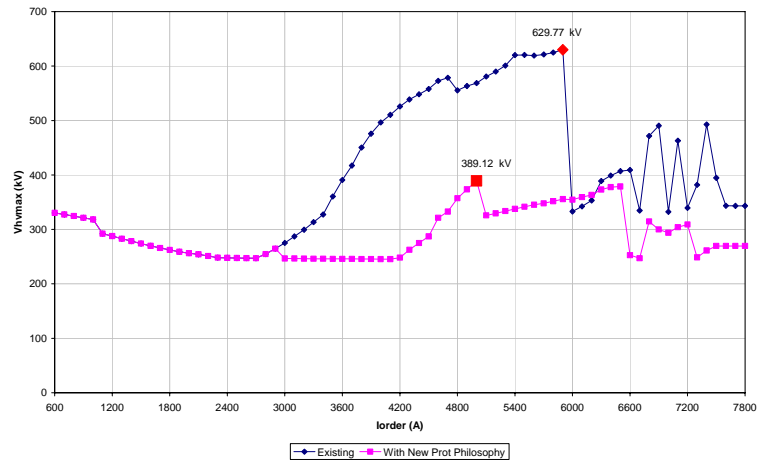
Local detection preferred



Current detection &
Control action

No Overvoltage

Limitation of Overvoltage New Protection Philosophy



De-icer installation

De-icer installation

DC converter valves



AC coupling reactors



HV connections and transformer



Harmonic filters



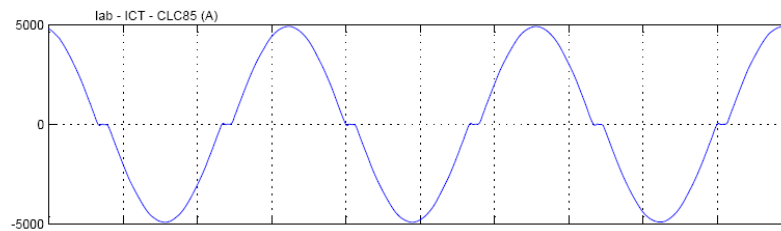
DC filters and DC bus



Commissioning

TCR current

Mise en service du déglaceur - Poste Lévis
Réduction par paliers du courant ICT
Procédé 1.4 - Section 3.1 - Étape 39
Jeudi 15 novembre 2007 - 19:15:23.681



▶ **Thank you for your attention**