VOLTAGE STABILITY OPERATING LIMITS AND PROCEDURES FOR USING
THE REAL TIME VOLTAGE STABILITY APPLICATION (RTVSA)
Supercedes 7T-50 dated 02 May 2006

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Original signed by:
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General Manager
Real Time Operations

Denotes Revision
1.0 **GENERAL**

This operating order describes the guidelines for maintaining voltage stability operating limits of the BC Hydro bulk electric system. These guidelines are complemented with the procedures for using in a coordinated manner the Real Time Voltage Security Assessment (RTVSA) application to support operation of the power system within voltage stability limits.

The primary concern is to ensure that system voltage stability is maintained after loss of a major transmission line or some other critical equipment. Failure to operate within secure limits may lead to system voltage collapse. Outages involving 500 kV lines, particularly the Interior to Lower Mainland lines, are often the most limiting conditions which will determine the permissible operating boundaries for a given system condition. At times of heavy power import from the BPA, loss of a Custer-Monroe 500 kV circuit in the BPA system can also become limiting. When operating within specified limits, the system will be voltage stable following the loss of any line and no remedial actions, such as generation shedding or load shedding, will be required to maintain voltage stability.

RTVSA has been implemented within the integrated EMS-DSATools environment for voltage security assessment against the major Interior to Lower Mainland contingencies (i.e. 5L41, 5L42, 5L44, 5L45, 5L47, 5L81, 5L82 and 5L87) for the BC Hydro bulk electric system.

2.0 **RESPONSIBILITIES**

The responsibilities in terms of roles are as follows:

2.1 **Transmission Coordinator**

- Follow the guidelines for maintaining voltage stability in the BC Hydro integrated system within secure operating limits.
- Monitor the performance of the tools used for calculating voltage stability limits.
- Monitor the current operating point with respect to voltage stability limits and implement preventive and corrective actions as required.
- Report any discrepancies or problems encountered while monitoring or using the RTVSA application. All problems should be logged as EMS/SCADA events in the CROW. For urgent problems, the Transmission Coordinator may contact the Real Time Systems EMS Help Desk staff for immediate assistance.

2.2 **System Control Manager**

- Contact the EMS support staff for application troubleshooting or enhancements required.

2.3 **Real Time Systems Network Team**

- Assist control room staff to resolve issues and questions regarding the RTVSA application.
- Ensure that State Estimator solution provides a consistent and accurate system condition.
- Coordinate with control room staff before installing new versions of the applications.
- Summarize new implemented changes before new versions are released.
- Resolve and follow-up issues assigned in the CROW.
3.0 OPERATING GUIDELINES FOR MAINTAINING VOLTAGE STABILITY

The voltage stability operating limits are significantly affected by the system network configuration, the system net load, the generation pattern and especially the reactive power reserves at BUT, VIT S/C and DMR SVC. The limits are also somewhat dependent on the loading of the HVDC tie between ARN and VIT because it has an impact on the VIT reactive power reserve. The availability of shunt capacitors is important since it also has an impact on dynamic reactive power reserve. The distribution of generation between the north, southern interior and coastal regions is important.

Outages to other equipment, such as 230 kV lines in the Lower Mainland and Vancouver Island areas, have some affect on the limits. Special considerations should be given when operating the system under such conditions; especially if a number of these outages have occurred or if the system is being operated close to its limit.

The 500 kV system voltage should be generally maintained at 525 kV. System voltage operating limits are prescribed in OO 7T-22. It is recommended to switch Lower Mainland and Vancouver Island capacitors and reactors to maximize dynamic reactive power reserves in the coastal area. BUT units and VIT S/Cs should be kept at zero or negative reactive generation. Similarly, DMR SVC should be kept at or below -40 MVar output.

It is also important to ensure that AVRs are in-service. A unit on manual voltage control has zero dynamic reactive power reserve. Similarly, line drop compensation (LDC) and joint var control (JVC) schemes should be kept in service. They are important for full utilization of reactive power reserves after a disturbance.

When the operation is outside the voltage stability operating limits, some or all of the following actions can be taken to move the operating point back to within the limits:

- Adjust (increase/decrease) North and Southern Interior generation.
- Increase Vancouver Island, Lower Mainland and Bridge River area generation.
- Maximize BC to US export on the east side by using the NLY Phase Shifter.
- Reduce HVDC transfer level.
- Adjust armed generation shedding in consultation with the RTVSA application
- Switch Lower Mainland and Vancouver Island area capacitors and reactors to maximize dynamic reactive power reserves.
- Decrease system voltages to their lower limits (especially at VIT) to increase the dynamic reactive power reserves.

An automatic undervoltage load shedding (AULS) remedial action scheme has been implemented in the Lower Mainland and Vancouver Island area to maintain 500 kV system voltage stability following the loss of major transmission or reactive power support facilities. OO 6T-34 describes the operation of the scheme and the conditions under which the scheme should be armed.

4.0 REAL TIME VOLTAGE SECURITY ASSESSMENT (RTVSA)

4.1 FUNCTIONAL DESCRIPTION

The RTVSA is BC Hydro Grid Operations’ primary tool to assess real-time voltage stability limits in the transmission system. The application forms part of the real-time sequence and
runs outside of the EMS on a dedicated server (i.e. VSAT server).

The application uses current system conditions as determined by the State Estimator solution and armed generation shedding as recommended by the Transient Stability Analysis Pattern Matching (TSAPM) application. The application performs studies in real-time of a selected number of contingencies to calculate thermal and voltage stability limits. These results are presented on a display available in the EMS environment.

Key information available to the end-user after each run of the RTVSA and which the user needs to consider for analysis is as follows:

- Central Interior – South Interior (CI-SI) generation plot indicating current operating point, thermal and voltage stability regions, and on-line CI and SI generation capability limits. The safe operating region is bounded by the most restrictive limit which can be either the on-line generation capability or a post-contingency voltage stability limit. Thermal rating stability region is indicated within the voltage stable operating zone by a yellow area.

- Limiting constraints (thermal and voltage stability) and associated contingencies

4.2 RTVSA USER INTERFACE

The RTVSA results are displayed from Dynamic Security Assessment Output Analysis (DSA_OA) application that can be launched from EMS-WebFG by clicking on the button “RTVSAT 2-D Plot” on “Network Online Sequence” display (Figure 1).

![Network Online Sequence](image)

Figure 1: Network Online Sequence

Currently, monitoring of the application timestamp is required to ensure the result is being updated continuously (expected approx. every 2 minutes). A future development will include status box to enable visual monitoring of RTVSA status on the Network Online Sequence display. The box will flash red when RTVSA fails to provide valid solution for longer than 30 minutes.
The CI-SI generation 2-dimensional voltage security region (Figure 4) is the main display of RTVSA for real-time operations:

![Figure 2: 2-Dimensional Voltage Security Region](image)

The green area is the secure region. The green dots are the last secure points and the red dot is the first insecure point for a particular contingency.

Left-click on and keep on a dot (Figure 5), the point coordinates will be displayed.
Double-clicking on a red dot (first insecure point) will pop-up a small dialog (Figure 6) showing the contingency name, which causes the voltage collapse at the point.
4.3 RTVSA APPLICATION PROBLEMS

There are three major types of RTVSA failures:

A. RTVSA failure at EMS (“Network Online Sequence”)

<table>
<thead>
<tr>
<th>RTVSA</th>
<th>VSA COMPLETED</th>
<th>VSAFILES</th>
<th>Sleeping</th>
<th>25-Jun-2010 09:57:24</th>
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</thead>
</table>

The timestamp indicates the time of last successful run of RTVSA in EMS. If the last successful run is older than 30 minutes, call RTS Help Desk for support. The System Control Manager will determine the requirement to contact RTS based on the impact on current system operating point.

B. Communication between EMS and DSA Master

<table>
<thead>
<tr>
<th>Server</th>
<th>Status</th>
<th>File timestamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSAT</td>
<td>READY</td>
<td>25-Jun-2010 09:57:16</td>
</tr>
</tbody>
</table>

The timestamp indicates the time of last successful run of RTVSA in DSA Master. Similarly, if the last successful run is older than 30 minutes, call RTS Help Desk for support.

C. Bad state estimator solution

Even though some state estimator solutions are considered as “valid” based on the current criteria, the solutions may be “bad” to RTVSA because these “bad” solutions contain some buses with extreme low voltages, with which RTVSA may fail to provide a reasonable region (Figure 10) and consistent boundary of the security region.

Figures 11.1 and 11.2 show examples of inconsistent regions, where the 2-D graph changes significantly within a short period of time even though there is no major power system change in the real-time within the time frame.

If inconsistent regions switch back and forth for over 30 minutes, contact RTS Help Desk.
Figure 10: Unsolved basecase

Figure 11.1: Inconsistent security region (shrunk)
4.4 POTENTIAL VOLTAGE INSECURE SCENARIO

If the operating point resides consistently close to the security boundary (Figure 12) or even outside the security region, it may indicate the need to initiate control actions to improve the system operating point with respect to voltage stability limits. The control room will consider the current system condition and take appropriate action to improve the voltage stability margin. If in doubt of the legitimacy of the result, RTO will contact the RTS Help Desk.
4.5 **DSA FAILOVER**

DSA Master Servers need to failover from time to time for software installation and windows patches. However, planned failovers will happen much less frequently than EMS servers’ failover.

The on-shift SCM (System Control Manager) will be informed for any planned failover. Before failover, it is desirable to shut down DSA_OA and restart it after failover.

If unplanned failover occurs, DSA_OA may show a blank display (Figure 13). Simply shut down DSA_OA and observe the timestamp of last successful run of RTVSAT at DSA Master:

<table>
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<th>VSAT/TSAT server status</th>
<th>Status</th>
<th>File timestamp</th>
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</thead>
<tbody>
<tr>
<td>VSAT</td>
<td>READY</td>
<td>Last used file set: 25-Jun-2010 09:57:16</td>
</tr>
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Once it gets a fresh run, restart DSA_OA.

5.0 **VSLIM USER INTERFACE WITHIN TTC_CALCULATOR**

TTC Calculator is running in corporate PCs. The 2-dimensional voltage security region (Figure 8) can be called up from the menu (NI-SI VSA View Graph, Figure 7) of the application. Make sure to initiate ‘Run’ of the TTC Calculator before calling the menu. Refer to O.O. 7T-51 for more information on operation of the TTC Calculator.
Figure 7: TTC Calculator menu (NI-SI VSA Graph View)

Figure 8: 2-Dimensional voltage security region of VSLIM
## 6.0 REVISION HISTORY

<table>
<thead>
<tr>
<th>Revised By</th>
<th>Revision Date</th>
<th>Summary of Revision</th>
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<tbody>
<tr>
<td>AMS</td>
<td>01 May 2006</td>
<td>Major Revision</td>
</tr>
<tr>
<td>AMS</td>
<td>22 September 2011</td>
<td>Major Revision, update for BC Hydro and release of Powertech RTVSAT.</td>
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